CA8160 .

Georgia Institute of Technology
Office of Contract Administration
OCA PAD AMENDMENT - PROJECT HEADER INFORMATION

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OCA file #: — Project type: RES

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Prime #: DE-AC12-76SN00052 — Contract entity: GTRC

CFDA:
PE #:

Project unit: GTRI-EOEML — Unit code: 190
Project director(s):
PDPI- LACKEY W J MECH ENGR (404)894-0573

Sponsor : KNOLLS ATOMIC POWER LAB/SCHENECTADY, NY
Division Id: 240 / 533
Award period: 14-FEB-1997 to 06-JAN-1998 (performance) 06-FEB-1998 (reports)

Sponsor amount	New this change	Total to date
Contract value:	23,643.00	98,538.00
Funded:	23,643.00	98,538.00
Cost sharing amount:	0.00	0.00

Does subcontracting plan apply?

Title: LAMINATED MATRIX COMPOSITES

PROJECT ADMINISTRATIVE DATA

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Security class (U,C,S,TS): U
Defense priority rating :

ONR resident rep is ACO (Y/N): N
Supplemental sheet:

Equipment title vests with: SPON
non anticipated

Administrative comments -
Adds funds, expands the SOW, extends term, and adds 1 item of GP

CA8120 Georgia Institute of Technology Page: 1
Office of Contract Administration 29-JAN-1998 08:37
PROJECT CLOSEOUT - NOTICE

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12

Closeout Notice Date 29-JAN-1998

Project Number E-25-A21 Doch Id 40069

Center Number 24-6-R5398-000

Project Director LACKEY, W.

Project Unit MECH ENGR

Sponsor KNOLLS ATOMIC POWER LAB/SCHENECTADY, NY

Division Id 533

Contract Number PL0029663 SJ Contract Entity GTRC

Prime Contract Number DE-AC12-76SN00052

Title LAMINATED MATRIX COMPOSITES

Effective Completion Date 06-JAN-1998 (Performance) 06-FEB-1998 (Reports)

Closeout Action:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory and Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	Y	
Other	N	

Comments

Distribution Required:	
Project Director/Principal Investigator	Y
Research Administrative Network	Y
Accounting	Y
Research Security Department	N
Reports Coordinator	Y
Research Property Team	Y
Supply Services Department/Procurement	Y
Georgia Tech Research Corporation	Y
Project File	Y

NOTE: Final Patent Questionnaire sent to PDPI

A-5398
1

Georgia Tech
RESEARCH INSTITUTE

FAX COVER SHEET

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PAGES TO FOLLOW: 2

Notes: Lynne,
Here is the 1st Monthly Report.

J 3-20-97

A-5398-1

Laminated Matrix Composites

Monthly Progress Report

Period Covered: 2-14-97 to 3-13-97

Prepared for:

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Schenectady, NY 12309

Prepared by:

W. Jack Lackey, Giancarlo Giannetti,
and Michael Miller
Georgia Institute of Technology
Atlanta, GA 30332

March 20, 1997

Laminated Matrix Composites

Objective

The objective of this project is to prepare and characterize two geometries of laminated matrix composite samples using a C + SiC matrix.

Accomplishments

Task 1 - Numerous CVD coating runs were completed in an attempt to identify the proper conditions for achieving coatings of the desired layer thickness. Initial runs for carbon deposition gave soft, sooty coatings. Therefore, low pressure CVD runs were performed. Both hydrogen and argon have been investigated as diluents for the propylene (C_3H_6) reagent. The lower pressure runs eliminated the soot problem but higher deposition rates are needed.

For SiC deposition, atmospheric pressure with methyltrichlorosilane look promising based on several trial runs. If possible, the SiC layers will be deposited at atmospheric pressure in order to avoid the production of pyrophoric exhaust products.

Task 2 - A very extensive search (literature, vendors, data bases, and Web) was conducted to located a possible material to use as the reinforcement for the composites to be made in this task. A possible material was identified and it is being evaluated by the KAPL staff.

Plans

Next month we will continue to emphasize Task 1. Additional trial runs will be performed in order to identify suitable processing conditions. We will continue to use the SCS-6 SiC fiber as the substrate. Discussions will be held with KAPL to finalize selection of the reinforcement material for Task 2.

A-5398
2

A-5398-2

Laminated Matrix Composites

Monthly Progress Report

Period Covered: 3-14-97 to 4-13-97

Prepared for:

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Schenectady, NY 12309

Prepared by:

W. Jack Lackey and Michael Miller
Georgia Institute of Technology
Atlanta, GA 30332

April 17, 1997

Laminated Matrix Composites

Objective

The objective of this project is to prepare and characterize two geometries of laminated matrix composite samples using a C + SiC matrix.

Accomplishments

Task 1 - Again this month numerous CVD coating runs were completed in an attempt to identify the proper conditions for achieving coatings of the desired layer thickness. Low pressure CVD runs are being emphasized using propylene as the reagent and argon as the diluent. The desired high deposition rate has been achieved.

For SiC deposition, several runs made at 300 torr appear promising.

Task 2 - KAPL is preparing the reinforcement material for use in this task.

Plans

Next month we will continue to emphasize Task 1. Additional trial runs will be performed in order to identify suitable processing conditions. We will continue to use the SCS-6 fiber as the substrate.

E-25-A21
#3

E25-A21-3
Formerly A-5398

Laminated Matrix Composites

Monthly Progress Report

Period Covered 4-13-97 to 5-14-97

Prepared for:

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Schenectady, NY 12309

Prepared by:

Jack Lackey and Michael Miller
Georgia Institute of Technology
Atlanta, GA 30332

June 3, 1997

Laminated Matrix Composites

Objective

The object of this project is to prepare and characterize two geometries of laminated matrix composite samples using a C+SiC matrix.

Accomplishments

Task 1 - Again this month numerous CVD coating runs were completed in an attempt to identify the proper conditions for achieving coatings of the desired layer thickness. Low pressure CVD runs are being emphasized using propylene as the reagent and argon as the diluent. The desire high deposition rate has been achieved.

For SiC deposition, several runs made at 300 torr appeared promising.

Based on these trial experiments, three production runs were made. These runs resulted in product that will be delivered to KAPL. In one of these runs (#10) 60 layers of carbon and 60 layers of SiC were deposited. The cycle times were 5 minutes for carbon deposition and 3 minutes for SiC deposition. This resulted in 0.25 μm thick layers or slightly thicker on average.

In run No.11 the carbon and SiC cycle times were reduced to 4 and 2.5 minutes, respectively, and 50 rather than 60 layers were deposited. In run No. 12, the conditions used previously for run No. 10 were used but only 10 layers of carbon and 10 layers of SiC were deposited. Randomly selected samples from three production runs have been examined by SEM and a detailed report is being prepared.

Task 2 - The reinforcing material to be used in this tank was received from KAPL.

Next month we will complete the report for Task 1. Experimental work will begin on Task 2.

E- 25- A21
#4

July 8, 1997

Lynne,

Here are the "toothpick" samples. There are three types: TPB-10, -11 and -12 as described in the enclosed report. There are 15 samples of TPB-10, 6 of TPB-11 and 7 of TPB-12. I believe in most cases, and perhaps all, the identity of the top end of the samples is retained in case you wish to try to correlate performance with orientation. I have also enclosed the remainder of the monofilament supplied by KAPL. After reading the report, feel free to call me if you have questions.

Jack Lackey

E-25-A21
#4

E25-A21-4
Formerly A-5398

Laminated Matrix Composites

Monthly Progress Report

Period Covered 5-13-97 to 6-14-97

Prepared for:

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Schenectady, NY 12309

Prepared by:

Jack Lackey, Michael Miller, Harry King, Elliot Pickering, and Giancarlo Giannetti
Georgia institute of Technology
Atlanta, GA 30332

July 9, 1997

LAMINATED MATRIX COMPOSITES

OBJECTIVE

The objective of this project is to fabricate two types of ceramic composite samples: (1) "toothpick"-like samples consisting of multiple thin (0.25 μm) layers of alternating carbon and silicon carbide deposited onto 2" long SiC monofilament fibers, and (2) disk-shaped samples containing a laminated C+SiC matrix where the reinforcement material is carbon particulate. The latter sample type has several variants, i.e., differing layer thicknesses and two of the samples types are to have a SiC, rather than the laminated, matrix. One of the SiC matrix samples has a carbon interface coating while the other has no interface coating.

PROCEDURE AND EQUIPMENT

Task I- "Toothpick" Samples:

The chemical vapor deposition experiments were conducted in a water-cooled, resistively heated vertical furnace pictured in Figure 1. This system has a single reagent gas entry line that allows the connection of a multitude of different reagent sources. For these particular sources, four gas lines were connected to the injector. All four gas lines were metered with mass flow controllers calibrated to the individual gases. The gas line entered the furnace through a water-cooled gas injector at the base of the furnace. The gas injector served as an interface with the heated reaction chamber and provides thermal protection against premature decomposition of the gases. Another gas line feeds argon outside the reaction chamber to prevent an accumulation of reagents outside the reaction chamber, such as on the heating element or stainless steel furnace walls.

The reaction chamber is actually a three piece object constructed of machined graphite. The lower portion is an inverted cone with a small cylindrical nozzle on its base that connects with the gas injector. A tight seal is ensured there by the mounting the gas injector on springs external to the furnace. Above the inlet nozzle is a graphite gas diffuser plate set mid-way up the cone. This supports the samples to be coated and works to manipulate incoming gases into desired directions. In these experiments, the diffuser plate had a large central hole over which the similarly-pierced carbon felt sample holder (see Figure 2) was placed and a multitude of smaller holes radiating outward. The diffuser plate was held in position with carbon cement. Over this cone was a straight cylinder which serves to keep the reagent gases from depositing on the heating elements or attacking the stainless steel walls of the furnace; the cone and cylinder are merely screwed together with integral threading. Above the cylinder was the final piece of the reaction chamber, a thick disk, which directed the exhaust gases to the scrubber. The reaction chamber is capped with a centrally pierced lid that allows the introduction of a thermocouple or, in these experiments, visual inspection of the samples during the run.

Temperature control of the furnace was achieved via an optical pyrometer which was linked directly to the power control unit of the furnace. The pyrometer sighted on the outside surface of the graphite reaction chamber. Power is fed into the furnace to the graphite heating element via two large, water-cooled cables at the base of the furnace.

Propylene and argon, the reagent and diluent for the deposition of graphite respectively, are simply controlled by the valves on their high pressure storage tanks, their mass flow controllers, and an on-off valve that isolated them from the gas line headed for the injector. The addition of the on-off valve allowed not only selective leak testing of portions of the line prior to an experiment but provided protection against decomposition products of methyltrichlorosilane (MTS) which include hydrogen chloride. The MTS was in a "bubbler" where the hydrogen carrier gas was injected into the base of the bubbler. Valves were included on both the carrier gas injection line and the outflow line to allow isolation of the MTS from the external atmosphere when it was not in use and to maintain MTS at its operating pressure if, as in these experiments, different pressures were used on each reagent gas. Connecting to the MTS outflow line was the hydrogen diluent line, which mixed and diluted the MTS vapor as it moved toward the furnace. The MTS portion of the gas system was isolated from the injection line with an on-off valve and had access to a relief line that connected directly to the scrubber. The MTS is normally stored under argon at atmospheric pressure to prevent infiltration by atmospheric gases between experiments and for these reduced pressure runs had to be bled down without filling the reaction chamber with this silicon carbide forming material. The relief line enabled that operation to be conducted safely and without contamination of the furnace. Figure 1 is a representation of the furnace.

The sample holder consisted of a simple 30-35 mm flat torus formed out of carbon felt with a razor blade. The hole in its center fit around the central hole of the diffuser plate in the reaction chamber. The sample holder in practice had an octagonal perimeter and a square center hole. The holder, as taken from the roll of felt, was about 4-5 mm thick. Sample fibers were imbedded in the holder oriented approximately vertically. In practice the difficulty of aligning these fibers perfectly vertically was extremely difficult, especially with the production experiments that embedded over ten fibers in the holder. Fibers with an outward tilt were noted to be more likely to aquire nodules, or anomalous deposits perpendicular to the shaft of the fiber, and thus later experiments were run with fibers intentionally leaning slightly inward, which seemed to reduce the amount of nodules that developed. Fibers were typically 6.35 cm (TPB-10) to 7.62 cm long (TPB-11, TPB-12) in production runs, though earlier condition-optimization experiments used fibers 5 cm to 15 cm long. Figure 2 represents the sample holder.

The series of condition-optimization experiments refined data on optimum flow rates, operating pressures, and flow periods. The production runs were all at 1200°C and all used pressures of 25 torr for the deposition of carbon and 300 torr for SiC deposition. This pressure for SiC deposition enhanced uniformity yet avoided conditions where pyrophoric exhaust products might form. The production runs also used a set flow rate of 25 standard cubic centimeters per minute (sccm) of propylene diluted with 975 sccm of argon to deposit carbon and 50 sccm of MTS and 950 sccm of diluent hydrogen to deposit silicon carbide. The initial production experiment (TPB-10) used 60 five-minute propylene and 60 three-minute MTS cycles, a total of 120 deposition cycles. As the accompanying photomicrographs demonstrate, this produced a coating that was slightly too thick. The second production experiment (TPB-11) used 50 four-minute propylene cycles and 50 one hundred and fifty second MTS cycles. TPB-12 ran 20 total cycles at TPB-10's conditions. The weight of uncoated fibers provided by Knolls Atomic Power Laboratory is .00047 g per centimeter of length.

RESULTS

The majority of micrographs taken are from the initial production experiment, TPB-10. This was used as a baseline for further production runs and data gleaned from photomicrographs of later experiments. Two sets of micrographs were made and thus different identification systems were used.

The first series of micrographs was used to quickly aquire data about the thickness of layers using fracture surfaces. Samples were cut with a razor blade and mounted on carbon felt for observing in a scanning electron microscope.

Figure 3 shows a 300X magnification micrograph of a top section of sample 8 from run TPB-10. It only demonstrates basic features comparable to other micrographs, namely the silicon carbide core monofilament and its core carbon monofilament, and the outer thickness of the deposited graphite and silicon carbide coating. As can be seen down its length, the finished fiber is very nodular. The delamination visible between the deposit and core fiber was due to the sectioning of the fiber by a razor blade. Figure 4 is of the side of the sample piece of sample 8 as in photo 1, but focuses on a nodule and a small one at that - most nodules are considerably larger than the diameter of the fiber.

Figure 5 is a 1000X micrograph of the top of a middle section of sample 8 from experiment TPB-10. It not only captures delamination (again due to the razor blade sectioning) but hints of the multi-layered structure of the deposit. Near the core monofilament substrate, this micrograph shows that the layers are very regular and smooth but within 9.5 μm there is a sharp transformation to an irregular layering. Individual layers appear to be about 0.4 μm to 0.9 μm thick in this micrograph. Figure 6 shows part of the rough layer seen in figure 5 that clearly demonstrates the layering of the sample. Layers in this micrograph appear to be about 0.35 μm thick judging from measurements of the width of the shading bands in the lower left corner of the micrograph rather than the sharply defined ridges in the center and upper right (which may include multiple layers).

Figure 7 is a view of the top of the top section of sample 16 at 1000X magnification. Like figure 5, it shows the transition from smooth deposition to rough deposition. In the lower right corner this micrograph captures an excellent example of fracture following the layers rather than transversing through them. Layers appear to be approximately 0.7 μm thick as measured near the center of the micrograph. Figure 8 is an end-on view of a middle section of sample 16. It fractured badly when cut, but demonstrates a tightly held interface layer on the monofilament and irregular outer deposit.

This first series of micrographs also demonstrated a variation in overall coating thickness that varied by position along the length of a sample. The top of sample 8 had an overall thickness of 49 to 53 μm, not counting the delaminated area. The middle of sample 8 had a coating thickness of 60 to 65 μm. The top of sample 16 had a thickness of 33 to 38 μm while its middle had a coating thickness of 50-55 μm. Therefore, the middle of the samples appears to be more heavily coated than the top.

The second series of micrographs were of samples from the three production runs. These samples were mounted in epoxy and polished. These micrographs are labeled as (sample)(position)(experiment). For example, micrograph 8M10 is a micrograph of the middle of sample 8 from experiment TPB-10.

The micrograph of 8M10 shown in figure 9 captures trends that are apparent in most micrographs of the second set. The core silicon carbide-carbon monofilament appears harder than the coating or surrounding epoxy matrix and rises above the surface of epoxy. The deposited layers start out circular near the monofilament and then there is a region where the layers are less circular, more irregular. The region near the substrate and the outermost deposit appear dark and smooth. Figure 10 is a magnification of the inner layers near the monofilament, taken in the lower left boxed-in area of figure 9. The layers near the monofilament appear to be about 0.5 μm thick. Figure 11 is of the upper boxed-in area of figure 9. It aims to capture part of the rough middle layer and the smooth outer region. Layering is visible, but harder to differentiate apparently because, for the most part, the silicon carbide layers are just very thin lines between thicker carbon layers. Figure 12 of 8M10 is a magnification of the boxed in area of figure 11. Individual layers are apparent here. For the region show in figure 12, the carbon layers appear to be about 0.3 μm thick but the thin silicon carbide layers appear to be only 0.05 μm.

Figure 13 is an overview of the middle of sample 16 of experiment TPB-10. Like figure 9, it shows the monofilament, a smooth inner coating near the monofilament, an irregular middle region, and a smooth outer region. Figure 14 is an overview of the middle of sample 28 from experiment TPB-10. It demonstrates features similar to figures 13 and 9. The hint of elongation from top to bottom is the result of the sample being mounted and polished at a slight angle.

Figure 15 is an overview of the bottom section of sample 28. While showing features similar to figures 14, 13, and 9, the coating is noticeably thinner than its predecessors. Figure 16 is of the bottom section of sample 28 of experiment TPB-10. It shows layering like figure 11 and the layers appear to be 0.23 μm thick. Figure 17 is a low magnification overview of 16B10. Figure 18 is a somewhat lightly exposed close-up of the layering of the interface (average layer thickness: 0.33 μm) and middle region (average layer thickness: 0.28 μm) as taken from the boxed-in area of figure 17. Figure 11 shows similar but better defined features.

Figure 19 is a low magnification overview of 15M12. The coating is only very close to the monofilament and does not demonstrate the usual smooth inner layers/rough middle region/smooth outer layers that previous overviews showed. Figure 20 is a magnification of the boxed-in area of figure 19 of experiment 12, the experiment where only 20 total layers were deposited (using the same deposition conditions as experiment 10). Figure 20 captures the entire thickness of the deposited coating as well as some epoxy mounting matrix (in the upper left corner). The monofilament is in the lower left corner. Note that the bright band immediately beside the monofilament is actually the well-illuminated side of the monofilament, not a deposited coating layer.

Figure 21 is a lower magnification overview of the middle of sample 11 of experiment 11. It differs from previous overview photos in that it does demonstrate a smooth interface but quickly falls into something between the usual rough middle region and smooth outer layer. It is also a rather thin coating compared to previous overall coating thicknesses. Figure 22 examines the boxed-in portion of figure 21. The bright object in the lower right corner is the monofilament. Figure 23, a magnification of the boxed-in portion of figure 22, shows the layering of this area (coating thickness: about 0.25 μm for carbon and .05 μm for silicon carbide). The layers are thinner than in previous figures, as expected for the lower cycle times than seen in TPB-10.

One of the notable features captured in figures 23, 22, 18, 16, 12, 11, and 10 are large white bands or grains. We believe the white areas to be silicon carbide. They are often much thicker than surrounding carbon layers and certainly thicker than the very thin silicon carbide layers.

Trends are apparent in the samples from experiment TPB-10. The first series of micrographs showed that the coating in the middle was thicker than at the top of the samples; this holds true in the second series of photographs as well: From experiment 10, the middle sections of the 3 samples (8, 16, 28) have overall thicknesses between 51.3 μm and 61.7 μm. The bottom of the samples are only 24.5 μm to 38 μm (from samples 16 and 28). The bottom sections are even thinner than the top as noted in the first series of micrographs. Experiment 11 shows a thinner midsection than experiment 10's samples; the middle of sample 11 has only about a 26 μm coating., but experiment 11 was run with shorter and fewer flow cycles than experiment 10. Experiment 12 used one sixth the number of flow cycles than experiment 10. Thus, as expected, the middle section of sample 15 from experiment 12 was one sixth as thick as for samples from experiment 10 (8.3 μm to 10 μm).

Beyond microscopic studies of deposition microstructures, it was possible to study weight gains of individual samples. The samples, as previously noted, were mounted in a rough circle on a piece of carbon felt. As figure 2 shows, the felt had an orientation notch. This notch served to indicate a starting point for the numbering of samples in an experiment, which was always in a clockwise manner from the notch which itself was always at the "top" of the holder. Samples in a run were thus tracked from mounting to removal and could be weighed before and after an experiment was completed. Long duration experiments (TPB-10 and -11) often were weighed after a run with the loss of their bottom 6 mm or so of length. This loss was due to the solidification of the felt with carbon and silicon carbide and resultant bonding to the embedded samples. During removal, the bottom portions simply snapped off in the felt in many cases.

Weight gains in TPB-11 were notably lower than those of TPB-10, as was expected. It should be noted experiment TPB-10 produced samples that had far more nodular external formations than TPB-11, resulting in an upwardly skewed average weight gain as shown in tables 1 and 2. Experiment TPB-12's average weight gain was approximately one-fifth that of TPB-11, per tables 2 and 3. This in turn shows an approximately linear relationship between the number of deposition cycles and weight gains (noting that TPB-11 and TPB-12 only had slightly different deposition times for either type of layer).

FIGURES

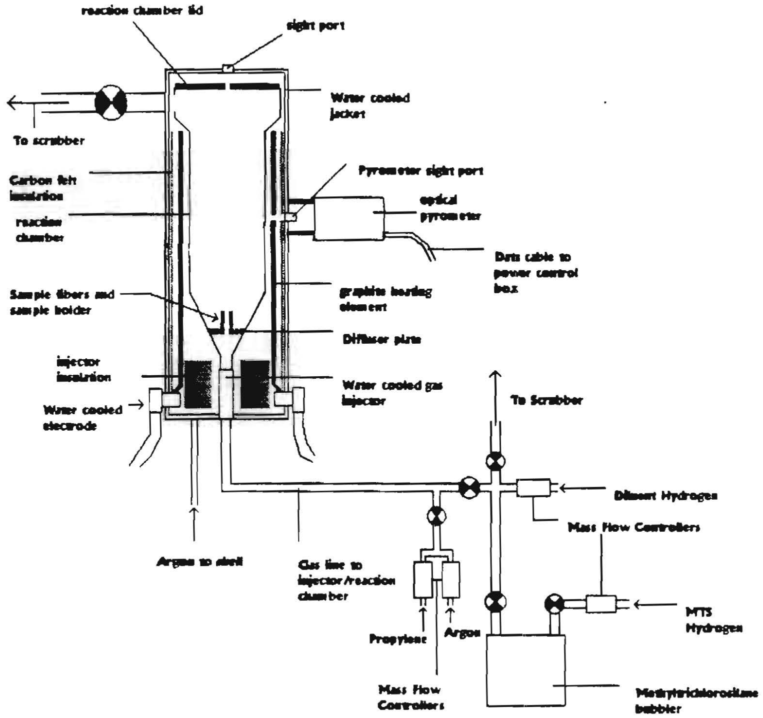


Figure 1: The CVD furnace and reagent delivery system.

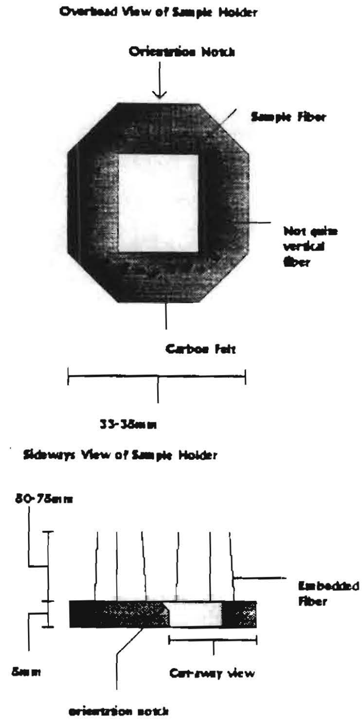


Figure 2: The sample holder, overhead and sideways views.

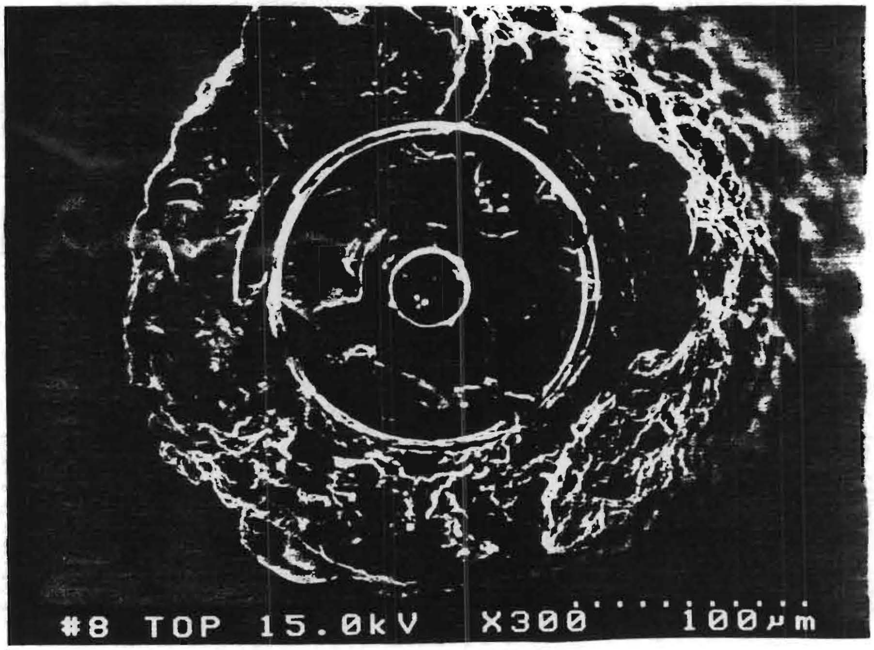


Figure 3: Top of sample from experiment TPB-10

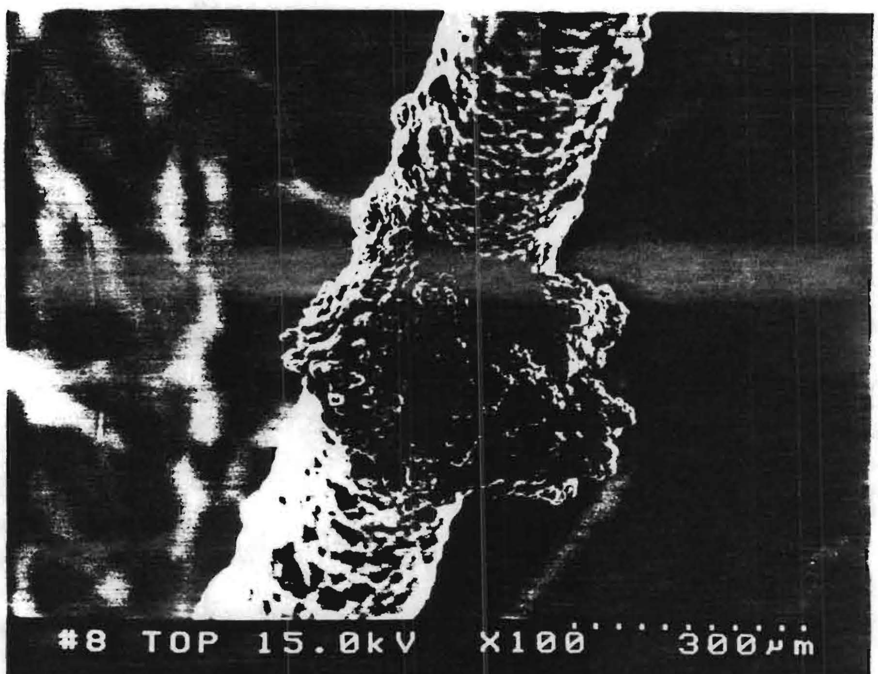


Figure 4: Top of sample 8, experiment TPB-10, side view.

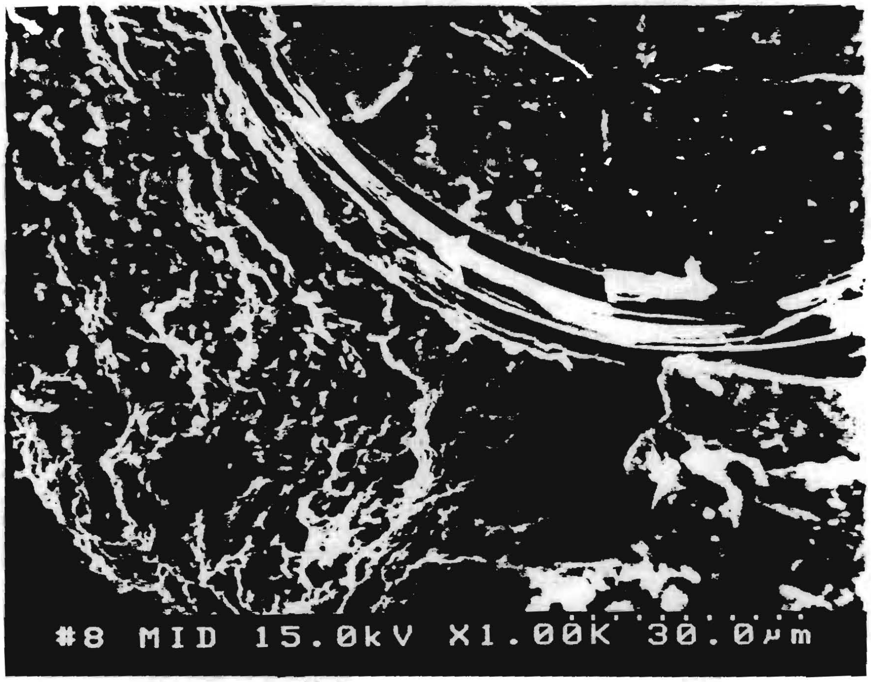


Figure 5: Middle section of sample, experiment TPB-10.

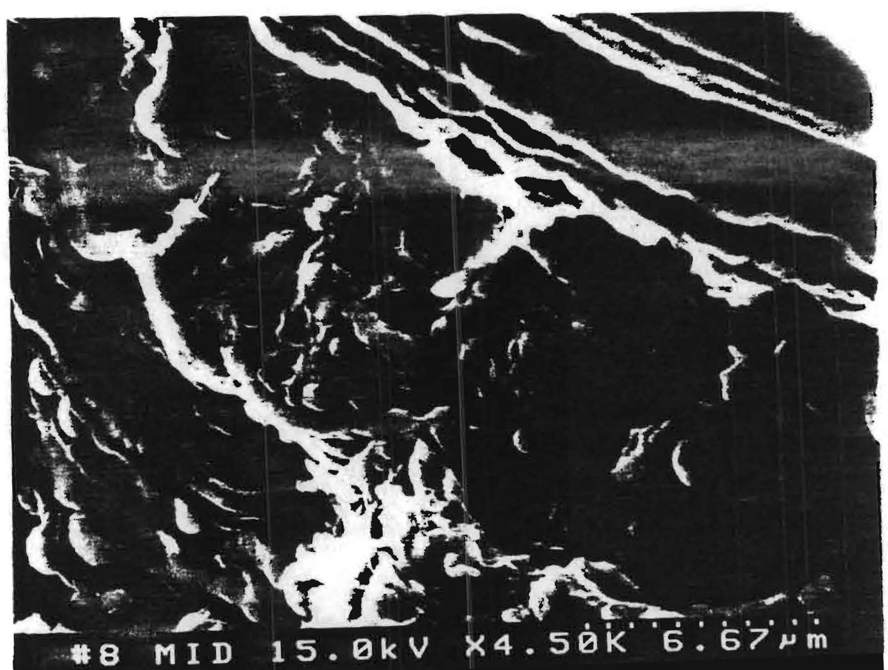


Figure 6: Middle section of sample 8, experiment TPB-10.

Figure 7: Top of sample 16, experiment TPB-10.

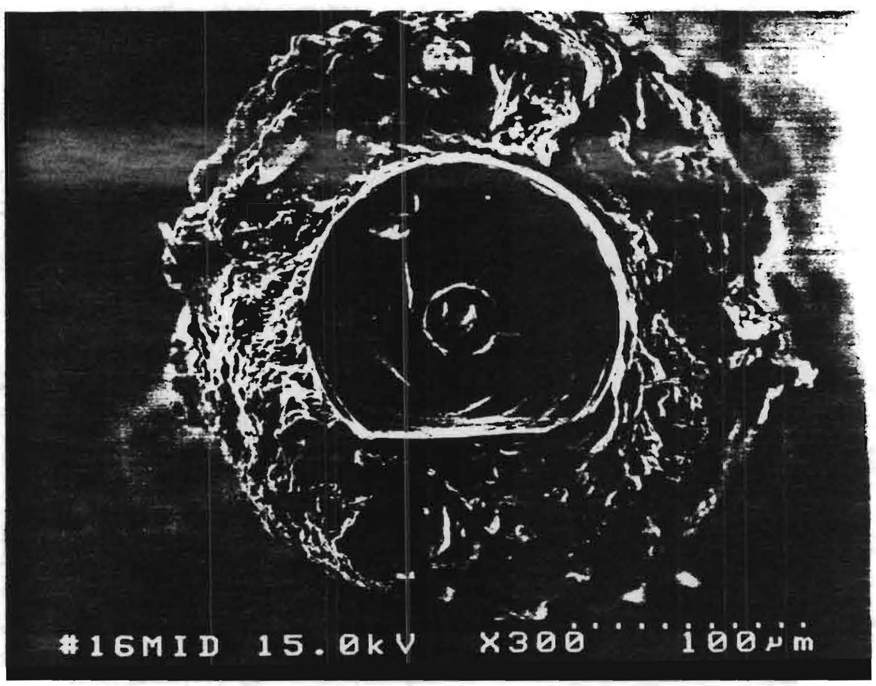


Figure 8: Middle section of sample 16, experiment TPB-10.

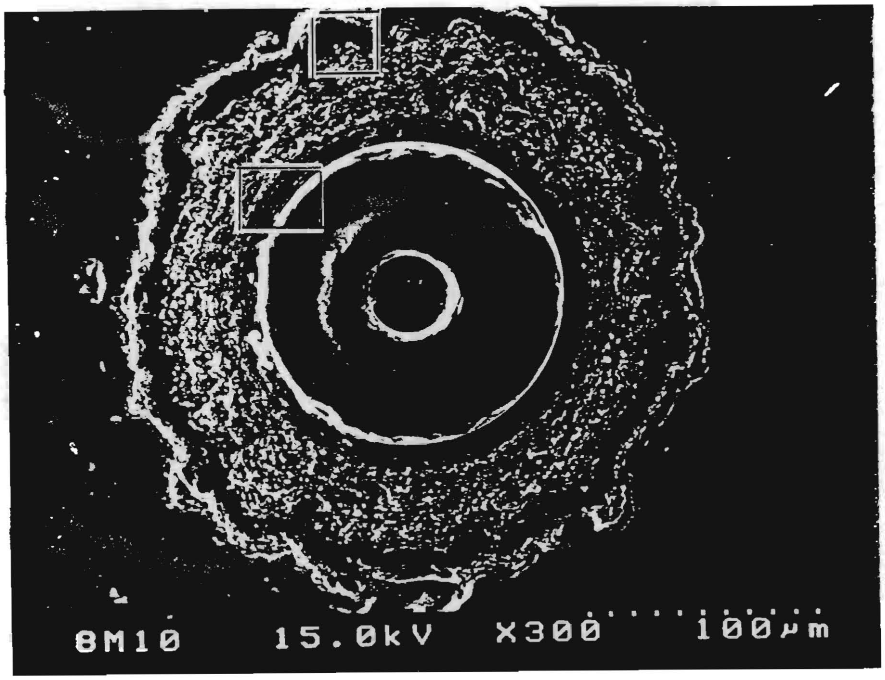


Figure 9: Middle section of sample 8, experiment TPB-10, first micrograph of second series. Overview.

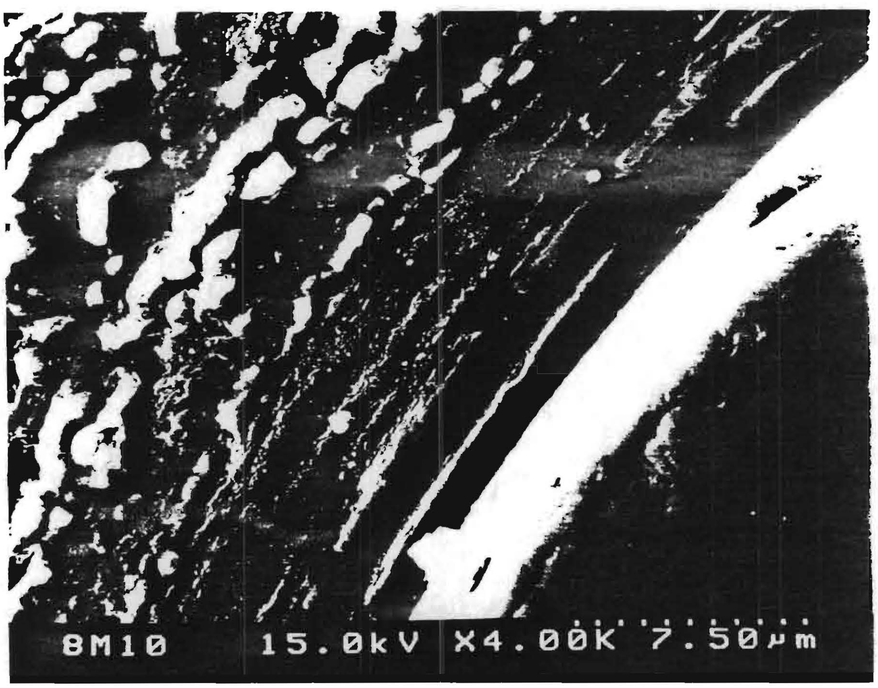


Figure 10: Middle section of sample 8, experiment TPB-10.

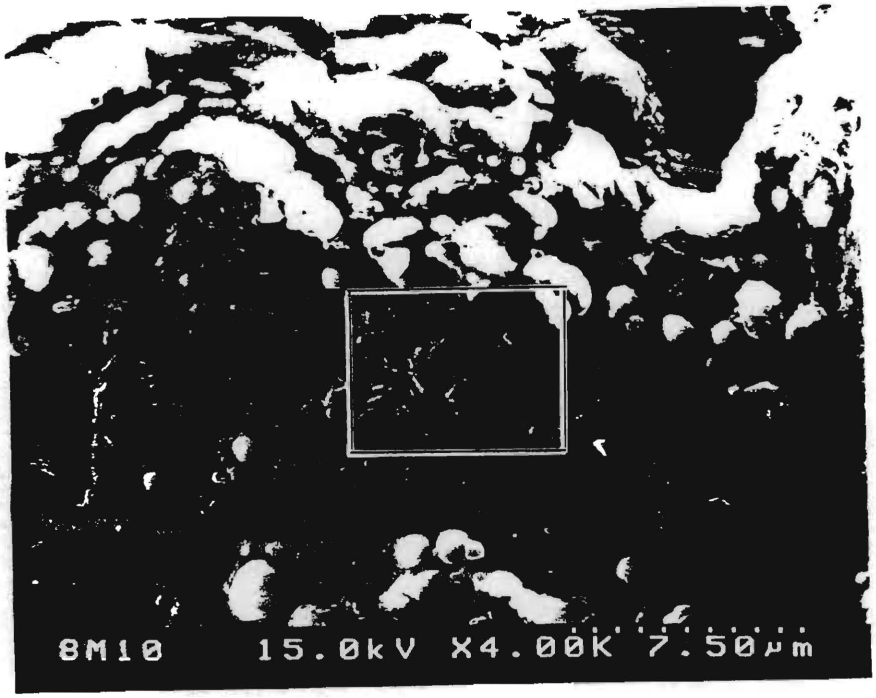


Figure 11: Middle section of sample 8, experiment TPB-10.

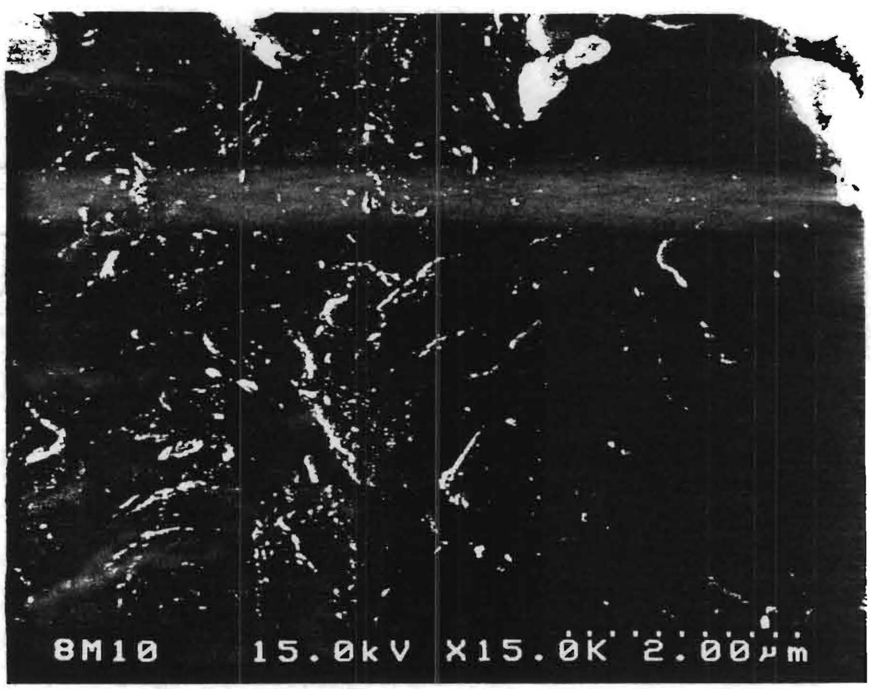


Figure 12: Middle section of sample 8, experiment TPB-10.

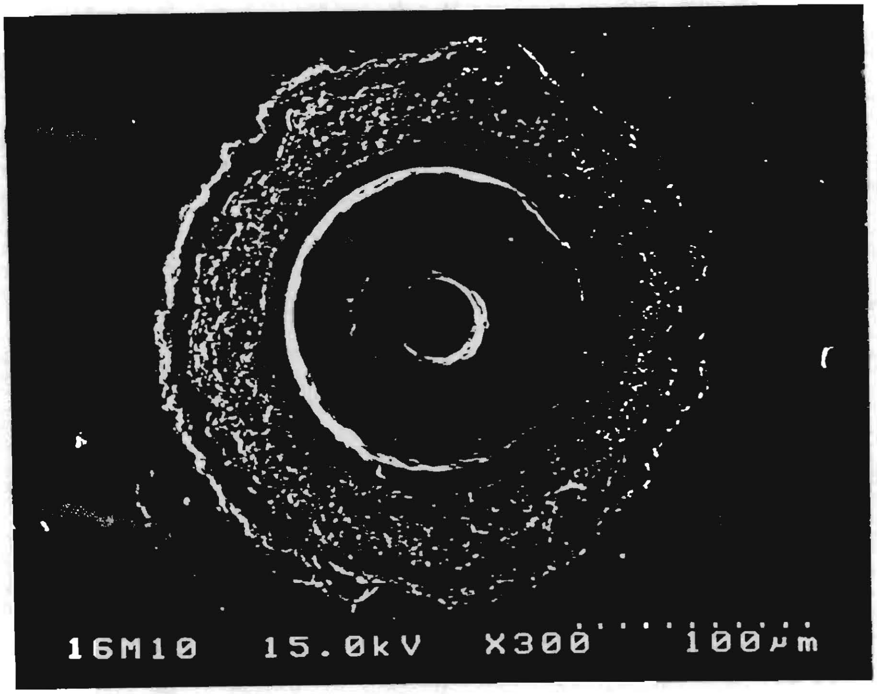


Figure 13: Middle section of sample 16, experiment TPB-10, overview.

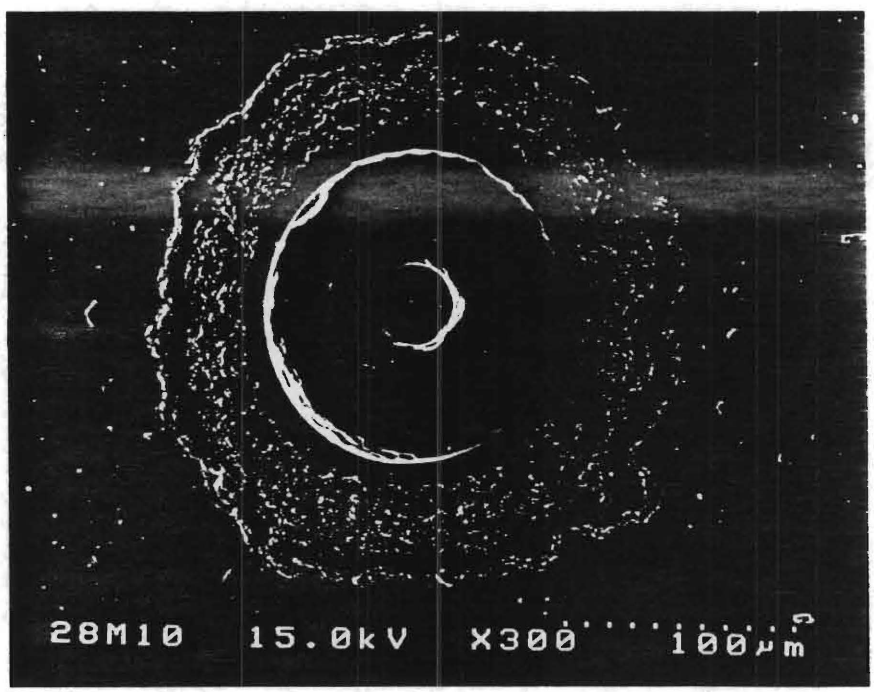


Figure 14: Middle section of sample 28, experiment TPB-10, overview.

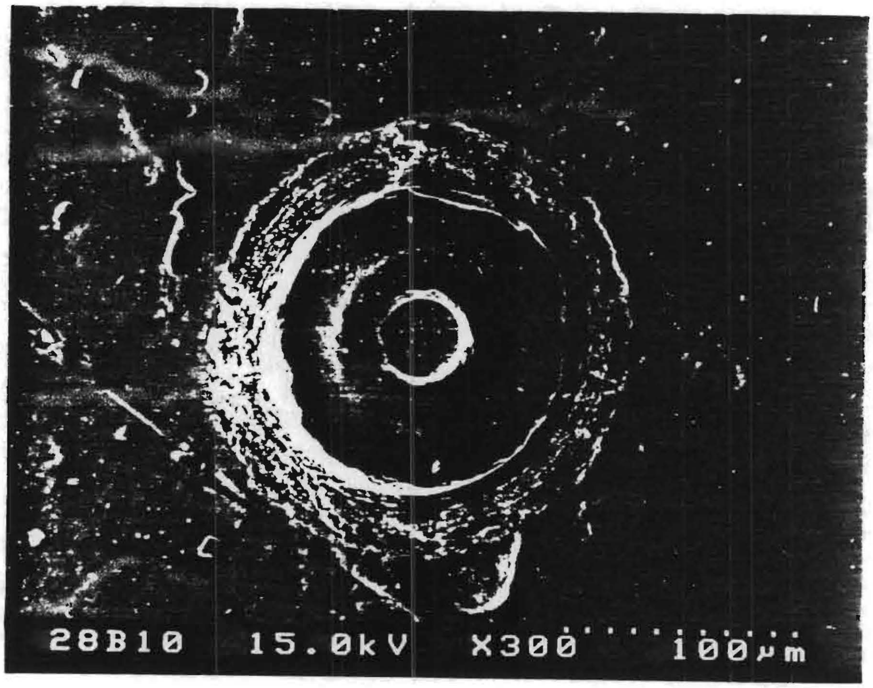


Figure 15: Overview of the bottom section of sample 28 of experiment TPB-10.

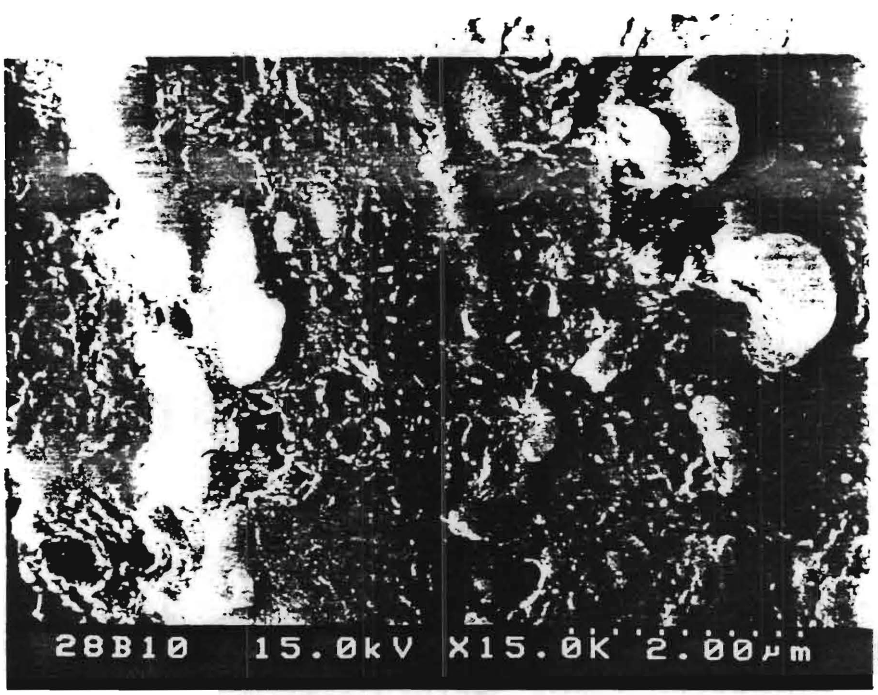


Figure 16: Bottom section of sample 28 of experiment TPB-10.

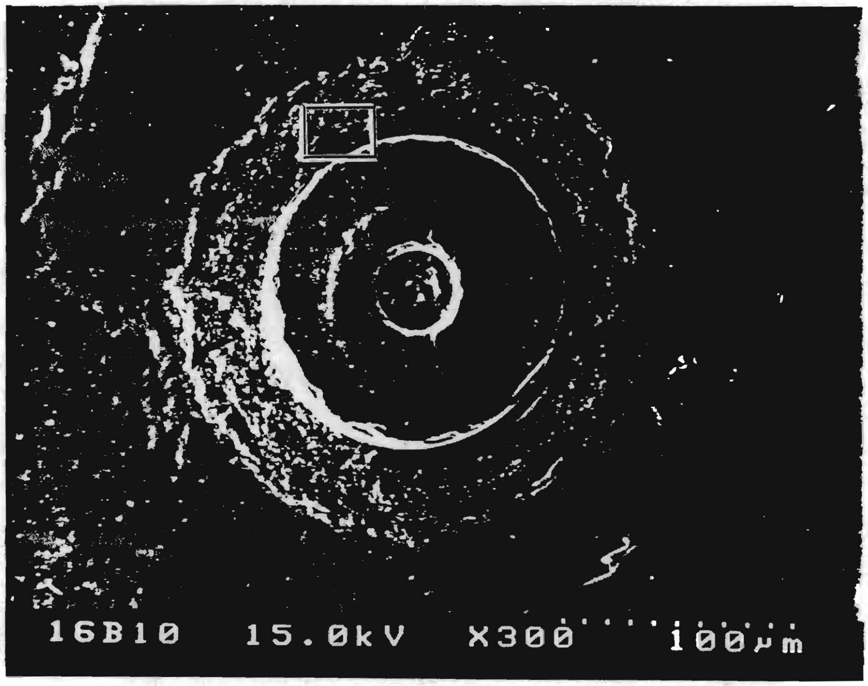


Figure 17: Bottom section of sample 16, experiment TPB-10, overview.

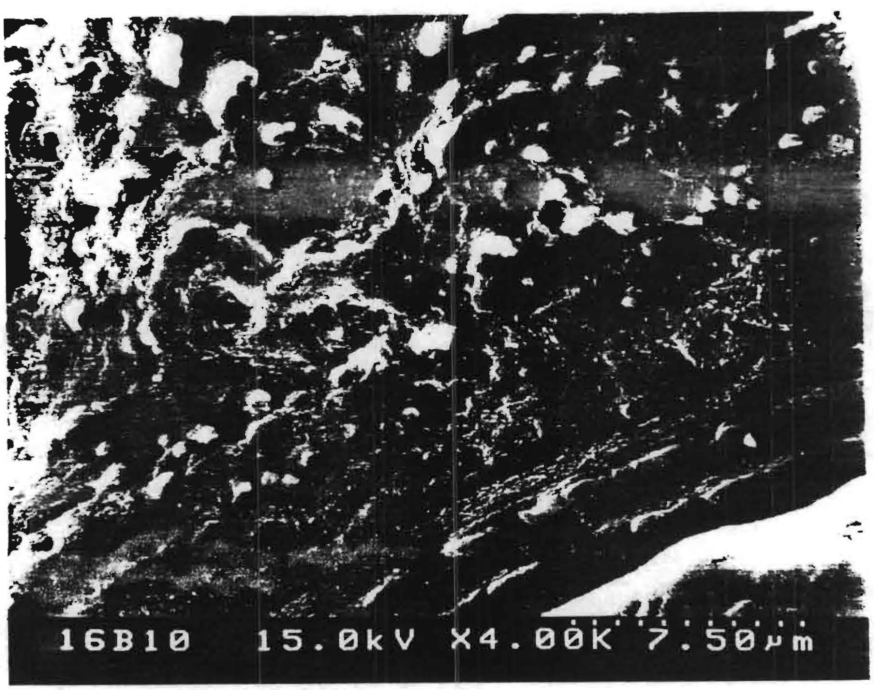


Figure 18: Bottom section of sample 16, experiment TPB-10.

Figure 19: Middle section of sample 15, experiment 12, overview.

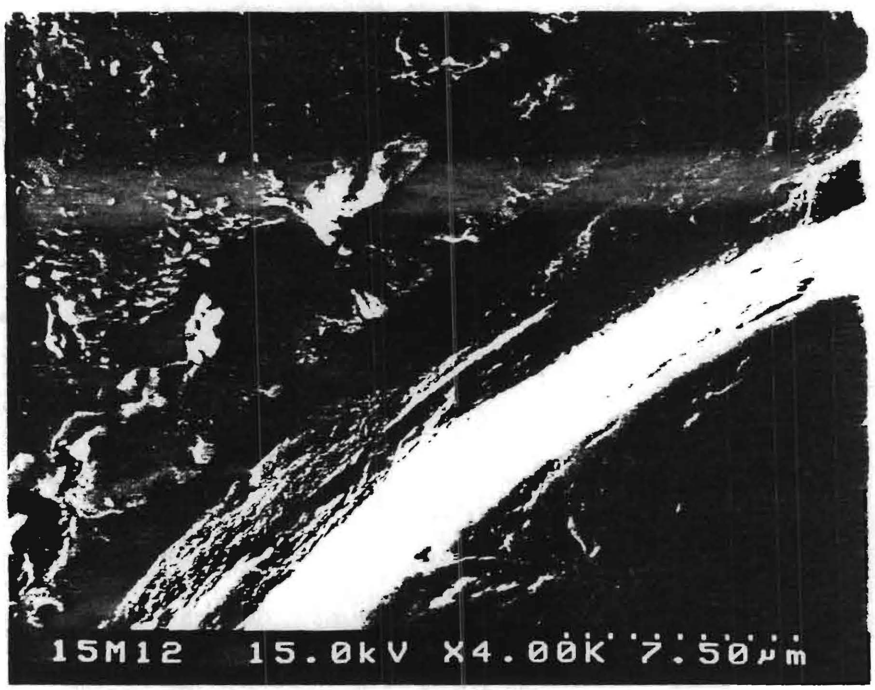


Figure 20: Middle section of sample 15, experiment TPB-12.

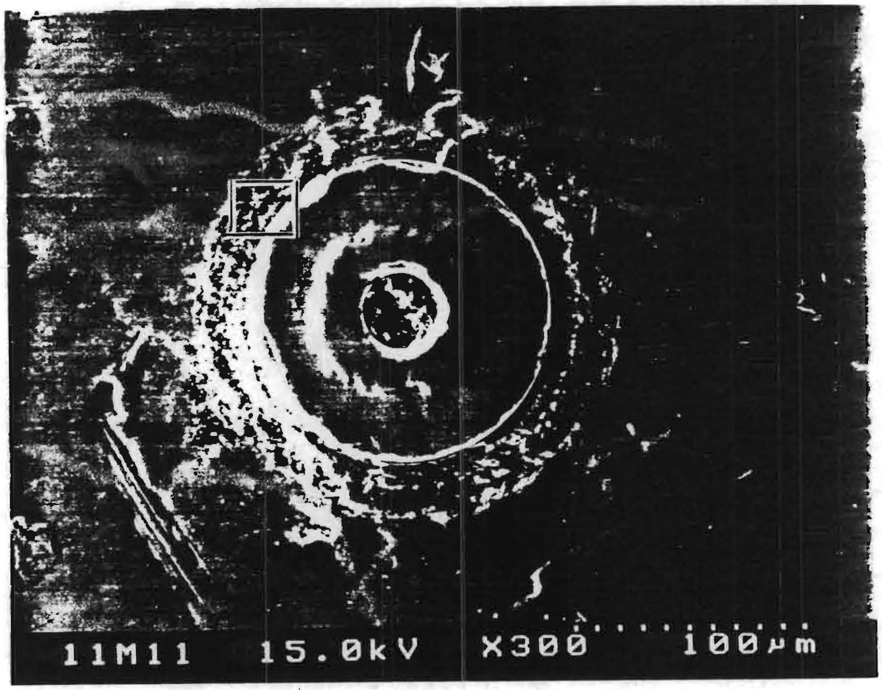


Figure 21: Middle section of sample 11, experiment TPB-11, overview.

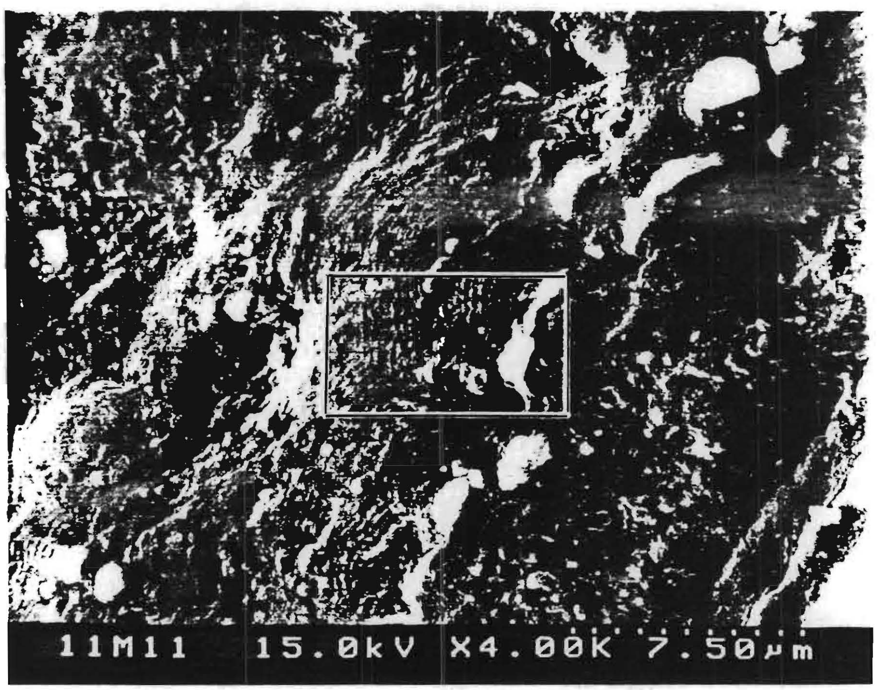


Figure 22: Middle section of sample 11, experiment TPB-11.

Figure 23: Middle section of sample 11, experiment TPB-11.

TABLES

EXPERIMENT TPB-10

Sample	Init Wt	Final Wt	Loss	Nodules
1	0.0029	0.0112	y	h
2	0.0033	0.0079	n	h
3	0.0029	0.0064	y	m
4	0.003	0.0062	y	l
5	0.003	0.0111	y	h
6	0.0031	0.0077	y	m
7	0.0031	0.0097	y	h
8	0.0031	0.0081	y	h
9	0.0032	0.0065	y	m
10	0.0031	0.0076	y	m
11	0.0029	0.0071	y	m
12	0.0031	0.01	y	h
13	0.0033	0.0067	y	l
14	0.0029	0.0087	n	h
15	0.0031	0.0072	y	m
16	0.0035	0.0065	y	m
17	0.0029	0.0086	y	h
18	0.0029	0.0079	y	h
19	0.003	0.0124	y	h
20	0.0031	0.0062	y	l
21	0.0029	0.0067	y	l
22	0.0027	0.0065	y	m
23	0.0031	0.0107	y	h
24	0.003	0.0065	y	l
25	0.0031	0.0087	y	h
26	0.0029	0.0062	y	m
27	0.0031	0.0116	y	h
28	0.0032	0.006	y	m
29	0.0032	0.0058	y	m
30	0.0034	0.0054	y	l
31	0.0032	0.0059	y	m
32	0.0031	0.0068	y	m
average	0.003072	0.007828		
avg. gain		0.004756		

Loss is a yes/no field for whether or not a portion of the bottom of the sample was broken off during removal from the carbon felt holder.

Nodules describes roughly how much nodular development a sample developed on its length: (n) none, (l) light, (m) moderate, (h) heavy

Table 1: Deposition data from experiment TPB-10

EXPERIMENT TPB-11

Sample	Init Wt	Final Wt	Loss	Nodules
1	0.0037	0.0057	n	n
2	0.0037	0.0051	y	n
3	0.0036	0.0054	n	n
4	0.0036	0.0059	n	n
5	0.0034	0.0046	y	n
6	0.0034	0.0051	y	n
7	0.0037	0.0061	n	n
8	0.0035	0.0059	n	n
9	0.0034	0.0047	y	n
10	0.0038	0.0064	y	m
11	0.0039	0.0051	y	n
12	0.0037	0.0061	y	n
13	0.0037	0.0054	y	n
14	0.0037	0.006	y	n
15	0.0037	0.0056	y	n
16	0.0038	0.0054	y	n
17	0.0036	0.005	y	n
18	0.0036	0.0065	y	m
19	0.0035	0.0054	n	n
20	0.0036	0.0073	n	m
21	0.0036	0.0063	y	l
22	0.0038	0.0073	n	m
23	0.0034	0.006	n	n
24	0.0036	0.0056	n	n
25	0.0037	0.0075	n	m
26	0.0038	0.0058	y	n
27	0.0036	0.0048	n	n
28	0.0036	0.0048	n	n
29	0.0035	0.0066	n	m
30	0.0035	0.005	n	n
31	0.0035	0.0076	n	m
32	0.0035	0.0072	n	m
33	0.0035	0.0081	n	h
34	0.0036	0.0057	n	n
average	0.003612	0.005912		
avg. gain		0.0023		

Table 2: Deposition data from experiment TPB-11.

EXPERIMENT TPB-12

Sample	Init Wt	Final Wt	Loss	Nodules
1	0.0037	0.0041	n	n
2	0.0038	0.0044	n	n
3	0.0036	0.0042	n	n
4	0.0036	0.0039	n	n
5	0.0036	0.0041	n	n
6	0.0037	0.004	n	n
7	0.0036	0.004	n	n
8	0.0035	0.0042	n	n
9	0.0036	0.0039	n	n
10	0.0037	0.0041	n	n
11	0.0036	0.004	n	n
12	0.0036	0.0041	n	n
13	0.0036	0.004	n	n
14	0.0037	0.0041	n	n
15	0.0037	0.0046	n	n
average	0.00364	0.004113		
avg. gain		0.000473		

Table 3: Deposition data from experiment TPB-12.

E-25-A21 5, 8, 9

E25-A21-5
Formerly A-5398

LAMINATED MATRIX COMPOSITES

Monthly Progress Report

Period Covered June 15, 1997 to October 14, 1997

Prepared for:

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Schenectady, New York 12309

Prepared by:

Jack Lackey, Harry King, Steven Crain, and Carolina Fernandez
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332-0405

October 15, 1997

LAMINATED MATRIX COMPOSITES

Objective

The objective of this project is to fabricate two types of ceramic composite samples: 1) "toothpick"-like samples consisting of multiple thin ($0.25\,\mu m$) layers of alternating carbon and silicon carbide deposited onto 2" long SiC monofilament fibers, and 2) disk-shaped samples containing a laminated C+SiC matrix where the reinforcement is carbon particles. Fabrication of the first type of samples has been completed and the samples shipped. Fabrication of the disk samples is in progress. These latter samples are of several types, i.e. differing layer thicknesses, and two of the samples are to have a SiC, rather than the laminated matrix. One of the SiC matrix samples has a carbon interface coating, while the other has no interface coating.

Accomplishments

Our effort is currently focused on fabrication of the disk-shaped composite samples. To date, fabrication of five of the seven types of disk composites has been completed. These samples and the run conditions used are identified in Table I. Note that two samples (instead of the one required) were prepared from the "all SiC matrix" type material. The six successful runs are summarized on the next page.

Table I. Run Conditions for Disk Composites

Run Type	all SiC	all SiC	C int, SiC	Equal B	Equal A	Equal C
Run #	K-1	K-2	K-3	K-4	K-5	K-6
C cycle time (min)	n/a	n/a	1@10min	3	1.5	4.5
SiC cycle time (min)	n/a	n/a	completion	6	3	9
propylene flow (sccm)	n/a	n/a	200	200	200	200
C-diluent (H2) flow (sccm)	n/a	n/a	200	200	200	200
target MTS flow (sccm)	50	100	50	50	50	50
actual MTS flow (sccm)	53.0	96.2	48.1	42.2	42.5	43.5
MTS-diluent (H2) flow (sccm)	500	1000	500	500	500	500
total run time	8 hrs	7h, 45 m	11h, 10m	18h, 18m	17h, 19.5m	15h, 45m
# C layers	0	0	1	122	231	70
#SiC layers	1	1	1	122	231	70
final back pressure (psi)	0.1	9.2	10.0	9.5	10.7	9.5
average bottom temp (C)	1100	1100	1100	930	930	930

K-1 was an all SiC run. However, it was terminated early due to a lack of increase in back pressure. The total run time was 8 hours. Despite the fact that the run was terminated early, the sample had a relatively low porosity of 17%.

K-2 was another all SiC run. However, the flow rates of the MTS and the H_2 diluent were doubled, with the attempt at making the run time shorter. The run time was terminated at a back pressure of 9.2 psi. The reason for the early termination was the increase in system back pressure (above the preform) from 795 to 990 torr in the time span of only 8 minutes. The porosity was again 17%.

K-3 was a SiC run, with a single C interface layer between the reinforcement particles and the matrix. The temperature of the preform during the interface deposition was 930°C. During the SiC deposition, the temperature was increased to 1100°C.

K-4 was the first successful laminated matrix run. The target layer thickness was 0.30 μm, as specified by the equal B conditions.

K-5 was the equal A, or 0.15 μm layer thickness, run.

K-6 was the equal C, or 0.45 μm layer thickness run. The back pressure at termination was 9.5 psi. The reason this run was stopped early was because of the continuous and rapid increase in system pressure, which was 816 torr upon termination.

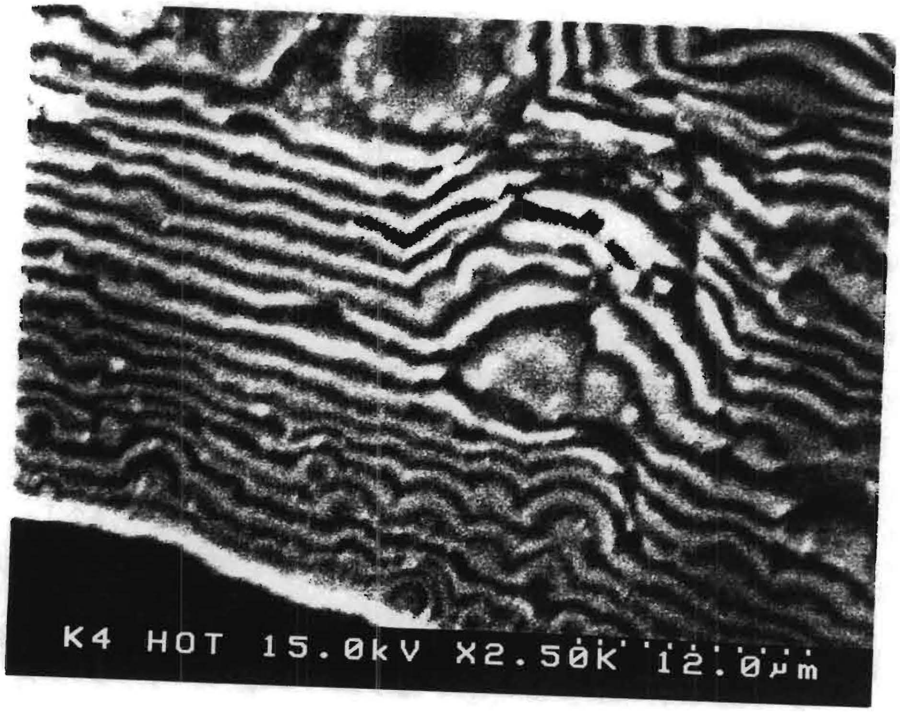
A polished cross section of Sample K-4 was thoroughly examined via SEM. Micrographs were taken in four areas, from the hot to the cold side of the sample. In each of the four areas, three pictures were taken. The first area was the region closest to the reinforcement particle. The second area was the region closest to the pore that was associated with the periphery of the coated particle. The final area was the area in between these two features. The information below provides further identification of each micrograph; a copy of each is attached. Note the desired layered microstructure was achieved. The layers are rather uniform in thickness and continuous. There is very little debris evident in the micrographs. Detailed measurements of layer thickness remain to be made.

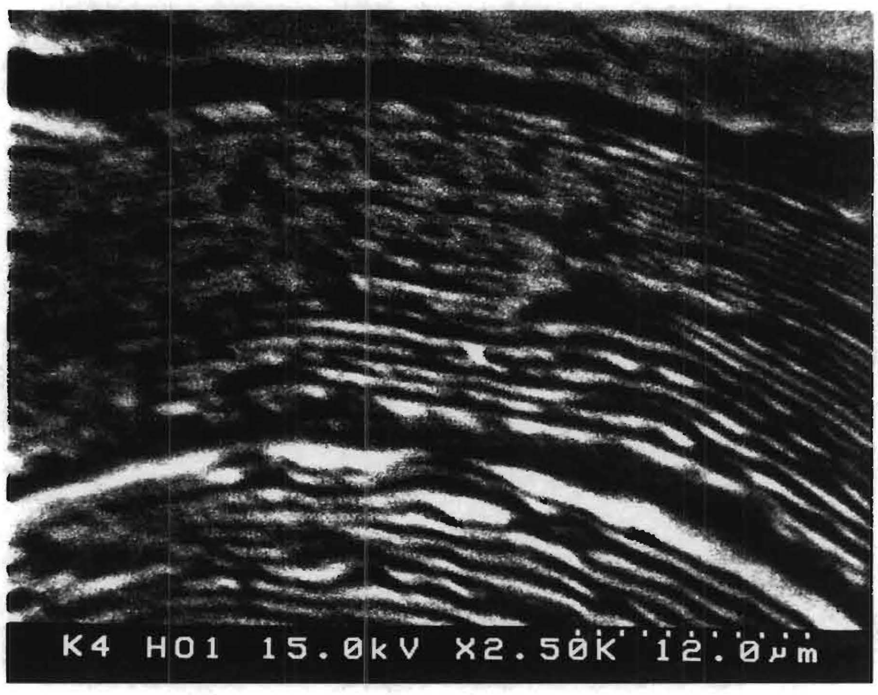
HOT region: Photos 1-3. Photo1 is the area closest to the reinforcement particle. The particle can be seen in the lower left hand corner. Photo 2 is the area between two particles. The dark line near the top of this micrograph is the region between two reinforcement particles. Photo 3 is from the area in between the two regions.

WARM region. Photos 4-6: Photo 4 is the area closest to the reinforcement particle. The particle can be seen in the lower left hand corner. Photo 6 is the area closest to the pore.. Photo 5 is the area in between the two regions. In all photos, the particle-to-pore area goes from left to right.

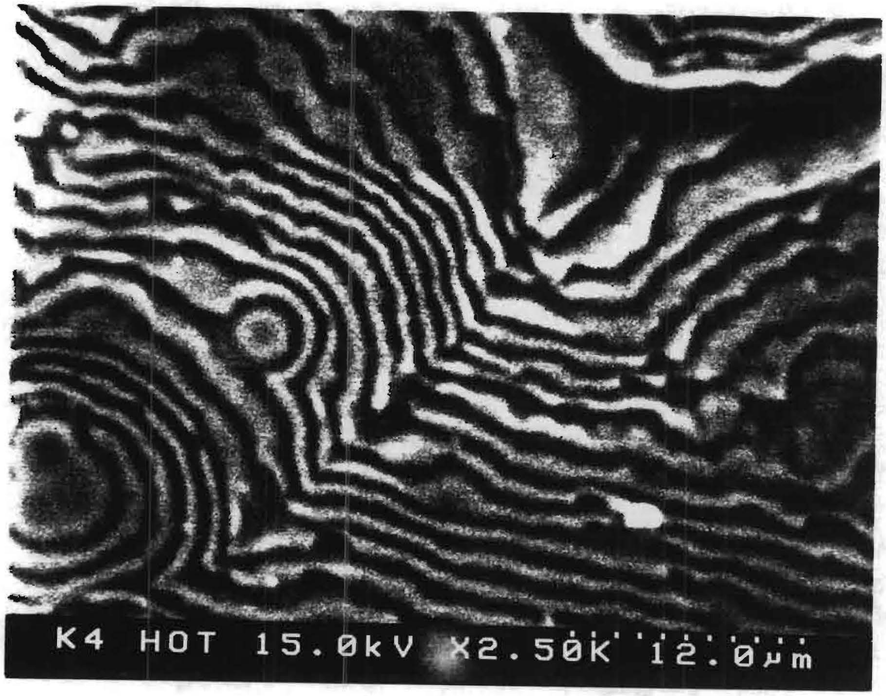
COOL region. Photos 7-9. Photo 7 is the region closest to the sphere. The particle can be seen at the bottom of the photo. Photo 8 is the region closest to the pore. The pore can be seen in the upper left hand corner of the photo. Photo 9 is the area between photos 7 and 8.

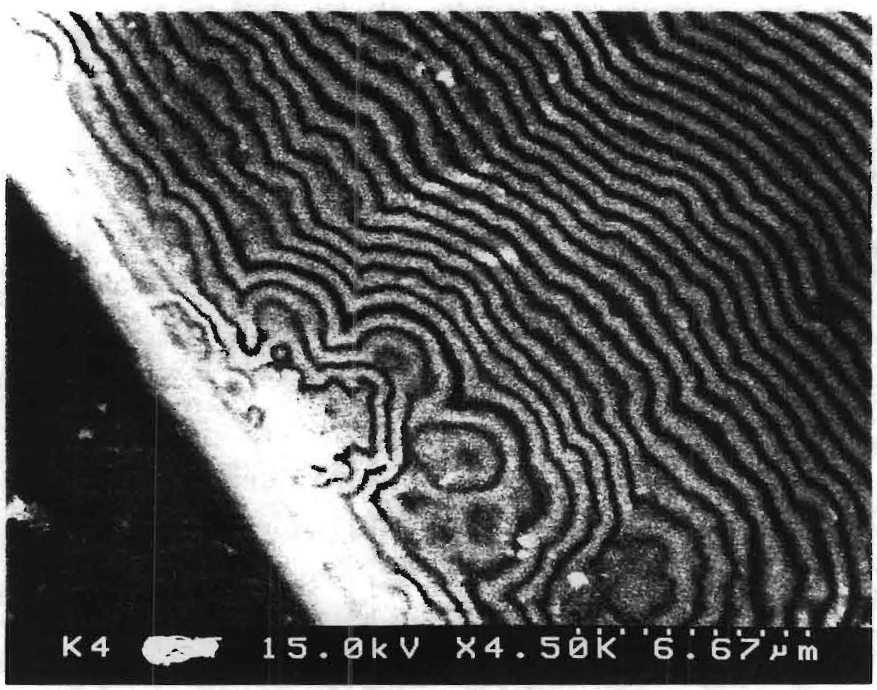
COLD region. Photos 10-12. Photo 10 is closest to the particle, which can be seen in the lower left hand region. Photo 11 is closest to the particle. Photo 12 is the area in between the two regions.



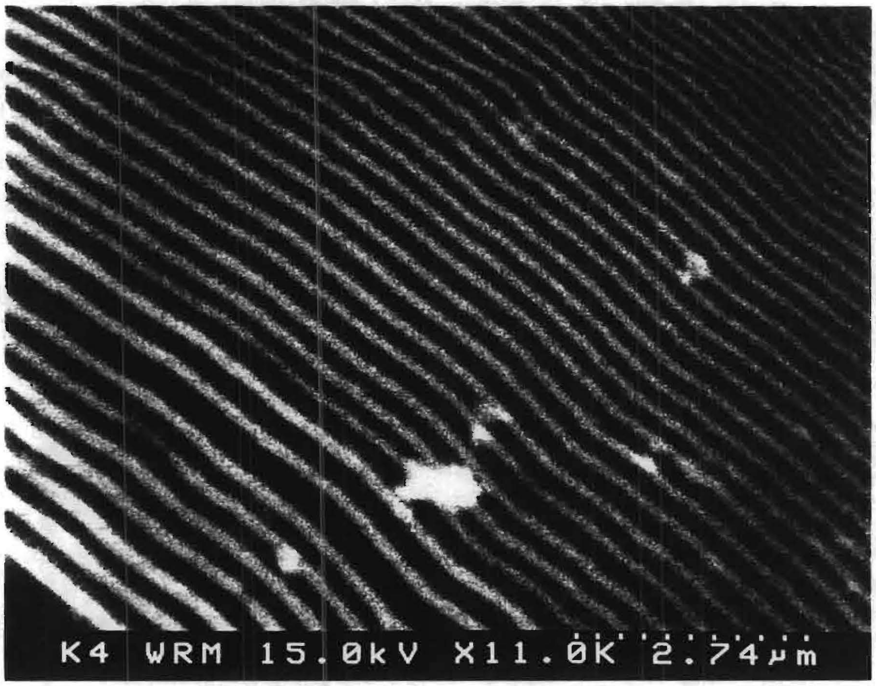


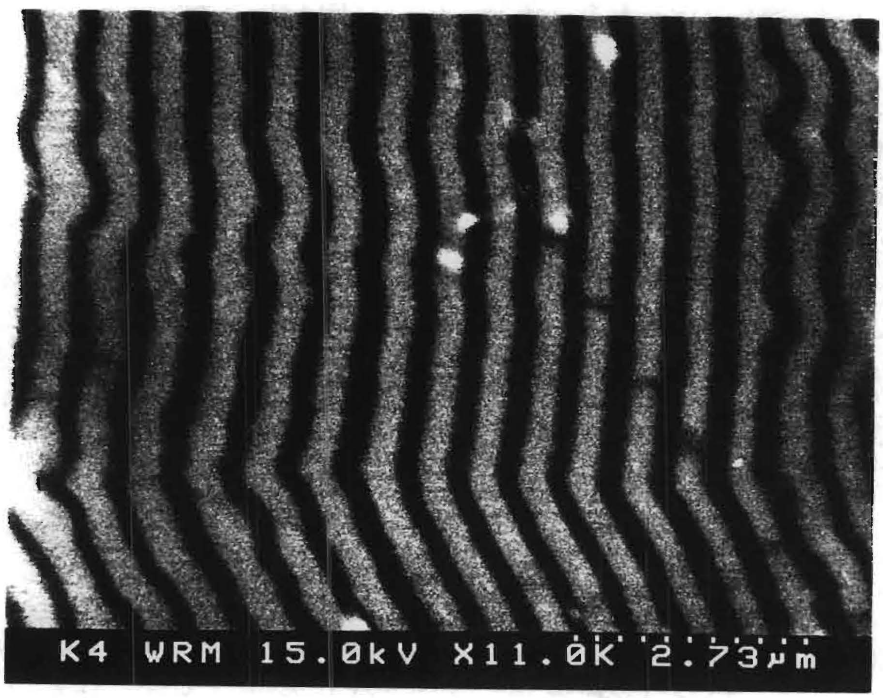
Sample K-4, Micrographs Nos. 1 and 2



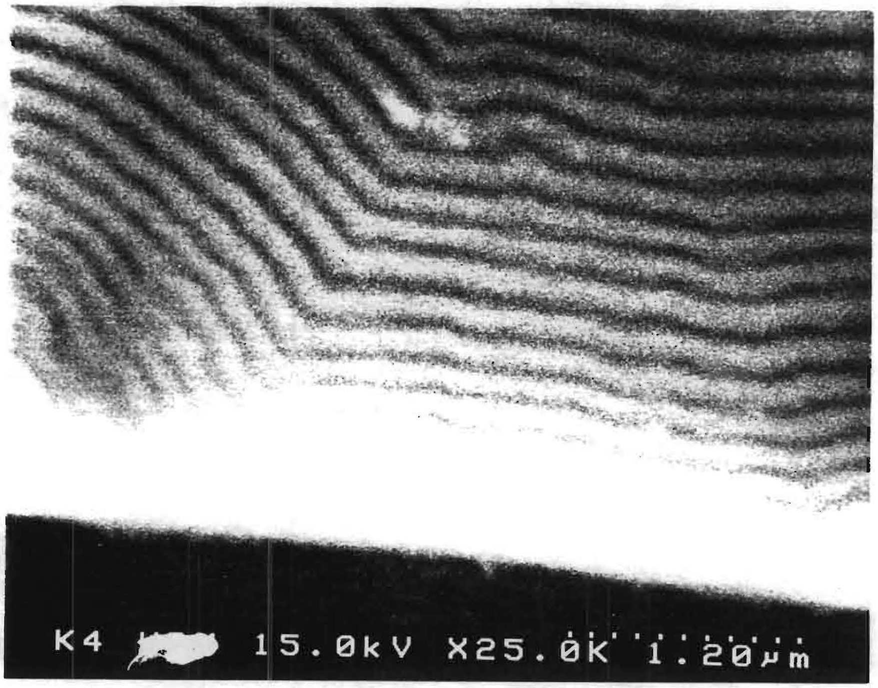


Sample K-4, Micrographs Nos. 3 and 4

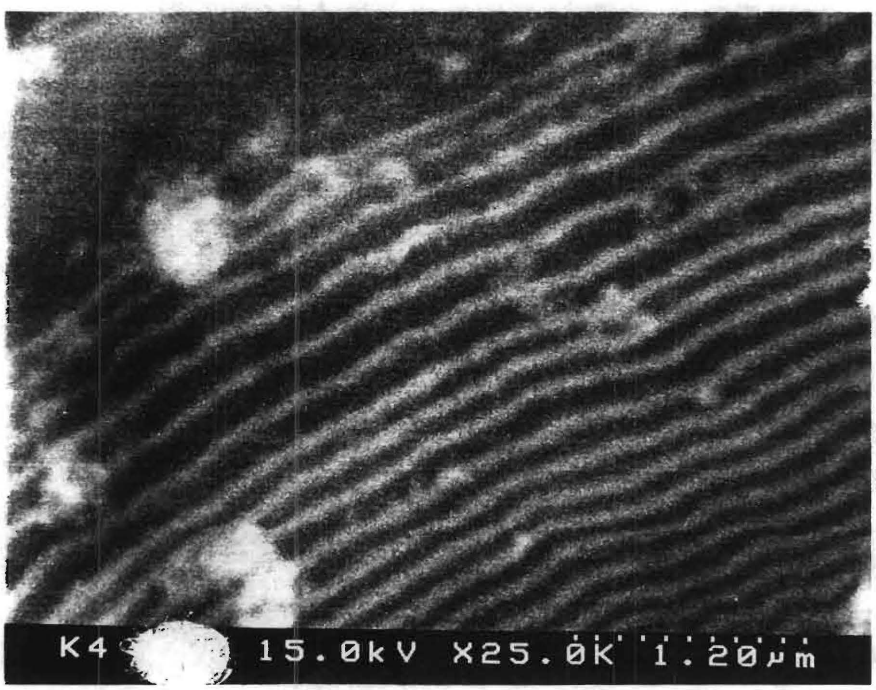




Sample K-4, Micrographs Nos. 5 and 6

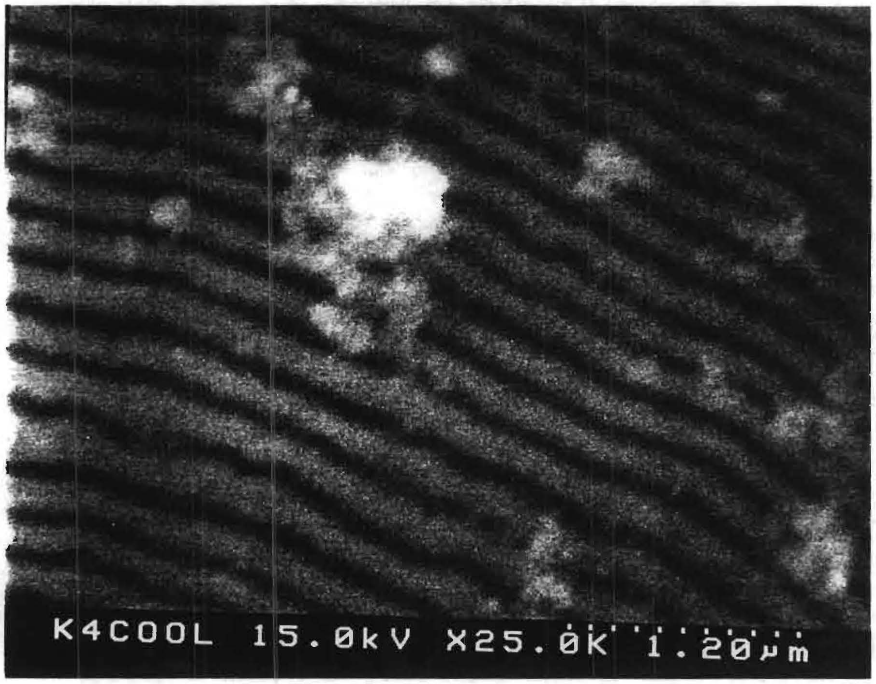


Cool

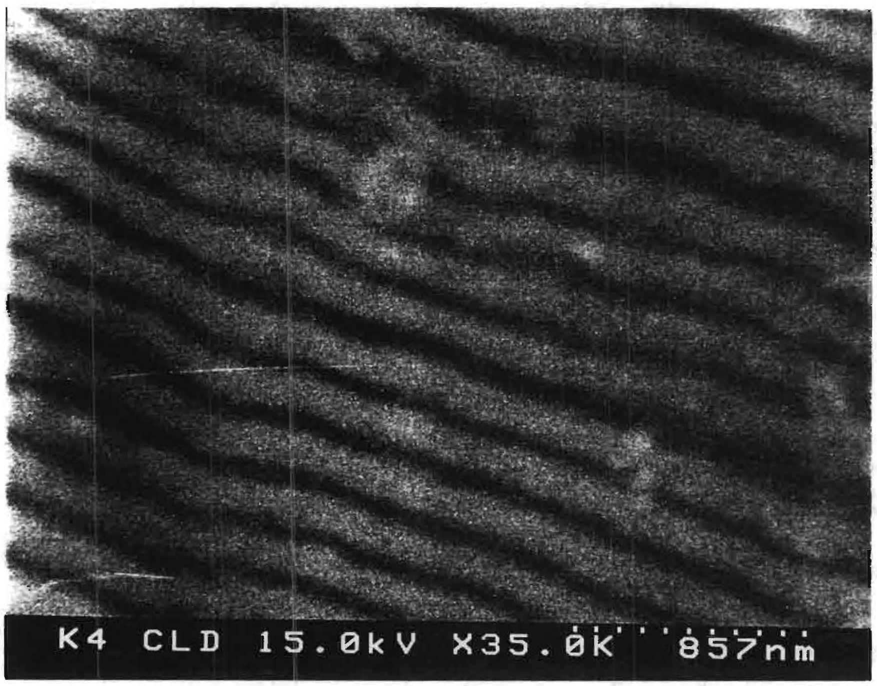


Cool

Sample K-4, Micrographs Nos. 7 and 8



Sample K-4, Micrographs Nos. 9 and 10



Sample K-4, Micrographs Nos. 11 and 12

*************** -COMM. JOURNAL- ******************* DATE OCT-16-1997 ***** TIME 11:32 *** P.01

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Georgia Institute of Technology
The George W. Woodruff School of Mechanical Engineering

January 28, 1998

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Building C1, Room 126
Post Office Box 1072
Schenectady, NY 12301-1072

Dear Lynne,

Attached are two copies of the Final Report for Tasks 1 and 2 on Laminated Matrix Composites. I appreciate the opportunity to have worked with you and hope we can collaborate again in the future.

I am sending the composite disks to you under separate cover.

Sincerely,

W. Jack Lackey

ATTACHMENTS

E25-A21-5
Formerly A-5398

LAMINATED MATRIX COMPOSITES

Final Report

Prepared for:

Ms. Lynne E. Kolaya
Knolls Atomic Power Laboratory
Schenectady, New York 12301-1072

Prepared by:

Jack Lackey, Harry King, Steven Crain, Elliot Pickering, and Carolina Fernandez
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332-0405

January 28, 1998

LAMINATED MATRIX COMPOSITES

Objective

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SiC cycle time (min)	n/a	n/a	completion	6	3	9
propylene flow (sccm)	n/a	n/a	200	200	200	200
C-diluent (H2) flow (sccm)	n/a	n/a	200	200	200	200
target MTS flow (sccm)	50	100	50	50	50	50
actual MTS flow (sccm)	53.0	96.2	48.1	42.2	42.5	43.5
MTS-diluent (H2) flow (sccm)	500	1000	500	500	500	500
total run time	8 hrs	7h, 45 m	11h, 10m	18h, 18m	17h, 19.5m	15h, 45m
# C layers	0	0	1	122	231	70
#SiC layers	1	1	1	122	231	70
final back pressure (psi)	0.1	9.2	10.0	9.5	10.7	9.5
average bottom temp (C)	1100	1100	1100	930	930	930

Experimental Procedure and Results

Each of the above samples were to be cut into eight specimens for flexure testing, and the remaining material was to be used for thermal conductivity testing. However, the samples were very fragile and it was extremely difficult to cut them into the sizes required for the three point-bending tests and conductivity testing. Samples for thermal conductivity could not be cut without the material severely fracturing (crumbling). Four samples were successfully cut for flexural testing. Their dimensions are listed in Table 2 along with the test results.

Table 2: Flexural Test Samples

			Sample Dimensions				
Sample #	Matrix	Flexural Test #	Length	Width	Height	Strength (MPa)	Modulus (Gpa)
K-3-2	All SiC with C Interface	1	19.4	3.27	4.21	3.8	1.0
K-3-1	All SiC with C Interface	2	21.37	2.95	2.98	8.8	1.1
K-1-1	All SiC	3	21.03	4.44	2.89	8.1	2.4
K-5-1	Equal A	4	16.7	2.7	2.2	12.6	3.2

The strain rate used for testing was 0.0003937 mm/min. The gage length was 15 mm, except for sample K-5 for which a gage length of 13 mm was used because of its short length.

flexural strength and elastic modulus (both in Pascals) were calculated from the following equations:

$$Strength = \frac{3FL}{2wh^2}$$

$$Elastic\ \ Modulus = \frac{L^3 F}{4wh^3 \delta}$$

where F = load at fracture in Newtons

L = distance between the two outer supports in meters

w = specimen width in meters

h = specimen height in meters

δ = measured deflection in meters

From Table 1, it can be seen that the measured strength values were very low, 3.8 to 12.6 MPa. The strongest of the specimens tested (K-5-1) had a laminated matrix.

It also had the highest elastic modulus, but all of the modulus values were very low, perhaps reflecting the low modulus of the carbon reinforcement rather than that of the matrix.

Discussion of Results [redacted]

The large diameter of the reinforcement particles relative to the size of the flexural test specimens is almost certainly the reason for the low strength (and modulus) values. Further work should be done with either a different reinforcement or much larger flexural test specimens. The height and width of the test specimens were only about two particle diameters. This resulted in very rough surfaces on the test specimens (an appreciable fraction of the specimen thickness). This alone could account for the low strengths observed. To illustrate this point, the following fracture mechanics equation $K = FS\sqrt{\pi a}$ was used to calculate the strength (S) with an assumed crack length (a) of 1 mm (the surface of the samples were typically this rough or rougher) and an assumed fracture toughness (K) of $10\ MPa \cdot m^{1/2}$. The geometric factor, F, was assumed to be unity. This calculation yields a strength value of 180 MPa, which is a reasonable value. Thus, surface roughness may very well account for the low strength values measured. Further work might also emphasize optimization of the FCVI process for laminated matrix composites. In the current study, there was not sufficient time to optimize matrix density.

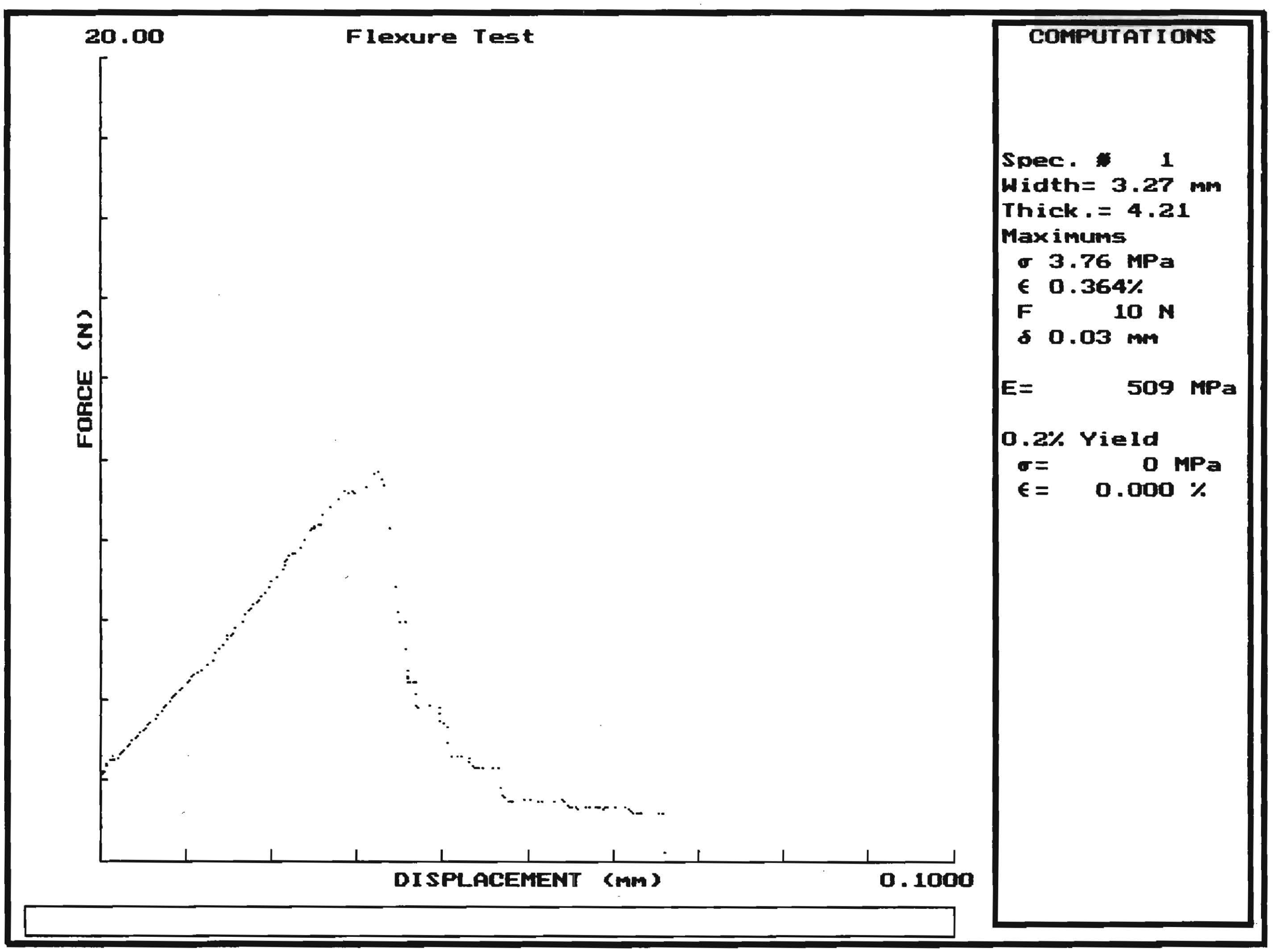
Appendix [redacted]

For completeness, the raw data from the four mechanical tests are attached. Also attached are two prior reports that provide details of the fabrication of both the "toothpick" and disk samples.

lexure Test Results
hu., Dec. 11, 1997

Sample Description: N
Span Length: 15.000 mm
Strain Measurement: None, crosshead deflection only
Crosshead Rate: 0.100 mm/Min.

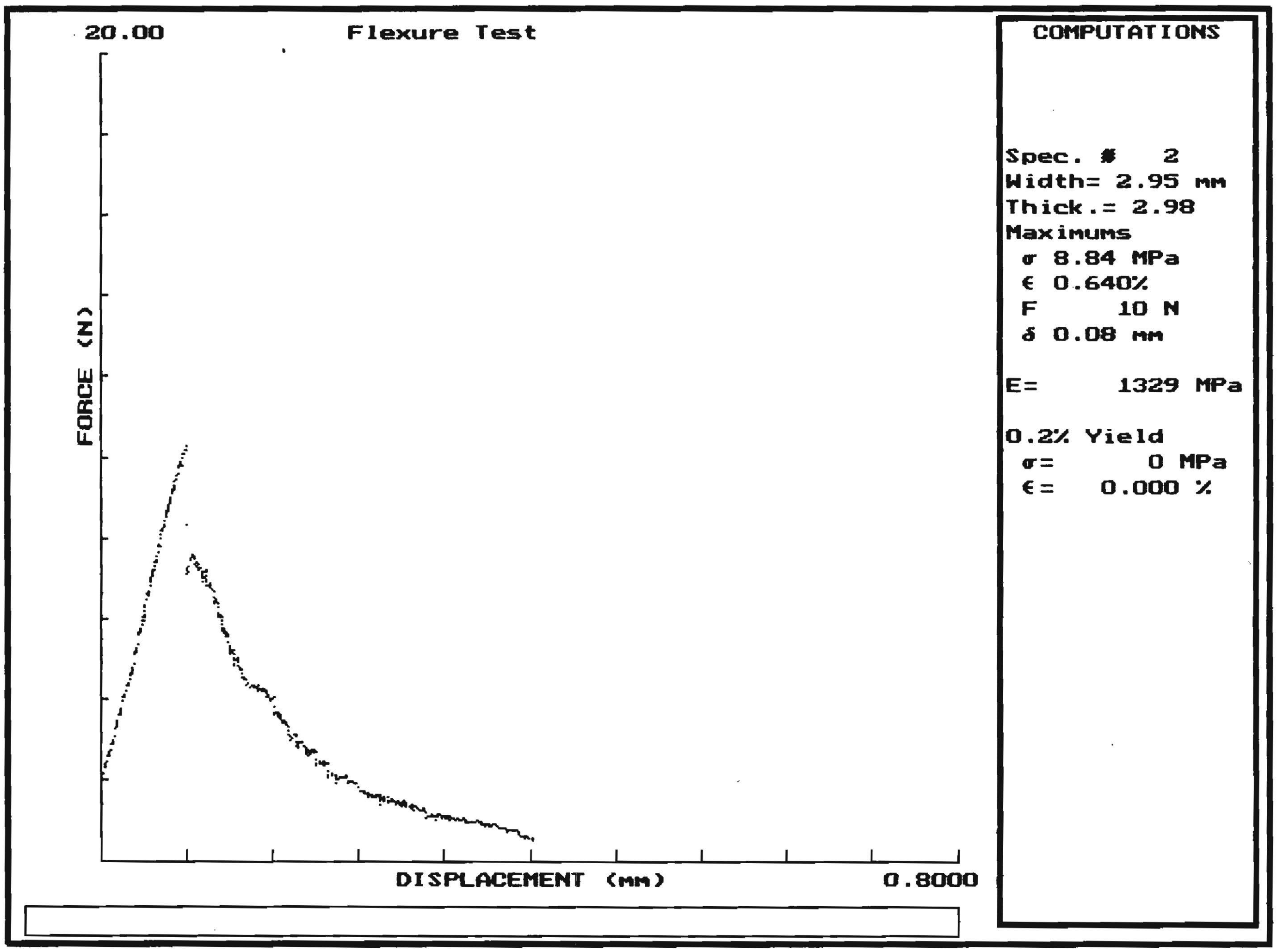
ipecimen Number: 1 File Name: test1X01.DAT K3-2
laterial: : I.D. Code: :
'echnician: : Condition: :
'idth = 3.27 mm Thickness= 4.21 mm
lodulus: 509. MPa
2% Yield
Stress: 0. MPa
Strain: 0.0000 %
'alues at Maximum Force:
P= 10. N δ= 0.0324 mm
σ= 4. MPa ε= 0.3641 %
'alues at "Breaking" Force (last data point):
P= 0. N δ= 0.0661 mm
σ= 0. MPa ε= 0.7417 %



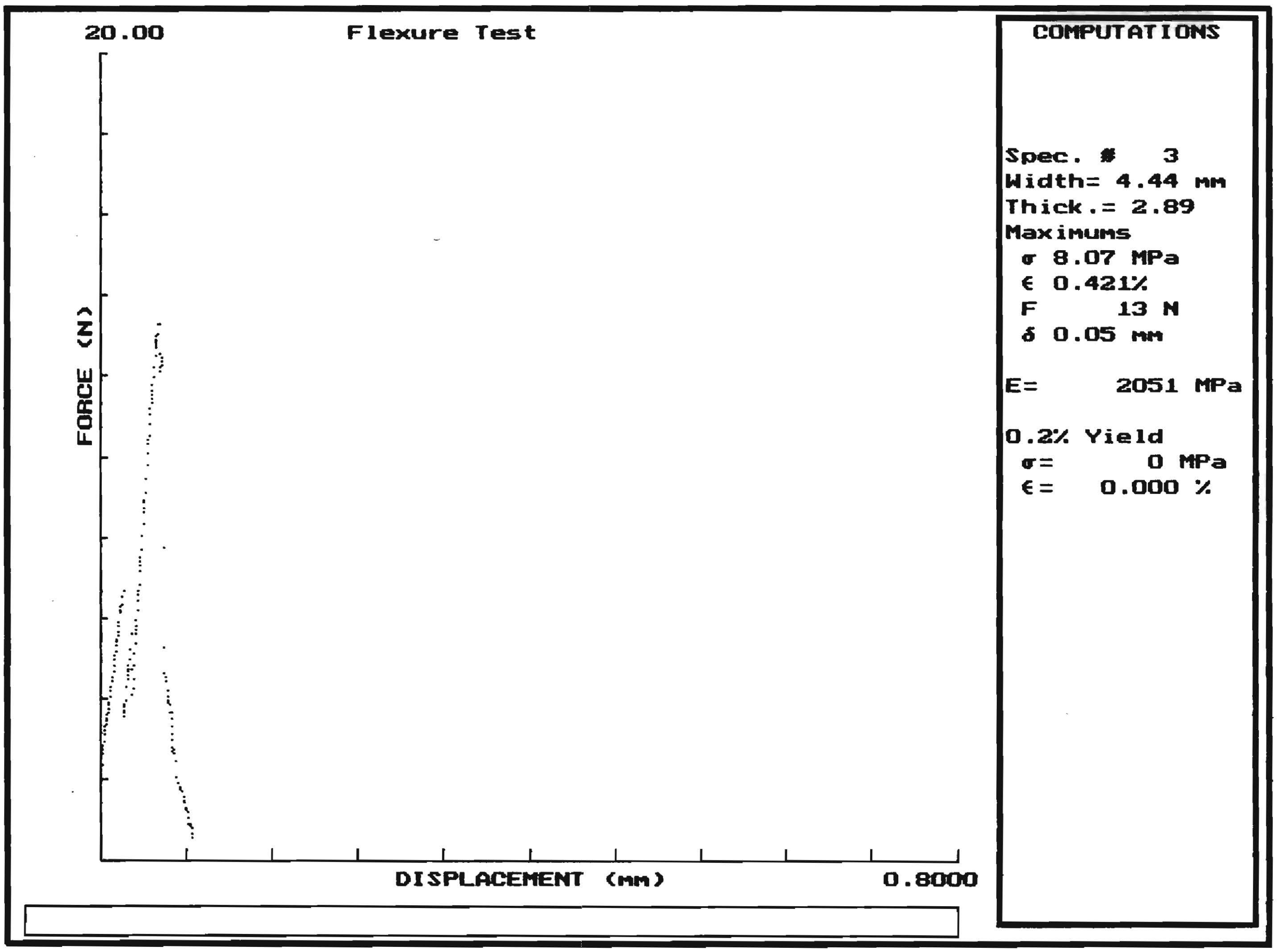
pecimen Number: 2 File Name: test1X02.DAT
idth = 2.95 mm Thickness= 2.98 mm
odulus: 1,329. MPa
2% Yield
Stress: 0. MPa
Strain: 0.0000 %

K-3-1

alues at Maximum Force:
P= 10. N δ= 0.0805 mm
σ= 9. MPa ε= 0.6396 %
alues at "Breaking" Force (last data point):
P= 1. N δ= 0.4030 mm
σ= 0. MPa ε= 3.2025 %



pecimen Number: 3 File Name: test1X03.DAT K-1-1
idth = 4.44 mm Thickness= 2.89 mm
odulus: 2,051. MPa
2% Yield
Stress: 0. MPa
Strain: 0.0000 %
alues at Maximum Force:
P= 13. N δ= 0.0547 mm
σ= 8. MPa ε= 0.4212 %
alues at "Breaking" Force (last data point):
P= 1. N δ= 0.0868 mm
σ= 0. MPa ε= 0.6688 %



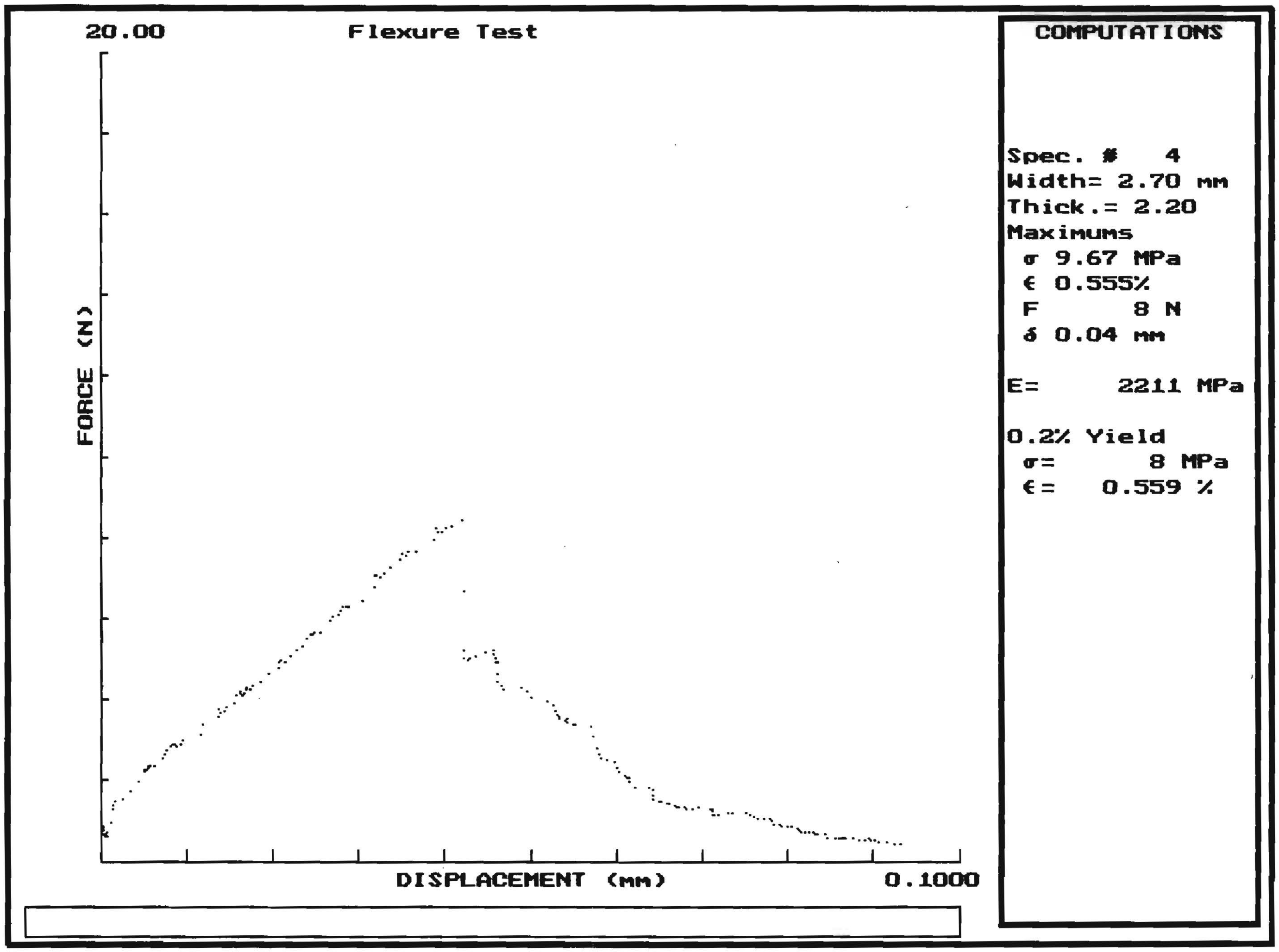
lexure Test, Group Summary
hu., Dec. 11, 1997
roup Population Count = 3

File Set Names: test1X01 test1X03

	Avg.	Std. Dev.	Coef. of Var.
odulus:	1,296. MPa	771.6 MPa	59.54 %
orce:	11. N	1.9 N	17.43 %
tress:	7. MPa	2.7 MPa	39.73 %
train:	1.5377 %	1.4423 %	93.79 %

Flexure Test Results
Thu., Dec. 11, 1997
Sample Description: N
Span Length: 10.000 mm
Strain Measurement: None, crosshead deflection only
Crosshead Rate: 0.100 mm/Min.

Specimen Number: 4 File Name: test1X04.DAT K5-1
Material: : I.D. Code: :
Technician: : Condition: :
Width = 2.70 mm Thickness= 2.20 mm
Modulus: 2,211. MPa
.2% Yield
Stress: 8. MPa
Strain: 0.5590 %
Values at Maximum Force:
P= 8. N δ= 0.0420 mm
σ= 10. MPa ε= 0.5550 %
Values at "Breaking" Force (last data point):
P= 0. N δ= 0.0928 mm
σ= 0. MPa ε= 1.2249 %



lexure Test, Group Summary
hu., Dec. 11, 1997

K-3-2

Width, Th	ick, Span,	Units	Code, CA	1 -	16			
3.27	0, 4.21000	00, 15	.00000000	0,				
3533.597	0000, 0.50	00000,	0	0, 0.	00000000,	0.00000000, 0.00000000, 0.0000		
NEXT IS:	Load, Disp	, Stre	ss, Time,	,Temp	, Axial,	Transverse, CHS 1 - 16		
2.1296,	0.00000,	0.827,	0.0379,	0.00,	0.00000,	0.00000,		
2.1802,	0.00000,	0.846,	0.0402,	0.00,	0.00000,	0.00000,		
2.1602,	0.00030,	0.839,	0.0415,	0.00,	0.00003,	0.00000,		
2.2132,	0.00030,	0.859,	0.0431,	0.00,	0.00003,	0.00000,		
2.2262,	0.00060,	0.864,	0.0432,	0.00,	0.00007,	0.00000,		
2.3369,	0.00090,	0.907,	0.0435,	0.00,	0.00010,	0.00000,		
2.4028,	0.00090,	0.933,	0.0435,	0.00,	0.00010,	0.00000,		
2.5030,	0.00120,	0.972,	0.0436,	0.00,	0.00013,	0.00000,		
2.5842,	0.00150,	1.003,	0.0437,	0.00,	0.00017,	0.00000,		
2.5100,	0.00150,	0.974,	0.0437,	0.00,	0.00017,	0.00000,		
2.5077,	0.00180,	0.974,	0.0438,	0.00,	0.00020,	0.00000,		
2.5595,	0.00210,	0.994,	0.0438,	0.00,	0.00024,	0.00000,		
2.6290,	0.00240,	1.021,	0.0439,	0.00,	0.00027,	0.00000,		
2.7067,	0.00270,	1.051,	0.0439,	0.00,	0.00030,	0.00000,		
2.7656,	0.00300,	1.074,	0.0440,	0.00,	0.00034,	0.00000,		
2.8292,	0.00330,	1.098,	0.0441,	0.00,	0.00037,	0.00000,		
2.8940,	0.00360,	1.123,	0.0441,	0.00,	0.00040,	0.00000,		
2.9765,	0.00390,	1.156,	0.0442,	0.00,	0.00044,	0.00000,		
3.0507,	0.00420,	1.184,	0.0443,	0.00,	0.00047,	0.00000,		
3.0990,	0.00450,	1.203,	0.0443,	0.00,	0.00051,	0.00000,		
3.1661,	0.00480,	1.229,	0.0444,	0.00,	0.00054,	0.00000,		
3.2203,	0.00511,	1.250,	0.0445,	0.00,	0.00057,	0.00000,		
3.2910,	0.00541,	1.278,	0.0445,	0.00,	0.00061,	0.00000,		
3.3722,	0.00571,	1.309,	0.0446,	0.00,	0.00064,	0.00000,		
3.4370,	0.00601,	1.334,	0.0446,	0.00,	0.00067,	0.00000,		
3.5148,	0.00661,	1.364,	0.0447,	0.00,	0.00074,	0.00000,		
3.5972,	0.00691,	1.396,	0.0448,	0.00,	0.00078,	0.00000,		
3.6997,	0.00721,	1.436,	0.0448,	0.00,	0.00081,	0.00000,		
3.7915,	0.00751,	1.472,	0.0449,	0.00,	0.00084,	0.00000,		
3.8834,	0.00781,	1.508,	0.0449,	0.00,	0.00088,	0.00000,		
3.9341,	0.00811,	1.527,	0.0450,	0.00,	0.00091,	0.00000,		
4.0318,	0.00841,	1.565,	0.0450,	0.00,	0.00094,	0.00000,		
4.0990,	0.00871,	1.591,	0.0451,	0.00,	0.00098,	0.00000,		
4.1543,	0.00901,	1.613,	0.0451,	0.00,	0.00101,	0.00000,		
4.2250,	0.00931,	1.640,	0.0452,	0.00,	0.00105,	0.00000,		
4.2874,	0.00961,	1.664,	0.0453,	0.00,	0.00108,	0.00000,		
4.4182,	0.01021,	1.715,	0.0453,	0.00,	0.00115,	0.00000,		
4.5100,	0.01051,	1.751,	0.0454,	0.00,	0.00118,	0.00000,		
4.5925,	0.01081,	1.783,	0.0454,	0.00,	0.00121,	0.00000,		
4.6455,	0.01111,	1.803,	0.0455,	0.00,	0.00125,	0.00000,		
4.6655,	0.01141,	1.811,	0.0456,	0.00,	0.00128,	0.00000,		
4.7209,	0.01201,	1.833,	0.0457,	0.00,	0.00135,	0.00000,		
4.8752,	0.01261,	1.893,	0.0458,	0.00,	0.00142,	0.00000,		
4.9942,	0.01321,	1.939,	0.0458,	0.00,	0.00148,	0.00000,		
5.1532,	0.01351,	2.001,	0.0459,	0.00,	0.00152,	0.00000,		

5.2603,	0.01411,	2.042,	0.0460,	0.00,	0.00158,	0.00000,		
5.3840,	0.01441,	2.090,	0.0460,	0.00,	0.00162,	0.00000,		
5.5089,	0.01502,	2.139,	0.0461,	0.00,	0.00169,	0.00000,		
5.5866,	0.01502,	2.169,	0.0461,	0.00,	0.00169,	0.00000,		
5.5913,	0.01532,	2.171,	0.0462,	0.00,	0.00172,	0.00000,		
5.6773,	0.01562,	2.204,	0.0462,	0.00,	0.00175,	0.00000,		
5.8092,	0.01592,	2.255,	0.0463,	0.00,	0.00179,	0.00000,		
5.9423,	0.01682,	2.307,	0.0464,	0.00,	0.00189,	0.00000,		
6.1543,	0.01712,	2.389,	0.0464,	0.00,	0.00192,	0.00000,		
6.2333,	0.01742,	2.420,	0.0465,	0.00,	0.00196,	0.00000,		
6.2898,	0.01772,	2.442,	0.0465,	0.00,	0.00199,	0.00000,		
6.3664,	0.01802,	2.472,	0.0466,	0.00,	0.00202,	0.00000,		
6.4441,	0.01832,	2.502,	0.0466,	0.00,	0.00206,	0.00000,		
6.4924,	0.01862,	2.520,	0.0467,	0.00,	0.00209,	0.00000,		
6.5819,	0.01892,	2.555,	0.0467,	0.00,	0.00212,	0.00000,		
6.6644,	0.01922,	2.587,	0.0468,	0.00,	0.00216,	0.00000,		
6.8222,	0.01982,	2.648,	0.0469,	0.00,	0.00223,	0.00000,		
6.9459,	0.02012,	2.696,	0.0469,	0.00,	0.00226,	0.00000,		
7.0731,	0.02072,	2.746,	0.0470,	0.00,	0.00233,	0.00000,		
7.2792,	0.02132,	2.826,	0.0470,	0.00,	0.00239,	0.00000,		
7.3734,	0.02162,	2.862,	0.0471,	0.00,	0.00243,	0.00000,		
7.4406,	0.02162,	2.889,	0.0472,	0.00,	0.00243,	0.00000,		
7.4971,	0.02192,	2.910,	0.0472,	0.00,	0.00246,	0.00000,		
7.5902,	0.02222,	2.947,	0.0473,	0.00,	0.00249,	0.00000,		
7.6396,	0.02252,	2.966,	0.0473,	0.00,	0.00253,	0.00000,		
7.6467,	0.02282,	2.969,	0.0474,	0.00,	0.00256,	0.00000,		
7.8069,	0.02342,	3.031,	0.0475,	0.00,	0.00263,	0.00000,		
7.9942,	0.02402,	3.103,	0.0475,	0.00,	0.00270,	0.00000,		
8.2380,	0.02462,	3.198,	0.0476,	0.00,	0.00276,	0.00000,		
8.3004,	0.02492,	3.222,	0.0476,	0.00,	0.00280,	0.00000,		
8.2639,	0.02523,	3.208,	0.0477,	0.00,	0.00283,	0.00000,		
8.3310,	0.02523,	3.234,	0.0479,	0.00,	0.00283,	0.00000,		
8.3935,	0.02553,	3.258,	0.0480,	0.00,	0.00287,	0.00000,		
8.3935,	0.02583,	3.258,	0.0482,	0.00,	0.00290,	0.00000,		
8.6373,	0.02613,	3.353,	0.0482,	0.00,	0.00293,	0.00000,		
8.7881,	0.02703,	3.412,	0.0483,	0.00,	0.00303,	0.00000,		
8.9883,	0.02793,	3.489,	0.0484,	0.00,	0.00314,	0.00000,		
9.1862,	0.02853,	3.566,	0.0484,	0.00,	0.00320,	0.00000,		
9.1744,	0.02913,	3.562,	0.0485,	0.00,	0.00327,	0.00000,		
9.1862,	0.02943,	3.566,	0.0486,	0.00,	0.00330,	0.00000,		
9.1485,	0.02973,	3.552,	0.0487,	0.00,	0.00334,	0.00000,		
9.2745,	0.03123,	3.600,	0.0487,	0.00,	0.00351,	0.00000,		
9.6255,	0.03213,	3.737,	0.0488,	0.00,	0.00361,	0.00000,		
9.6832,	0.03243,	3.759,	0.0488,	0.00,	0.00364,	0.00000,		
9.4936,	0.03303,	3.686,	0.0489,	0.00,	0.00371,	0.00000,		
9.3511,	0.03333,	3.630,	0.0489,	0.00,	0.00374,	0.00000,		
8.2686,	0.03393,	3.210,	0.0490,	0.00,	0.00381,	0.00000,		
6.8246,	0.03453,	2.649,	0.0491,	0.00,	0.00388,	0.00000,		
6.1968,	0.03483,	2.406,	0.0491,	0.00,	0.00391,	0.00000,		

5.9306,	0.03514,	2.302,	0.0492,	0.00,	0.00394,	0.00000,		
5.9353,	0.03574,	2.304,	0.0492,	0.00,	0.00401,	0.00000,		
5.2780,	0.03574,	2.049,	0.0493,	0.00,	0.00401,	0.00000,		
4.7338,	0.03604,	1.838,	0.0493,	0.00,	0.00405,	0.00000,		
4.6078,	0.03604,	1.789,	0.0494,	0.00,	0.00405,	0.00000,		
4.5395,	0.03604,	1.762,	0.0495,	0.00,	0.00405,	0.00000,		
4.4653,	0.03604,	1.733,	0.0495,	0.00,	0.00405,	0.00000,		
4.4382,	0.03634,	1.723,	0.0496,	0.00,	0.00408,	0.00000,		
4.4394,	0.03664,	1.723,	0.0497,	0.00,	0.00411,	0.00000,		
4.4488,	0.03694,	1.727,	0.0498,	0.00,	0.00415,	0.00000,		
4.1390,	0.03694,	1.607,	0.0498,	0.00,	0.00415,	0.00000,		
3.8446,	0.03694,	1.493,	0.0499,	0.00,	0.00415,	0.00000,		
3.8057,	0.03724,	1.477,	0.0499,	0.00,	0.00418,	0.00000,		
3.8599,	0.03844,	1.498,	0.0500,	0.00,	0.00432,	0.00000,		
3.8292,	0.03964,	1.487,	0.0500,	0.00,	0.00445,	0.00000,		
3.6490,	0.03964,	1.417,	0.0501,	0.00,	0.00445,	0.00000,		
3.4700,	0.03964,	1.347,	0.0502,	0.00,	0.00445,	0.00000,		
3.4040,	0.04024,	1.321,	0.0502,	0.00,	0.00452,	0.00000,		
3.3392,	0.04054,	1.296,	0.0503,	0.00,	0.00455,	0.00000,		
2.9140,	0.04054,	1.131,	0.0503,	0.00,	0.00455,	0.00000,		
2.6054,	0.04114,	1.011,	0.0504,	0.00,	0.00462,	0.00000,		
2.5842,	0.04174,	1.003,	0.0504,	0.00,	0.00469,	0.00000,		
2.5842,	0.04234,	1.003,	0.0505,	0.00,	0.00475,	0.00000,		
2.5348,	0.04324,	0.984,	0.0505,	0.00,	0.00485,	0.00000,		
2.4464,	0.04324,	0.950,	0.0506,	0.00,	0.00485,	0.00000,		
2.3487,	0.04354,	0.912,	0.0507,	0.00,	0.00489,	0.00000,		
2.3133,	0.04384,	0.898,	0.0508,	0.00,	0.00492,	0.00000,		
2.2886,	0.04414,	0.888,	0.0509,	0.00,	0.00496,	0.00000,		
2.3051,	0.04444,	0.895,	0.0509,	0.00,	0.00499,	0.00000,		
2.3039,	0.04474,	0.894,	0.0510,	0.00,	0.00502,	0.00000,		
2.3251,	0.04595,	0.903,	0.0511,	0.00,	0.00516,	0.00000,		
2.2874,	0.04655,	0.888,	0.0511,	0.00,	0.00523,	0.00000,		
1.8280,	0.04685,	0.710,	0.0512,	0.00,	0.00526,	0.00000,		
1.6313,	0.04715,	0.633,	0.0512,	0.00,	0.00529,	0.00000,		
1.5630,	0.04745,	0.607,	0.0514,	0.00,	0.00533,	0.00000,		
1.5018,	0.04775,	0.583,	0.0515,	0.00,	0.00536,	0.00000,		
1.4982,	0.04805,	0.582,	0.0517,	0.00,	0.00539,	0.00000,		
1.4688,	0.04835,	0.570,	0.0518,	0.00,	0.00543,	0.00000,		
1.5218,	0.04955,	0.591,	0.0519,	0.00,	0.00556,	0.00000,		
1.5512,	0.05045,	0.602,	0.0520,	0.00,	0.00566,	0.00000,		
1.4971,	0.05135,	0.581,	0.0522,	0.00,	0.00577,	0.00000,		
1.4829,	0.05165,	0.576,	0.0522,	0.00,	0.00580,	0.00000,		
1.4876,	0.05315,	0.578,	0.0523,	0.00,	0.00597,	0.00000,		
1.5112,	0.05405,	0.587,	0.0524,	0.00,	0.00607,	0.00000,		
1.4594,	0.05435,	0.567,	0.0525,	0.00,	0.00610,	0.00000,		
1.3722,	0.05465,	0.533,	0.0525,	0.00,	0.00614,	0.00000,		
1.3310,	0.05495,	0.517,	0.0526,	0.00,	0.00617,	0.00000,		
1.3286,	0.05526,	0.516,	0.0527,	0.00,	0.00620,	0.00000,		
1.3227,	0.05556,	0.514,	0.0527,	0.00,	0.00624,	0.00000,		

1.3004,	0.05586,	0.505,	0.0528,	0.00,	0.00627,	0.00000,		
1.3357,	0.05676,	0.519,	0.0529,	0.00,	0.00637,	0.00000,		
1.3439,	0.05736,	0.522,	0.0529,	0.00,	0.00644,	0.00000,		
1.3557,	0.05796,	0.526,	0.0530,	0.00,	0.00651,	0.00000,		
1.3404,	0.05826,	0.520,	0.0530,	0.00,	0.00654,	0.00000,		
1.3121,	0.05856,	0.509,	0.0532,	0.00,	0.00657,	0.00000,		
1.2992,	0.05886,	0.504,	0.0534,	0.00,	0.00661,	0.00000,		
1.3263,	0.05916,	0.515,	0.0534,	0.00,	0.00664,	0.00000,		
1.3510,	0.05946,	0.524,	0.0535,	0.00,	0.00668,	0.00000,		
1.3475,	0.06036,	0.523,	0.0535,	0.00,	0.00678,	0.00000,		
1.3345,	0.06156,	0.518,	0.0536,	0.00,	0.00691,	0.00000,		
1.2839,	0.06186,	0.498,	0.0536,	0.00,	0.00695,	0.00000,		
1.2309,	0.06216,	0.478,	0.0538,	0.00,	0.00698,	0.00000,		
1.2038,	0.06246,	0.467,	0.0539,	0.00,	0.00701,	0.00000,		
1.2120,	0.06276,	0.471,	0.0540,	0.00,	0.00705,	0.00000,		
1.1885,	0.06306,	0.461,	0.0541,	0.00,	0.00708,	0.00000,		
1.1755,	0.06336,	0.456,	0.0542,	0.00,	0.00711,	0.00000,		
1.1661,	0.06547,	0.453,	0.0542,	0.00,	0.00735,	0.00000,		
1.1661,	0.06577,	0.453,	0.0543,	0.00,	0.00738,	0.00000,		
0.2061,	0.06607,	0.085,	0.0544,	0.00,	0.00742,	0.00000,		

K-3-1

Width, Th	ick, Span,	Units	Code, CA	1 -	16			
2.95	0, 2.98000	00, 15	.00000000	0,				
3533.597	0000, 0.50	00000,	0	0, 0.	00000000,	0.00000000, 0.00000000, 0.0000		
NEXT IS:	Load, Disp	, Stre	ss, Time,	,Temp	, Axial,	Transverse, CHS 1 - 16		
1.7079,	0.00000,	1.467,	0.0373,	0.00,	0.00000,	0.00000,		
1.5242,	0.00000,	1.309,	0.0374,	0.00,	0.00000,	0.00000,		
1.4735,	0.00000,	1.266,	0.0384,	0.00,	0.00000,	0.00000,		
1.4217,	0.00000,	1.221,	0.0404,	0.00,	0.00000,	0.00000,		
1.4311,	0.00030,	1.229,	0.0410,	0.00,	0.00002,	0.00000,		
1.3781,	0.00030,	1.184,	0.0422,	0.00,	0.00002,	0.00000,		
1.3545,	0.00060,	1.163,	0.0429,	0.00,	0.00005,	0.00000,		
1.4217,	0.00060,	1.221,	0.0433,	0.00,	0.00005,	0.00000,		
1.5206,	0.00090,	1.306,	0.0434,	0.00,	0.00007,	0.00000,		
1.6973,	0.00120,	1.458,	0.0435,	0.00,	0.00010,	0.00000,		
1.9423,	0.00180,	1.668,	0.0435,	0.00,	0.00014,	0.00000,		
2.1378,	0.00360,	1.836,	0.0436,	0.00,	0.00029,	0.00000,		
2.3369,	0.00390,	2.007,	0.0437,	0.00,	0.00031,	0.00000,		
2.3263,	0.00420,	1.998,	0.0437,	0.00,	0.00033,	0.00000,		
2.3345,	0.00450,	2.005,	0.0438,	0.00,	0.00036,	0.00000,		
2.3816,	0.00480,	2.046,	0.0438,	0.00,	0.00038,	0.00000,		
2.4052,	0.00511,	2.066,	0.0439,	0.00,	0.00041,	0.00000,		
2.4370,	0.00691,	2.093,	0.0440,	0.00,	0.00055,	0.00000,		
2.5783,	0.00721,	2.214,	0.0441,	0.00,	0.00057,	0.00000,		
2.6160,	0.00781,	2.247,	0.0441,	0.00,	0.00062,	0.00000,		
2.5901,	0.00811,	2.225,	0.0443,	0.00,	0.00064,	0.00000,		
2.6596,	0.00841,	2.284,	0.0444,	0.00,	0.00067,	0.00000,		
2.6926,	0.00871,	2.313,	0.0445,	0.00,	0.00069,	0.00000,		
2.7338,	0.00931,	2.348,	0.0446,	0.00,	0.00074,	0.00000,		
2.8657,	0.01081,	2.461,	0.0446,	0.00,	0.00086,	0.00000,		
2.9600,	0.01141,	2.542,	0.0447,	0.00,	0.00091,	0.00000,		
2.8893,	0.01141,	2.482,	0.0450,	0.00,	0.00091,	0.00000,		
2.9129,	0.01171,	2.502,	0.0451,	0.00,	0.00093,	0.00000,		
2.9612,	0.01201,	2.543,	0.0452,	0.00,	0.00095,	0.00000,		
3.0848,	0.01441,	2.649,	0.0452,	0.00,	0.00115,	0.00000,		
3.2733,	0.01471,	2.811,	0.0453,	0.00,	0.00117,	0.00000,		
3.3475,	0.01502,	2.875,	0.0454,	0.00,	0.00119,	0.00000,		
3.3557,	0.01532,	2.882,	0.0454,	0.00,	0.00122,	0.00000,		
3.3934,	0.01562,	2.915,	0.0455,	0.00,	0.00124,	0.00000,		
3.4040,	0.01592,	2.924,	0.0456,	0.00,	0.00126,	0.00000,		
3.4523,	0.01652,	2.965,	0.0456,	0.00,	0.00131,	0.00000,		
3.5972,	0.01832,	3.090,	0.0457,	0.00,	0.00146,	0.00000,		
3.7126,	0.01862,	3.189,	0.0458,	0.00,	0.00148,	0.00000,		
3.6985,	0.01892,	3.177,	0.0458,	0.00,	0.00150,	0.00000,		
3.6325,	0.01922,	3.120,	0.0459,	0.00,	0.00153,	0.00000,		
3.6844,	0.01922,	3.164,	0.0460,	0.00,	0.00153,	0.00000,		
3.7633,	0.02012,	3.232,	0.0460,	0.00,	0.00160,	0.00000,		
3.9470,	0.02192,	3.390,	0.0461,	0.00,	0.00174,	0.00000,		
4.0648,	0.02222,	3.491,	0.0462,	0.00,	0.00177,	0.00000,		
4.0342,	0.02252,	3.465,	0.0463,	0.00,	0.00179,	0.00000,		

4.0318,	0.02282,	3.463,	0.0466,	0.00,	0.00181,	0.00000,		
4.0884,	0.02342,	3.511,	0.0467,	0.00,	0.00186,	0.00000,		
4.2050,	0.02553,	3.612,	0.0467,	0.00,	0.00203,	0.00000,		
4.3451,	0.02553,	3.732,	0.0468,	0.00,	0.00203,	0.00000,		
4.3581,	0.02583,	3.743,	0.0468,	0.00,	0.00205,	0.00000,		
4.3663,	0.02613,	3.750,	0.0469,	0.00,	0.00208,	0.00000,		
4.3687,	0.02643,	3.752,	0.0471,	0.00,	0.00210,	0.00000,		
4.4005,	0.02673,	3.779,	0.0471,	0.00,	0.00212,	0.00000,		
4.4676,	0.02913,	3.837,	0.0472,	0.00,	0.00231,	0.00000,		
4.6443,	0.02913,	3.989,	0.0472,	0.00,	0.00231,	0.00000,		
4.5878,	0.02943,	3.940,	0.0474,	0.00,	0.00234,	0.00000,		
4.6196,	0.02973,	3.968,	0.0475,	0.00,	0.00236,	0.00000,		
4.6844,	0.02973,	4.023,	0.0476,	0.00,	0.00236,	0.00000,		
4.6973,	0.03003,	4.034,	0.0477,	0.00,	0.00239,	0.00000,		
4.7315,	0.03033,	4.064,	0.0478,	0.00,	0.00241,	0.00000,		
4.7916,	0.03063,	4.115,	0.0478,	0.00,	0.00243,	0.00000,		
4.8728,	0.03153,	4.185,	0.0479,	0.00,	0.00251,	0.00000,		
5.1002,	0.03303,	4.380,	0.0480,	0.00,	0.00263,	0.00000,		
5.1909,	0.03333,	4.458,	0.0480,	0.00,	0.00265,	0.00000,		
5.1897,	0.03363,	4.457,	0.0481,	0.00,	0.00267,	0.00000,		
5.2415,	0.03393,	4.502,	0.0483,	0.00,	0.00270,	0.00000,		
5.2757,	0.03453,	4.531,	0.0484,	0.00,	0.00274,	0.00000,		
5.3558,	0.03634,	4.600,	0.0484,	0.00,	0.00289,	0.00000,		
5.6078,	0.03664,	4.816,	0.0485,	0.00,	0.00291,	0.00000,		
5.6738,	0.03694,	4.873,	0.0485,	0.00,	0.00294,	0.00000,		
5.6479,	0.03724,	4.851,	0.0486,	0.00,	0.00296,	0.00000,		
5.7009,	0.03754,	4.896,	0.0488,	0.00,	0.00298,	0.00000,		
5.7433,	0.03814,	4.933,	0.0488,	0.00,	0.00303,	0.00000,		
5.8669,	0.04024,	5.039,	0.0489,	0.00,	0.00320,	0.00000,		
6.0271,	0.04024,	5.177,	0.0489,	0.00,	0.00320,	0.00000,		
5.9435,	0.04024,	5.105,	0.0490,	0.00,	0.00320,	0.00000,		
5.9412,	0.04054,	5.103,	0.0491,	0.00,	0.00322,	0.00000,		
5.9659,	0.04084,	5.124,	0.0493,	0.00,	0.00325,	0.00000,		
6.0531,	0.04084,	5.199,	0.0493,	0.00,	0.00325,	0.00000,		
6.1096,	0.04114,	5.247,	0.0495,	0.00,	0.00327,	0.00000,		
6.1779,	0.04144,	5.306,	0.0496,	0.00,	0.00329,	0.00000,		
6.2639,	0.04204,	5.380,	0.0497,	0.00,	0.00334,	0.00000,		
6.3463,	0.04234,	5.451,	0.0497,	0.00,	0.00336,	0.00000,		
6.4865,	0.04414,	5.571,	0.0498,	0.00,	0.00351,	0.00000,		
6.6208,	0.04444,	5.686,	0.0498,	0.00,	0.00353,	0.00000,		
6.5960,	0.04474,	5.665,	0.0499,	0.00,	0.00356,	0.00000,		
6.6243,	0.04505,	5.689,	0.0500,	0.00,	0.00358,	0.00000,		
6.6962,	0.04595,	5.751,	0.0501,	0.00,	0.00365,	0.00000,		
6.8304,	0.04655,	5.866,	0.0501,	0.00,	0.00370,	0.00000,		
6.8999,	0.04715,	5.926,	0.0502,	0.00,	0.00375,	0.00000,		
6.9600,	0.04775,	5.978,	0.0502,	0.00,	0.00379,	0.00000,		
7.0283,	0.04805,	6.036,	0.0503,	0.00,	0.00382,	0.00000,		
7.0436,	0.04835,	6.050,	0.0504,	0.00,	0.00384,	0.00000,		
7.0672,	0.04865,	6.070,	0.0504,	0.00,	0.00387,	0.00000,		

7.0931,	0.04895,	6.092,	0.0505,	0.00,	0.00389,	0.00000,		
7.1438,	0.04925,	6.136,	0.0505,	0.00,	0.00391,	0.00000,		
7.1862,	0.04955,	6.172,	0.0506,	0.00,	0.00394,	0.00000,		
7.2050,	0.04985,	6.188,	0.0506,	0.00,	0.00396,	0.00000,		
7.2121,	0.05045,	6.194,	0.0507,	0.00,	0.00401,	0.00000,		
7.3299,	0.05105,	6.295,	0.0507,	0.00,	0.00406,	0.00000,		
7.4182,	0.05135,	6.371,	0.0508,	0.00,	0.00408,	0.00000,		
7.4217,	0.05165,	6.374,	0.0509,	0.00,	0.00410,	0.00000,		
7.4606,	0.05195,	6.408,	0.0510,	0.00,	0.00413,	0.00000,		
7.4041,	0.05195,	6.359,	0.0510,	0.00,	0.00413,	0.00000,		
7.4641,	0.05225,	6.411,	0.0512,	0.00,	0.00415,	0.00000,		
7.5360,	0.05285,	6.472,	0.0513,	0.00,	0.00420,	0.00000,		
7.6585,	0.05405,	6.578,	0.0513,	0.00,	0.00430,	0.00000,		
7.7986,	0.05435,	6.698,	0.0514,	0.00,	0.00432,	0.00000,		
7.8199,	0.05465,	6.716,	0.0514,	0.00,	0.00434,	0.00000,		
7.8010,	0.05495,	6.700,	0.0515,	0.00,	0.00437,	0.00000,		
7.8010,	0.05586,	6.700,	0.0517,	0.00,	0.00444,	0.00000,		
7.9848,	0.05616,	6.858,	0.0518,	0.00,	0.00446,	0.00000,		
8.0731,	0.05706,	6.934,	0.0518,	0.00,	0.00453,	0.00000,		
8.1661,	0.05736,	7.014,	0.0519,	0.00,	0.00456,	0.00000,		
8.1603,	0.05766,	7.009,	0.0520,	0.00,	0.00458,	0.00000,		
8.1756,	0.05826,	7.022,	0.0520,	0.00,	0.00463,	0.00000,		
8.2321,	0.05856,	7.070,	0.0521,	0.00,	0.00465,	0.00000,		
8.2309,	0.05886,	7.069,	0.0521,	0.00,	0.00468,	0.00000,		
8.2321,	0.05916,	7.070,	0.0522,	0.00,	0.00470,	0.00000,		
8.2568,	0.05946,	7.092,	0.0523,	0.00,	0.00473,	0.00000,		
8.3369,	0.06006,	7.160,	0.0523,	0.00,	0.00477,	0.00000,		
8.4465,	0.06066,	7.254,	0.0524,	0.00,	0.00482,	0.00000,		
8.5124,	0.06126,	7.311,	0.0524,	0.00,	0.00487,	0.00000,		
8.5702,	0.06156,	7.361,	0.0525,	0.00,	0.00489,	0.00000,		
8.5878,	0.06186,	7.376,	0.0525,	0.00,	0.00492,	0.00000,		
8.6102,	0.06216,	7.395,	0.0527,	0.00,	0.00494,	0.00000,		
8.6526,	0.06246,	7.431,	0.0527,	0.00,	0.00496,	0.00000,		
8.6726,	0.06276,	7.449,	0.0528,	0.00,	0.00499,	0.00000,		
8.6832,	0.06306,	7.458,	0.0528,	0.00,	0.00501,	0.00000,		
8.7245,	0.06336,	7.493,	0.0529,	0.00,	0.00504,	0.00000,		
8.7527,	0.06366,	7.517,	0.0529,	0.00,	0.00506,	0.00000,		
8.7987,	0.06396,	7.557,	0.0530,	0.00,	0.00508,	0.00000,		
8.8199,	0.06426,	7.575,	0.0531,	0.00,	0.00511,	0.00000,		
8.8729,	0.06486,	7.621,	0.0531,	0.00,	0.00515,	0.00000,		
8.9200,	0.06547,	7.661,	0.0532,	0.00,	0.00520,	0.00000,		
8.9800,	0.06577,	7.713,	0.0533,	0.00,	0.00523,	0.00000,		
9.0283,	0.06637,	7.754,	0.0534,	0.00,	0.00527,	0.00000,		
9.1025,	0.06667,	7.818,	0.0534,	0.00,	0.00530,	0.00000,		
9.1343,	0.06727,	7.845,	0.0535,	0.00,	0.00535,	0.00000,		
9.2050,	0.06787,	7.906,	0.0535,	0.00,	0.00539,	0.00000,		
9.2015,	0.06817,	7.903,	0.0536,	0.00,	0.00542,	0.00000,		
9.2274,	0.06937,	7.925,	0.0537,	0.00,	0.00551,	0.00000,		
9.3805,	0.06967,	8.057,	0.0538,	0.00,	0.00554,	0.00000,		

9.3016,	0.06967,	7.989,	0.0540,	0.00,	0.00554,	0.00000,		
9.2451,	0.06967,	7.940,	0.0541,	0.00,	0.00554,	0.00000,		
9.2227,	0.06997,	7.921,	0.0541,	0.00,	0.00556,	0.00000,		
9.3028,	0.06997,	7.990,	0.0542,	0.00,	0.00556,	0.00000,		
9.3782,	0.07027,	8.055,	0.0543,	0.00,	0.00558,	0.00000,		
9.4524,	0.07087,	8.118,	0.0543,	0.00,	0.00563,	0.00000,		
9.5242,	0.07117,	8.180,	0.0544,	0.00,	0.00566,	0.00000,		
9.5560,	0.07147,	8.207,	0.0545,	0.00,	0.00568,	0.00000,		
9.5843,	0.07237,	8.232,	0.0545,	0.00,	0.00575,	0.00000,		
9.7091,	0.07327,	8.339,	0.0546,	0.00,	0.00582,	0.00000,		
9.7998,	0.07357,	8.417,	0.0547,	0.00,	0.00585,	0.00000,		
9.8222,	0.07417,	8.436,	0.0547,	0.00,	0.00589,	0.00000,		
9.8799,	0.07447,	8.486,	0.0548,	0.00,	0.00592,	0.00000,		
9.7987,	0.07447,	8.416,	0.0549,	0.00,	0.00592,	0.00000,		
9.7669,	0.07477,	8.388,	0.0550,	0.00,	0.00594,	0.00000,		
9.7928,	0.07658,	8.411,	0.0551,	0.00,	0.00609,	0.00000,		
9.9871,	0.07688,	8.578,	0.0552,	0.00,	0.00611,	0.00000,		
10.0602,	0.07748,	8.640,	0.0552,	0.00,	0.00616,	0.00000,		
10.0861,	0.07808,	8.663,	0.0553,	0.00,	0.00620,	0.00000,		
10.1638,	0.07868,	8.729,	0.0553,	0.00,	0.00625,	0.00000,		
10.1638,	0.07898,	8.729,	0.0554,	0.00,	0.00628,	0.00000,		
10.2463,	0.08048,	8.800,	0.0555,	0.00,	0.00640,	0.00000,		
10.1603,	0.08048,	8.726,	0.0556,	0.00,	0.00640,	0.00000,		
8.3416,	0.08048,	7.164,	0.0556,	0.00,	0.00640,	0.00000,		
7.2721,	0.08048,	6.246,	0.0557,	0.00,	0.00640,	0.00000,		
7.2050,	0.08048,	6.188,	0.0557,	0.00,	0.00640,	0.00000,		
7.1885,	0.08078,	6.174,	0.0558,	0.00,	0.00642,	0.00000,		
7.1320,	0.08078,	6.125,	0.0559,	0.00,	0.00642,	0.00000,		
7.1284,	0.08108,	6.122,	0.0563,	0.00,	0.00644,	0.00000,		
7.1544,	0.08168,	6.145,	0.0564,	0.00,	0.00649,	0.00000,		
7.2839,	0.08318,	6.256,	0.0564,	0.00,	0.00661,	0.00000,		
7.4500,	0.08468,	6.399,	0.0565,	0.00,	0.00673,	0.00000,		
7.5230,	0.08498,	6.461,	0.0565,	0.00,	0.00675,	0.00000,		
7.5513,	0.08559,	6.486,	0.0566,	0.00,	0.00680,	0.00000,		
7.5807,	0.08589,	6.511,	0.0567,	0.00,	0.00683,	0.00000,		
7.5760,	0.08649,	6.507,	0.0567,	0.00,	0.00687,	0.00000,		
7.5442,	0.08769,	6.480,	0.0568,	0.00,	0.00697,	0.00000,		
7.4853,	0.08799,	6.429,	0.0568,	0.00,	0.00699,	0.00000,		
7.3770,	0.08829,	6.336,	0.0569,	0.00,	0.00702,	0.00000,		
7.3676,	0.08859,	6.328,	0.0569,	0.00,	0.00704,	0.00000,		
7.3958,	0.08919,	6.352,	0.0570,	0.00,	0.00709,	0.00000,		
7.3946,	0.08979,	6.351,	0.0571,	0.00,	0.00714,	0.00000,		
7.2969,	0.09009,	6.267,	0.0572,	0.00,	0.00716,	0.00000,		
7.3157,	0.09039,	6.283,	0.0573,	0.00,	0.00718,	0.00000,		
7.2780,	0.09099,	6.251,	0.0574,	0.00,	0.00723,	0.00000,		
7.3393,	0.09129,	6.303,	0.0574,	0.00,	0.00725,	0.00000,		
7.3334,	0.09159,	6.298,	0.0575,	0.00,	0.00728,	0.00000,		
7.2721,	0.09159,	6.246,	0.0576,	0.00,	0.00728,	0.00000,		
7.2439,	0.09189,	6.222,	0.0577,	0.00,	0.00730,	0.00000,		

7.1920,	0.09189,	6.177,	0.0577,	0.00,	0.00730,	0.00000,		
7.1862,	0.09219,	6.172,	0.0578,	0.00,	0.00733,	0.00000,		
7.2651,	0.09429,	6.240,	0.0579,	0.00,	0.00749,	0.00000,		
7.1673,	0.09459,	6.156,	0.0580,	0.00,	0.00752,	0.00000,		
7.1237,	0.09489,	6.118,	0.0580,	0.00,	0.00754,	0.00000,		
7.1308,	0.09520,	6.124,	0.0581,	0.00,	0.00756,	0.00000,		
7.0637,	0.09550,	6.067,	0.0583,	0.00,	0.00759,	0.00000,		
7.0001,	0.09550,	6.012,	0.0584,	0.00,	0.00759,	0.00000,		
6.9400,	0.09550,	5.961,	0.0585,	0.00,	0.00759,	0.00000,		
7.0107,	0.09640,	6.021,	0.0586,	0.00,	0.00766,	0.00000,		
7.1426,	0.09670,	6.135,	0.0586,	0.00,	0.00768,	0.00000,		
7.1602,	0.09850,	6.150,	0.0587,	0.00,	0.00783,	0.00000,		
7.2262,	0.09880,	6.206,	0.0588,	0.00,	0.00785,	0.00000,		
7.0519,	0.09910,	6.057,	0.0588,	0.00,	0.00788,	0.00000,		
6.9518,	0.09910,	5.971,	0.0589,	0.00,	0.00788,	0.00000,		
6.8964,	0.09910,	5.923,	0.0589,	0.00,	0.00788,	0.00000,		
6.8057,	0.09940,	5.845,	0.0590,	0.00,	0.00790,	0.00000,		
6.8104,	0.09970,	5.849,	0.0590,	0.00,	0.00792,	0.00000,		
6.8422,	0.10000,	5.877,	0.0591,	0.00,	0.00795,	0.00000,		
6.8410,	0.10030,	5.876,	0.0592,	0.00,	0.00797,	0.00000,		
6.8611,	0.10270,	5.893,	0.0594,	0.00,	0.00816,	0.00000,		
6.8045,	0.10330,	5.844,	0.0595,	0.00,	0.00821,	0.00000,		
6.7503,	0.10360,	5.798,	0.0596,	0.00,	0.00823,	0.00000,		
6.7233,	0.10480,	5.774,	0.0596,	0.00,	0.00833,	0.00000,		
6.6844,	0.10631,	5.741,	0.0597,	0.00,	0.00845,	0.00000,		
6.5383,	0.10661,	5.616,	0.0598,	0.00,	0.00847,	0.00000,		
6.4512,	0.10661,	5.541,	0.0599,	0.00,	0.00847,	0.00000,		
6.4076,	0.10721,	5.503,	0.0601,	0.00,	0.00852,	0.00000,		
6.4311,	0.10841,	5.524,	0.0602,	0.00,	0.00861,	0.00000,		
6.4618,	0.10901,	5.550,	0.0602,	0.00,	0.00866,	0.00000,		
6.3946,	0.10961,	5.492,	0.0603,	0.00,	0.00871,	0.00000,		
6.2886,	0.10991,	5.401,	0.0604,	0.00,	0.00873,	0.00000,		
6.2674,	0.11051,	5.383,	0.0605,	0.00,	0.00878,	0.00000,		
6.1567,	0.11051,	5.288,	0.0606,	0.00,	0.00878,	0.00000,		
6.0860,	0.11051,	5.227,	0.0606,	0.00,	0.00878,	0.00000,		
6.0342,	0.11081,	5.183,	0.0607,	0.00,	0.00881,	0.00000,		
6.0648,	0.11141,	5.209,	0.0609,	0.00,	0.00885,	0.00000,		
6.0943,	0.11201,	5.234,	0.0610,	0.00,	0.00890,	0.00000,		
6.0554,	0.11261,	5.201,	0.0611,	0.00,	0.00895,	0.00000,		
6.0554,	0.11351,	5.201,	0.0612,	0.00,	0.00902,	0.00000,		
5.9671,	0.11351,	5.125,	0.0612,	0.00,	0.00902,	0.00000,		
5.8269,	0.11381,	5.005,	0.0613,	0.00,	0.00904,	0.00000,		
5.7715,	0.11411,	4.957,	0.0614,	0.00,	0.00907,	0.00000,		
5.7209,	0.11471,	4.914,	0.0615,	0.00,	0.00912,	0.00000,		
5.7480,	0.11532,	4.937,	0.0615,	0.00,	0.00916,	0.00000,		
5.7268,	0.11622,	4.919,	0.0616,	0.00,	0.00924,	0.00000,		
5.6644,	0.11652,	4.865,	0.0617,	0.00,	0.00926,	0.00000,		
5.6467,	0.11712,	4.850,	0.0619,	0.00,	0.00931,	0.00000,		
5.5642,	0.11772,	4.779,	0.0620,	0.00,	0.00935,	0.00000,		

5.5972,	0.11832,	4.807,	0.0621,	0.00,	0.00940,	0.00000,		
5.6114,	0.11892,	4.819,	0.0621,	0.00,	0.00945,	0.00000,		
5.5949,	0.11982,	4.805,	0.0622,	0.00,	0.00952,	0.00000,		
5.5407,	0.12012,	4.759,	0.0623,	0.00,	0.00955,	0.00000,		
5.4335,	0.12012,	4.667,	0.0623,	0.00,	0.00955,	0.00000,		
5.3357,	0.12042,	4.583,	0.0624,	0.00,	0.00957,	0.00000,		
5.2745,	0.12042,	4.530,	0.0624,	0.00,	0.00957,	0.00000,		
5.2073,	0.12042,	4.472,	0.0625,	0.00,	0.00957,	0.00000,		
5.1520,	0.12042,	4.425,	0.0625,	0.00,	0.00957,	0.00000,		
5.1202,	0.12132,	4.398,	0.0629,	0.00,	0.00964,	0.00000,		
5.1155,	0.12192,	4.394,	0.0630,	0.00,	0.00969,	0.00000,		
5.1567,	0.12252,	4.429,	0.0631,	0.00,	0.00974,	0.00000,		
5.2085,	0.12402,	4.473,	0.0632,	0.00,	0.00986,	0.00000,		
5.2062,	0.12492,	4.471,	0.0632,	0.00,	0.00993,	0.00000,		
5.1002,	0.12492,	4.380,	0.0633,	0.00,	0.00993,	0.00000,		
5.0295,	0.12523,	4.320,	0.0634,	0.00,	0.00995,	0.00000,		
4.9541,	0.12523,	4.255,	0.0635,	0.00,	0.00995,	0.00000,		
4.8987,	0.12523,	4.207,	0.0635,	0.00,	0.00995,	0.00000,		
4.8340,	0.12523,	4.152,	0.0638,	0.00,	0.00995,	0.00000,		
4.8457,	0.12583,	4.162,	0.0640,	0.00,	0.01000,	0.00000,		
4.9729,	0.12733,	4.271,	0.0641,	0.00,	0.01012,	0.00000,		
5.0130,	0.12823,	4.306,	0.0641,	0.00,	0.01019,	0.00000,		
4.9565,	0.12853,	4.257,	0.0642,	0.00,	0.01021,	0.00000,		
4.9070,	0.12913,	4.214,	0.0642,	0.00,	0.01026,	0.00000,		
4.8505,	0.12913,	4.166,	0.0643,	0.00,	0.01026,	0.00000,		
4.7998,	0.12973,	4.122,	0.0644,	0.00,	0.01031,	0.00000,		
4.7456,	0.13063,	4.076,	0.0646,	0.00,	0.01038,	0.00000,		
4.7503,	0.13183,	4.080,	0.0646,	0.00,	0.01048,	0.00000,		
4.6561,	0.13273,	3.999,	0.0647,	0.00,	0.01055,	0.00000,		
4.5395,	0.13303,	3.899,	0.0648,	0.00,	0.01057,	0.00000,		
4.5042,	0.13423,	3.868,	0.0649,	0.00,	0.01067,	0.00000,		
4.5430,	0.13514,	3.902,	0.0649,	0.00,	0.01074,	0.00000,		
4.5053,	0.13574,	3.870,	0.0650,	0.00,	0.01079,	0.00000,		
4.5053,	0.13634,	3.870,	0.0656,	0.00,	0.01083,	0.00000,		
4.3345,	0.13634,	3.723,	0.0656,	0.00,	0.01083,	0.00000,		
4.3451,	0.13694,	3.732,	0.0657,	0.00,	0.01088,	0.00000,		
4.3970,	0.13844,	3.776,	0.0657,	0.00,	0.01100,	0.00000,		
4.3192,	0.13904,	3.710,	0.0658,	0.00,	0.01105,	0.00000,		
4.3098,	0.13964,	3.702,	0.0660,	0.00,	0.01110,	0.00000,		
4.3181,	0.14054,	3.709,	0.0660,	0.00,	0.01117,	0.00000,		
4.3404,	0.14174,	3.728,	0.0661,	0.00,	0.01126,	0.00000,		
4.3557,	0.14264,	3.741,	0.0661,	0.00,	0.01134,	0.00000,		
4.3063,	0.14384,	3.699,	0.0662,	0.00,	0.01143,	0.00000,		
4.3039,	0.14444,	3.697,	0.0664,	0.00,	0.01148,	0.00000,		
4.3169,	0.14505,	3.708,	0.0664,	0.00,	0.01153,	0.00000,		
4.3181,	0.14565,	3.709,	0.0665,	0.00,	0.01157,	0.00000,		
4.3110,	0.14625,	3.703,	0.0666,	0.00,	0.01162,	0.00000,		
4.3251,	0.14685,	3.715,	0.0667,	0.00,	0.01167,	0.00000,		
4.2686,	0.14715,	3.666,	0.0669,	0.00,	0.01169,	0.00000,		

4.2168,	0.14775,	3.622,	0.0670,	0.00,	0.01174,	0.00000,		
4.2639,	0.14835,	3.662,	0.0670,	0.00,	0.01179,	0.00000,		
4.2709,	0.14895,	3.668,	0.0671,	0.00,	0.01184,	0.00000,		
4.2344,	0.14955,	3.637,	0.0672,	0.00,	0.01188,	0.00000,		
4.2403,	0.15015,	3.642,	0.0673,	0.00,	0.01193,	0.00000,		
4.2026,	0.15075,	3.610,	0.0674,	0.00,	0.01198,	0.00000,		
4.1814,	0.15135,	3.591,	0.0676,	0.00,	0.01203,	0.00000,		
4.2109,	0.15255,	3.617,	0.0677,	0.00,	0.01212,	0.00000,		
4.2332,	0.15315,	3.636,	0.0678,	0.00,	0.01217,	0.00000,		
4.2038,	0.15375,	3.611,	0.0679,	0.00,	0.01222,	0.00000,		
4.2003,	0.15435,	3.607,	0.0679,	0.00,	0.01227,	0.00000,		
4.2073,	0.15495,	3.614,	0.0680,	0.00,	0.01231,	0.00000,		
4.1532,	0.15495,	3.567,	0.0680,	0.00,	0.01231,	0.00000,		
4.0613,	0.15526,	3.488,	0.0682,	0.00,	0.01234,	0.00000,		
4.0731,	0.15586,	3.498,	0.0683,	0.00,	0.01239,	0.00000,		
4.0766,	0.15646,	3.501,	0.0684,	0.00,	0.01243,	0.00000,		
4.0813,	0.15736,	3.505,	0.0684,	0.00,	0.01250,	0.00000,		
3.9647,	0.15796,	3.405,	0.0686,	0.00,	0.01255,	0.00000,		
3.9941,	0.15856,	3.430,	0.0686,	0.00,	0.01260,	0.00000,		
4.0118,	0.16066,	3.446,	0.0688,	0.00,	0.01277,	0.00000,		
4.0295,	0.16126,	3.461,	0.0688,	0.00,	0.01281,	0.00000,		
3.8292,	0.16156,	3.289,	0.0689,	0.00,	0.01284,	0.00000,		
3.6797,	0.16216,	3.160,	0.0689,	0.00,	0.01289,	0.00000,		
3.6314,	0.16276,	3.119,	0.0691,	0.00,	0.01293,	0.00000,		
3.6526,	0.16366,	3.137,	0.0692,	0.00,	0.01301,	0.00000,		
3.6632,	0.16426,	3.146,	0.0693,	0.00,	0.01305,	0.00000,		
3.6384,	0.16486,	3.125,	0.0695,	0.00,	0.01310,	0.00000,		
3.6479,	0.16547,	3.133,	0.0696,	0.00,	0.01315,	0.00000,		
3.5760,	0.16607,	3.071,	0.0697,	0.00,	0.01320,	0.00000,		
3.5795,	0.16667,	3.074,	0.0697,	0.00,	0.01324,	0.00000,		
3.5736,	0.16727,	3.069,	0.0698,	0.00,	0.01329,	0.00000,		
3.6172,	0.16787,	3.107,	0.0699,	0.00,	0.01334,	0.00000,		
3.6219,	0.16847,	3.111,	0.0700,	0.00,	0.01339,	0.00000,		
3.5524,	0.16847,	3.051,	0.0701,	0.00,	0.01339,	0.00000,		
3.4983,	0.16847,	3.005,	0.0701,	0.00,	0.01339,	0.00000,		
3.4865,	0.16937,	2.994,	0.0704,	0.00,	0.01346,	0.00000,		
3.4052,	0.16967,	2.925,	0.0705,	0.00,	0.01348,	0.00000,		
3.4217,	0.17057,	2.939,	0.0707,	0.00,	0.01355,	0.00000,		
3.4771,	0.17207,	2.986,	0.0708,	0.00,	0.01367,	0.00000,		
3.4323,	0.17267,	2.948,	0.0709,	0.00,	0.01372,	0.00000,		
3.3628,	0.17267,	2.888,	0.0710,	0.00,	0.01372,	0.00000,		
3.3510,	0.17357,	2.878,	0.0711,	0.00,	0.01379,	0.00000,		
3.3381,	0.17447,	2.867,	0.0712,	0.00,	0.01386,	0.00000,		
3.3322,	0.17508,	2.862,	0.0712,	0.00,	0.01391,	0.00000,		
3.3180,	0.17568,	2.850,	0.0713,	0.00,	0.01396,	0.00000,		
3.2250,	0.17568,	2.770,	0.0714,	0.00,	0.01396,	0.00000,		
3.1119,	0.17568,	2.673,	0.0714,	0.00,	0.01396,	0.00000,		
3.0589,	0.17598,	2.627,	0.0715,	0.00,	0.01398,	0.00000,		
2.9894,	0.17598,	2.568,	0.0718,	0.00,	0.01398,	0.00000,		

3.0318,	0.17928,	2.604,	0.0722,	0.00,	0.01425,	0.00000,		
3.1272,	0.18078,	2.686,	0.0722,	0.00,	0.01437,	0.00000,		
3.1084,	0.18258,	2.670,	0.0723,	0.00,	0.01451,	0.00000,		
3.0789,	0.18318,	2.644,	0.0724,	0.00,	0.01456,	0.00000,		
2.9470,	0.18318,	2.531,	0.0724,	0.00,	0.01456,	0.00000,		
2.8634,	0.18318,	2.459,	0.0725,	0.00,	0.01456,	0.00000,		
2.8069,	0.18348,	2.411,	0.0726,	0.00,	0.01458,	0.00000,		
2.8622,	0.18348,	2.458,	0.0727,	0.00,	0.01458,	0.00000,		
2.8869,	0.18408,	2.480,	0.0729,	0.00,	0.01463,	0.00000,		
2.9129,	0.18468,	2.502,	0.0730,	0.00,	0.01468,	0.00000,		
2.9258,	0.18589,	2.513,	0.0730,	0.00,	0.01477,	0.00000,		
2.9553,	0.18709,	2.538,	0.0731,	0.00,	0.01487,	0.00000,		
2.9352,	0.18799,	2.521,	0.0732,	0.00,	0.01494,	0.00000,		
2.8563,	0.19009,	2.453,	0.0733,	0.00,	0.01511,	0.00000,		
2.8575,	0.19069,	2.454,	0.0733,	0.00,	0.01515,	0.00000,		
2.7751,	0.19099,	2.383,	0.0734,	0.00,	0.01518,	0.00000,		
2.7162,	0.19099,	2.333,	0.0734,	0.00,	0.01518,	0.00000,		
2.6643,	0.19099,	2.288,	0.0737,	0.00,	0.01518,	0.00000,		
2.7185,	0.19189,	2.335,	0.0738,	0.00,	0.01525,	0.00000,		
2.7503,	0.19369,	2.362,	0.0739,	0.00,	0.01539,	0.00000,		
2.7668,	0.19429,	2.376,	0.0739,	0.00,	0.01544,	0.00000,		
2.6985,	0.19429,	2.318,	0.0741,	0.00,	0.01544,	0.00000,		
2.6208,	0.19429,	2.251,	0.0742,	0.00,	0.01544,	0.00000,		
2.6290,	0.19489,	2.258,	0.0744,	0.00,	0.01549,	0.00000,		
2.6596,	0.19550,	2.284,	0.0745,	0.00,	0.01554,	0.00000,		
2.6938,	0.19670,	2.314,	0.0746,	0.00,	0.01563,	0.00000,		
2.7468,	0.19790,	2.359,	0.0746,	0.00,	0.01573,	0.00000,		
2.7185,	0.19880,	2.335,	0.0747,	0.00,	0.01580,	0.00000,		
2.6879,	0.19970,	2.309,	0.0748,	0.00,	0.01587,	0.00000,		
2.7044,	0.20030,	2.323,	0.0749,	0.00,	0.01592,	0.00000,		
2.5089,	0.20150,	2.155,	0.0751,	0.00,	0.01601,	0.00000,		
2.4170,	0.20180,	2.076,	0.0752,	0.00,	0.01604,	0.00000,		
2.3416,	0.20180,	2.011,	0.0754,	0.00,	0.01604,	0.00000,		
2.4076,	0.20480,	2.068,	0.0758,	0.00,	0.01628,	0.00000,		
2.4688,	0.20541,	2.120,	0.0758,	0.00,	0.01632,	0.00000,		
2.4123,	0.20541,	2.072,	0.0759,	0.00,	0.01632,	0.00000,		
2.4240,	0.20691,	2.082,	0.0760,	0.00,	0.01644,	0.00000,		
2.4653,	0.20841,	2.117,	0.0761,	0.00,	0.01656,	0.00000,		
2.3746,	0.20871,	2.039,	0.0762,	0.00,	0.01659,	0.00000,		
2.3899,	0.21021,	2.053,	0.0763,	0.00,	0.01670,	0.00000,		
2.3922,	0.21141,	2.055,	0.0763,	0.00,	0.01680,	0.00000,		
2.2203,	0.21171,	1.907,	0.0765,	0.00,	0.01682,	0.00000,		
2.0719,	0.21201,	1.779,	0.0765,	0.00,	0.01685,	0.00000,		
2.1237,	0.21291,	1.824,	0.0769,	0.00,	0.01692,	0.00000,		
2.0624,	0.21291,	1.771,	0.0770,	0.00,	0.01692,	0.00000,		
2.1084,	0.21562,	1.811,	0.0771,	0.00,	0.01713,	0.00000,		
2.1685,	0.21592,	1.862,	0.0771,	0.00,	0.01716,	0.00000,		
2.1048,	0.21622,	1.808,	0.0773,	0.00,	0.01718,	0.00000,		
2.0990,	0.21862,	1.803,	0.0775,	0.00,	0.01737,	0.00000,		

2.0566,	0.21982,	1.766,	0.0776,	0.00,	0.01747,	0.00000,		
1.9953,	0.22012,	1.714,	0.0776,	0.00,	0.01749,	0.00000,		
1.9388,	0.22012,	1.665,	0.0777,	0.00,	0.01749,	0.00000,		
1.9918,	0.22072,	1.711,	0.0783,	0.00,	0.01754,	0.00000,		
2.0377,	0.22222,	1.750,	0.0783,	0.00,	0.01766,	0.00000,		
2.0601,	0.22342,	1.769,	0.0785,	0.00,	0.01775,	0.00000,		
2.0507,	0.22523,	1.761,	0.0787,	0.00,	0.01790,	0.00000,		
2.0848,	0.22673,	1.791,	0.0789,	0.00,	0.01802,	0.00000,		
2.0931,	0.22823,	1.798,	0.0789,	0.00,	0.01814,	0.00000,		
2.0483,	0.22943,	1.759,	0.0791,	0.00,	0.01823,	0.00000,		
1.9823,	0.23003,	1.703,	0.0794,	0.00,	0.01828,	0.00000,		
1.9211,	0.23033,	1.650,	0.0795,	0.00,	0.01830,	0.00000,		
1.9423,	0.23153,	1.668,	0.0798,	0.00,	0.01840,	0.00000,		
1.9765,	0.23273,	1.698,	0.0799,	0.00,	0.01849,	0.00000,		
1.9505,	0.23393,	1.675,	0.0801,	0.00,	0.01859,	0.00000,		
1.9458,	0.23514,	1.671,	0.0802,	0.00,	0.01869,	0.00000,		
1.9399,	0.23694,	1.666,	0.0804,	0.00,	0.01883,	0.00000,		
1.9223,	0.23844,	1.651,	0.0804,	0.00,	0.01895,	0.00000,		
1.8210,	0.23904,	1.564,	0.0805,	0.00,	0.01900,	0.00000,		
1.7974,	0.24024,	1.544,	0.0806,	0.00,	0.01909,	0.00000,		
1.7409,	0.24114,	1.495,	0.0808,	0.00,	0.01916,	0.00000,		
1.7114,	0.24234,	1.470,	0.0810,	0.00,	0.01926,	0.00000,		
1.7220,	0.24354,	1.479,	0.0812,	0.00,	0.01935,	0.00000,		
1.7162,	0.24505,	1.474,	0.0813,	0.00,	0.01947,	0.00000,		
1.6620,	0.24565,	1.427,	0.0815,	0.00,	0.01952,	0.00000,		
1.6914,	0.24715,	1.453,	0.0817,	0.00,	0.01964,	0.00000,		
1.6714,	0.24895,	1.436,	0.0819,	0.00,	0.01978,	0.00000,		
1.6160,	0.24895,	1.388,	0.0820,	0.00,	0.01978,	0.00000,		
1.5630,	0.24955,	1.342,	0.0823,	0.00,	0.01983,	0.00000,		
1.6137,	0.25075,	1.386,	0.0825,	0.00,	0.01993,	0.00000,		
1.6431,	0.25195,	1.411,	0.0825,	0.00,	0.02002,	0.00000,		
1.5677,	0.25225,	1.346,	0.0826,	0.00,	0.02005,	0.00000,		
1.5972,	0.25405,	1.372,	0.0831,	0.00,	0.02019,	0.00000,		
1.6231,	0.25586,	1.394,	0.0832,	0.00,	0.02033,	0.00000,		
1.5831,	0.25706,	1.360,	0.0834,	0.00,	0.02043,	0.00000,		
1.6125,	0.25826,	1.385,	0.0834,	0.00,	0.02052,	0.00000,		
1.6419,	0.25946,	1.410,	0.0835,	0.00,	0.02062,	0.00000,		
1.5713,	0.25946,	1.350,	0.0835,	0.00,	0.02062,	0.00000,		
1.4723,	0.25946,	1.265,	0.0836,	0.00,	0.02062,	0.00000,		
1.3969,	0.25976,	1.200,	0.0839,	0.00,	0.02064,	0.00000,		
1.4582,	0.25976,	1.252,	0.0840,	0.00,	0.02064,	0.00000,		
1.5230,	0.26006,	1.308,	0.0841,	0.00,	0.02067,	0.00000,		
1.5359,	0.26156,	1.319,	0.0842,	0.00,	0.02079,	0.00000,		
1.5701,	0.26306,	1.349,	0.0843,	0.00,	0.02090,	0.00000,		
1.5018,	0.26306,	1.290,	0.0844,	0.00,	0.02090,	0.00000,		
1.5230,	0.26456,	1.308,	0.0848,	0.00,	0.02102,	0.00000,		
1.5783,	0.26667,	1.356,	0.0849,	0.00,	0.02119,	0.00000,		
1.5041,	0.26727,	1.292,	0.0850,	0.00,	0.02124,	0.00000,		
1.4429,	0.26727,	1.239,	0.0851,	0.00,	0.02124,	0.00000,		

1.5030,	0.26877,	1.291,	0.0853,	0.00,	0.02136,	0.00000,		
1.5312,	0.27087,	1.315,	0.0854,	0.00,	0.02153,	0.00000,		
1.4947,	0.27207,	1.284,	0.0856,	0.00,	0.02162,	0.00000,		
1.4935,	0.27327,	1.283,	0.0858,	0.00,	0.02172,	0.00000,		
1.4370,	0.27417,	1.234,	0.0859,	0.00,	0.02179,	0.00000,		
1.3663,	0.27417,	1.173,	0.0861,	0.00,	0.02179,	0.00000,		
1.4205,	0.27477,	1.220,	0.0863,	0.00,	0.02184,	0.00000,		
1.4500,	0.27598,	1.245,	0.0865,	0.00,	0.02193,	0.00000,		
1.4676,	0.27748,	1.260,	0.0865,	0.00,	0.02205,	0.00000,		
1.4123,	0.27778,	1.213,	0.0867,	0.00,	0.02207,	0.00000,		
1.3946,	0.27898,	1.198,	0.0869,	0.00,	0.02217,	0.00000,		
1.4511,	0.28108,	1.246,	0.0870,	0.00,	0.02234,	0.00000,		
1.3875,	0.28138,	1.192,	0.0871,	0.00,	0.02236,	0.00000,		
1.3322,	0.28138,	1.144,	0.0872,	0.00,	0.02236,	0.00000,		
1.4075,	0.28168,	1.209,	0.0875,	0.00,	0.02238,	0.00000,		
1.4570,	0.28288,	1.251,	0.0877,	0.00,	0.02248,	0.00000,		
1.4323,	0.28468,	1.230,	0.0878,	0.00,	0.02262,	0.00000,		
1.3781,	0.28498,	1.184,	0.0879,	0.00,	0.02265,	0.00000,		
1.3263,	0.28498,	1.139,	0.0879,	0.00,	0.02265,	0.00000,		
1.3381,	0.28739,	1.149,	0.0883,	0.00,	0.02284,	0.00000,		
1.3993,	0.28889,	1.202,	0.0884,	0.00,	0.02296,	0.00000,		
1.3251,	0.28889,	1.138,	0.0884,	0.00,	0.02296,	0.00000,		
1.2733,	0.28889,	1.094,	0.0885,	0.00,	0.02296,	0.00000,		
1.3169,	0.29009,	1.131,	0.0887,	0.00,	0.02305,	0.00000,		
1.3239,	0.29189,	1.137,	0.0888,	0.00,	0.02320,	0.00000,		
1.2438,	0.29219,	1.068,	0.0890,	0.00,	0.02322,	0.00000,		
1.3169,	0.29309,	1.131,	0.0892,	0.00,	0.02329,	0.00000,		
1.2945,	0.29489,	1.112,	0.0893,	0.00,	0.02343,	0.00000,		
1.2768,	0.29610,	1.097,	0.0895,	0.00,	0.02353,	0.00000,		
1.2250,	0.29640,	1.052,	0.0897,	0.00,	0.02355,	0.00000,		
1.2285,	0.29760,	1.055,	0.0898,	0.00,	0.02365,	0.00000,		
1.2203,	0.29910,	1.048,	0.0900,	0.00,	0.02377,	0.00000,		
1.2320,	0.30030,	1.058,	0.0904,	0.00,	0.02386,	0.00000,		
1.2662,	0.30180,	1.088,	0.0906,	0.00,	0.02398,	0.00000,		
1.2097,	0.30300,	1.039,	0.0907,	0.00,	0.02408,	0.00000,		
1.0671,	0.30330,	0.917,	0.0908,	0.00,	0.02410,	0.00000,		
1.0872,	0.30450,	0.934,	0.0910,	0.00,	0.02420,	0.00000,		
1.1119,	0.30601,	0.955,	0.0911,	0.00,	0.02432,	0.00000,		
1.1095,	0.30751,	0.953,	0.0913,	0.00,	0.02444,	0.00000,		
1.1366,	0.30901,	0.976,	0.0916,	0.00,	0.02456,	0.00000,		
1.1131,	0.31021,	0.956,	0.0918,	0.00,	0.02465,	0.00000,		
1.0130,	0.31141,	0.870,	0.0920,	0.00,	0.02475,	0.00000,		
1.0813,	0.31291,	0.929,	0.0920,	0.00,	0.02487,	0.00000,		
1.1496,	0.31411,	0.987,	0.0922,	0.00,	0.02496,	0.00000,		
1.0777,	0.31441,	0.926,	0.0923,	0.00,	0.02499,	0.00000,		
1.1366,	0.31622,	0.976,	0.0925,	0.00,	0.02513,	0.00000,		
1.0978,	0.31742,	0.943,	0.0928,	0.00,	0.02522,	0.00000,		
1.0377,	0.31832,	0.891,	0.0931,	0.00,	0.02530,	0.00000,		
1.0754,	0.31982,	0.924,	0.0932,	0.00,	0.02542,	0.00000,		

1.0825,	0.32102,	0.930,	0.0934,	0.00,	0.02551,	0.00000,		
1.0236,	0.32162,	0.879,	0.0936,	0.00,	0.02556,	0.00000,		
1.0683,	0.32282,	0.918,	0.0937,	0.00,	0.02565,	0.00000,		
1.0613,	0.32402,	0.911,	0.0939,	0.00,	0.02575,	0.00000,		
1.0895,	0.32553,	0.936,	0.0940,	0.00,	0.02587,	0.00000,		
0.9918,	0.32553,	0.852,	0.0942,	0.00,	0.02587,	0.00000,		
1.0318,	0.32673,	0.886,	0.0943,	0.00,	0.02596,	0.00000,		
1.0459,	0.32793,	0.898,	0.0944,	0.00,	0.02606,	0.00000,		
1.0342,	0.32913,	0.888,	0.0947,	0.00,	0.02615,	0.00000,		
1.0106,	0.33033,	0.868,	0.0949,	0.00,	0.02625,	0.00000,		
1.0530,	0.33153,	0.904,	0.0951,	0.00,	0.02635,	0.00000,		
1.0236,	0.33273,	0.879,	0.0952,	0.00,	0.02644,	0.00000,		
0.9977,	0.33423,	0.857,	0.0954,	0.00,	0.02656,	0.00000,		
0.9741,	0.33544,	0.837,	0.0957,	0.00,	0.02666,	0.00000,		
0.9988,	0.33694,	0.858,	0.0959,	0.00,	0.02678,	0.00000,		
1.0318,	0.33814,	0.886,	0.0960,	0.00,	0.02687,	0.00000,		
0.9541,	0.33934,	0.819,	0.0963,	0.00,	0.02697,	0.00000,		
1.0047,	0.34024,	0.863,	0.0964,	0.00,	0.02704,	0.00000,		
0.9399,	0.34054,	0.807,	0.0965,	0.00,	0.02706,	0.00000,		
0.9635,	0.34174,	0.828,	0.0967,	0.00,	0.02716,	0.00000,		
0.9446,	0.34324,	0.811,	0.0969,	0.00,	0.02728,	0.00000,		
0.9517,	0.34474,	0.817,	0.0972,	0.00,	0.02740,	0.00000,		
0.9388,	0.34595,	0.806,	0.0973,	0.00,	0.02749,	0.00000,		
0.9340,	0.34745,	0.802,	0.0976,	0.00,	0.02761,	0.00000,		
0.9494,	0.34865,	0.815,	0.0977,	0.00,	0.02771,	0.00000,		
0.9635,	0.34985,	0.828,	0.0978,	0.00,	0.02780,	0.00000,		
0.9753,	0.35105,	0.838,	0.0980,	0.00,	0.02790,	0.00000,		
0.9399,	0.35255,	0.807,	0.0983,	0.00,	0.02802,	0.00000,		
0.9411,	0.35375,	0.808,	0.0984,	0.00,	0.02811,	0.00000,		
0.8810,	0.35495,	0.757,	0.0987,	0.00,	0.02821,	0.00000,		
0.9199,	0.35616,	0.790,	0.0989,	0.00,	0.02830,	0.00000,		
0.8905,	0.35736,	0.765,	0.0991,	0.00,	0.02840,	0.00000,		
0.9128,	0.35856,	0.784,	0.0993,	0.00,	0.02849,	0.00000,		
0.8445,	0.35886,	0.725,	0.0994,	0.00,	0.02852,	0.00000,		
0.8905,	0.36036,	0.765,	0.0997,	0.00,	0.02864,	0.00000,		
0.8999,	0.36156,	0.773,	0.0997,	0.00,	0.02873,	0.00000,		
0.8445,	0.36216,	0.725,	0.0998,	0.00,	0.02878,	0.00000,		
0.8669,	0.36366,	0.745,	0.1001,	0.00,	0.02890,	0.00000,		
0.8999,	0.36517,	0.773,	0.1003,	0.00,	0.02902,	0.00000,		
0.8858,	0.36667,	0.761,	0.1006,	0.00,	0.02914,	0.00000,		
0.8799,	0.36817,	0.756,	0.1007,	0.00,	0.02926,	0.00000,		
0.8445,	0.36967,	0.725,	0.1009,	0.00,	0.02938,	0.00000,		
0.8233,	0.37117,	0.707,	0.1010,	0.00,	0.02950,	0.00000,		
0.8080,	0.37237,	0.694,	0.1012,	0.00,	0.02959,	0.00000,		
0.7998,	0.37357,	0.687,	0.1013,	0.00,	0.02969,	0.00000,		
0.8080,	0.37477,	0.694,	0.1016,	0.00,	0.02978,	0.00000,		
0.7974,	0.37598,	0.685,	0.1017,	0.00,	0.02988,	0.00000,		
0.7809,	0.37718,	0.671,	0.1019,	0.00,	0.02997,	0.00000,		
0.7232,	0.37778,	0.621,	0.1023,	0.00,	0.03002,	0.00000,		

0.7750,	0.37868,	0.666,	0.1024,	0.00,	0.03009,	0.00000,		
0.7550,	0.37988,	0.648,	0.1025,	0.00,	0.03019,	0.00000,		
0.7303,	0.38108,	0.627,	0.1029,	0.00,	0.03028,	0.00000,		
0.7362,	0.38228,	0.632,	0.1030,	0.00,	0.03038,	0.00000,		
0.7691,	0.38348,	0.661,	0.1031,	0.00,	0.03047,	0.00000,		
0.7421,	0.38498,	0.637,	0.1033,	0.00,	0.03059,	0.00000,		
0.7409,	0.38619,	0.636,	0.1035,	0.00,	0.03069,	0.00000,		
0.7397,	0.38739,	0.635,	0.1038,	0.00,	0.03078,	0.00000,		
0.7397,	0.38859,	0.635,	0.1040,	0.00,	0.03088,	0.00000,		
0.6938,	0.38979,	0.596,	0.1042,	0.00,	0.03098,	0.00000,		
0.6384,	0.39069,	0.548,	0.1043,	0.00,	0.03105,	0.00000,		
0.5842,	0.39189,	0.502,	0.1045,	0.00,	0.03114,	0.00000,		
0.6078,	0.39309,	0.522,	0.1047,	0.00,	0.03124,	0.00000,		
0.6078,	0.39459,	0.522,	0.1049,	0.00,	0.03136,	0.00000,		
0.5795,	0.39580,	0.498,	0.1051,	0.00,	0.03145,	0.00000,		
0.5866,	0.39730,	0.504,	0.1053,	0.00,	0.03157,	0.00000,		
0.5736,	0.39850,	0.493,	0.1054,	0.00,	0.03167,	0.00000,		
0.5406,	0.39970,	0.464,	0.1057,	0.00,	0.03176,	0.00000,		
0.5548,	0.40240,	0.476,	0.1060,	0.00,	0.03198,	0.00000,		
0.4912,	0.40300,	0.440,	0.1061,	0.00,	0.03203,	0.00000,		

K-1-1

Width, Th	ick, Span,	Units	Code, CA	1 -	16			
4.44	0, 2.89000	00, 15	.00000000	0,				
3533.597	0000, 0.50	00000,	0	0, 0.	00000000,	0.00000000, 0.00000000, 0.0000		
NEXT IS:	Load, Disp	, Stre	ss, Time,	,Temp	, Axial,	Transverse, CHS 1 - 16		
1.3958,	0.00000,	0.847,	0.1378,	0.00,	0.00000,	0.00000,		
1.3439,	0.00000,	0.815,	0.1382,	0.00,	0.00000,	0.00000,		
1.2921,	0.00060,	0.784,	0.1434,	0.00,	0.00005,	0.00000,		
1.3557,	0.00060,	0.823,	0.1436,	0.00,	0.00005,	0.00000,		
1.4394,	0.00090,	0.873,	0.1437,	0.00,	0.00007,	0.00000,		
1.4982,	0.00090,	0.909,	0.1438,	0.00,	0.00007,	0.00000,		
1.5736,	0.00090,	0.955,	0.1440,	0.00,	0.00007,	0.00000,		
1.7032,	0.00120,	1.033,	0.1441,	0.00,	0.00009,	0.00000,		
1.7939,	0.00120,	1.088,	0.1442,	0.00,	0.00009,	0.00000,		
1.8905,	0.00120,	1.147,	0.1443,	0.00,	0.00009,	0.00000,		
2.0306,	0.00150,	1.232,	0.1445,	0.00,	0.00012,	0.00000,		
2.1673,	0.00180,	1.315,	0.1445,	0.00,	0.00014,	0.00000,		
2.3404,	0.00240,	1.420,	0.1446,	0.00,	0.00019,	0.00000,		
2.6514,	0.00270,	1.609,	0.1446,	0.00,	0.00021,	0.00000,		
2.7480,	0.00300,	1.667,	0.1447,	0.00,	0.00023,	0.00000,		
2.8222,	0.00330,	1.712,	0.1447,	0.00,	0.00025,	0.00000,		
2.9447,	0.00390,	1.787,	0.1448,	0.00,	0.00030,	0.00000,		
3.1249,	0.00450,	1.896,	0.1449,	0.00,	0.00035,	0.00000,		
3.2262,	0.00480,	1.957,	0.1449,	0.00,	0.00037,	0.00000,		
3.3133,	0.00541,	2.010,	0.1450,	0.00,	0.00042,	0.00000,		
3.3699,	0.00601,	2.045,	0.1451,	0.00,	0.00046,	0.00000,		
3.4488,	0.00631,	2.093,	0.1452,	0.00,	0.00049,	0.00000,		
3.5265,	0.00661,	2.140,	0.1453,	0.00,	0.00051,	0.00000,		
3.5972,	0.00691,	2.183,	0.1453,	0.00,	0.00053,	0.00000,		
3.6549,	0.00751,	2.218,	0.1455,	0.00,	0.00058,	0.00000,		
3.7397,	0.00781,	2.269,	0.1455,	0.00,	0.00060,	0.00000,		
3.8422,	0.00811,	2.331,	0.1456,	0.00,	0.00062,	0.00000,		
3.8928,	0.00841,	2.362,	0.1457,	0.00,	0.00065,	0.00000,		
4.0542,	0.00961,	2.460,	0.1459,	0.00,	0.00074,	0.00000,		
4.1932,	0.01021,	2.544,	0.1459,	0.00,	0.00079,	0.00000,		
4.2921,	0.01081,	2.604,	0.1460,	0.00,	0.00083,	0.00000,		
4.4276,	0.01171,	2.686,	0.1461,	0.00,	0.00090,	0.00000,		
4.5466,	0.01261,	2.759,	0.1461,	0.00,	0.00097,	0.00000,		
4.6749,	0.01321,	2.836,	0.1462,	0.00,	0.00102,	0.00000,		
4.8422,	0.01381,	2.938,	0.1462,	0.00,	0.00106,	0.00000,		
4.9741,	0.01411,	3.018,	0.1463,	0.00,	0.00109,	0.00000,		
5.0613,	0.01441,	3.071,	0.1464,	0.00,	0.00111,	0.00000,		
5.1755,	0.01502,	3.140,	0.1465,	0.00,	0.00116,	0.00000,		
5.3263,	0.01562,	3.232,	0.1465,	0.00,	0.00120,	0.00000,		
5.4135,	0.01592,	3.285,	0.1466,	0.00,	0.00123,	0.00000,		
5.4665,	0.01652,	3.317,	0.1466,	0.00,	0.00127,	0.00000,		
5.5513,	0.01682,	3.368,	0.1467,	0.00,	0.00130,	0.00000,		
5.6632,	0.01712,	3.436,	0.1467,	0.00,	0.00132,	0.00000,		
5.8057,	0.01772,	3.523,	0.1468,	0.00,	0.00137,	0.00000,		
5.8846,	0.01802,	3.570,	0.1469,	0.00,	0.00139,	0.00000,		

6.1225,	0.01892,	3.715,	0.1470,	0.00,	0.00146,	0.00000,		
6.2780,	0.01922,	3.809,	0.1470,	0.00,	0.00148,	0.00000,		
6.2074,	0.01952,	3.766,	0.1471,	0.00,	0.00150,	0.00000,		
6.3169,	0.02132,	3.833,	0.1474,	0.00,	0.00164,	0.00000,		
6.5501,	0.02162,	3.974,	0.1475,	0.00,	0.00167,	0.00000,		
6.6573,	0.02252,	4.039,	0.1475,	0.00,	0.00174,	0.00000,		
3.7262,	0.02282,	2.261,	0.1476,	0.00,	0.00176,	0.00000,		
3.5795,	0.02312,	2.172,	0.1476,	0.00,	0.00178,	0.00000,		
3.6879,	0.02342,	2.238,	0.1477,	0.00,	0.00181,	0.00000,		
3.8069,	0.02342,	2.310,	0.1478,	0.00,	0.00181,	0.00000,		
3.8599,	0.02342,	2.342,	0.1480,	0.00,	0.00181,	0.00000,		
3.9364,	0.02432,	2.388,	0.1481,	0.00,	0.00187,	0.00000,		
4.3133,	0.02492,	2.617,	0.1482,	0.00,	0.00192,	0.00000,		
4.5006,	0.02643,	2.731,	0.1483,	0.00,	0.00204,	0.00000,		
4.5678,	0.02703,	2.771,	0.1483,	0.00,	0.00208,	0.00000,		
4.6620,	0.02703,	2.829,	0.1484,	0.00,	0.00208,	0.00000,		
4.7138,	0.02733,	2.860,	0.1484,	0.00,	0.00211,	0.00000,		
4.8104,	0.02763,	2.919,	0.1485,	0.00,	0.00213,	0.00000,		
4.9930,	0.02793,	3.029,	0.1486,	0.00,	0.00215,	0.00000,		
5.2003,	0.02853,	3.155,	0.1487,	0.00,	0.00220,	0.00000,		
5.5960,	0.02973,	3.395,	0.1487,	0.00,	0.00229,	0.00000,		
4.7386,	0.03093,	2.875,	0.1488,	0.00,	0.00238,	0.00000,		
4.0954,	0.03093,	2.485,	0.1488,	0.00,	0.00238,	0.00000,		
4.2356,	0.03153,	2.570,	0.1489,	0.00,	0.00243,	0.00000,		
4.5006,	0.03213,	2.731,	0.1490,	0.00,	0.00248,	0.00000,		
4.8351,	0.03273,	2.934,	0.1490,	0.00,	0.00252,	0.00000,		
5.1379,	0.03303,	3.117,	0.1491,	0.00,	0.00255,	0.00000,		
5.3404,	0.03363,	3.240,	0.1491,	0.00,	0.00259,	0.00000,		
5.5913,	0.03393,	3.392,	0.1492,	0.00,	0.00262,	0.00000,		
5.7256,	0.03423,	3.474,	0.1492,	0.00,	0.00264,	0.00000,		
5.8128,	0.03453,	3.527,	0.1493,	0.00,	0.00266,	0.00000,		
5.9624,	0.03453,	3.618,	0.1494,	0.00,	0.00266,	0.00000,		
6.1791,	0.03544,	3.749,	0.1495,	0.00,	0.00273,	0.00000,		
6.4429,	0.03604,	3.909,	0.1496,	0.00,	0.00278,	0.00000,		
6.5960,	0.03634,	4.002,	0.1496,	0.00,	0.00280,	0.00000,		
6.6797,	0.03664,	4.053,	0.1497,	0.00,	0.00282,	0.00000,		
6.8410,	0.03754,	4.151,	0.1498,	0.00,	0.00289,	0.00000,		
7.1508,	0.03784,	4.339,	0.1498,	0.00,	0.00292,	0.00000,		
7.3240,	0.03814,	4.444,	0.1500,	0.00,	0.00294,	0.00000,		
7.4005,	0.03844,	4.490,	0.1502,	0.00,	0.00296,	0.00000,		
7.4865,	0.03874,	4.542,	0.1503,	0.00,	0.00299,	0.00000,		
7.6797,	0.03964,	4.660,	0.1503,	0.00,	0.00305,	0.00000,		
8.0213,	0.04054,	4.867,	0.1504,	0.00,	0.00312,	0.00000,		
8.3464,	0.04114,	5.064,	0.1504,	0.00,	0.00317,	0.00000,		
8.6267,	0.04144,	5.234,	0.1505,	0.00,	0.00319,	0.00000,		
8.7115,	0.04144,	5.286,	0.1505,	0.00,	0.00319,	0.00000,		
8.8434,	0.04204,	5.366,	0.1507,	0.00,	0.00324,	0.00000,		
8.9318,	0.04204,	5.419,	0.1508,	0.00,	0.00324,	0.00000,		
8.8670,	0.04234,	5.380,	0.1508,	0.00,	0.00326,	0.00000,		

9.1190,	0.04324,	5.533,	0.1509,	0.00,	0.00333,	0.00000,		
9.4583,	0.04414,	5.739,	0.1510,	0.00,	0.00340,	0.00000,		
9.7822,	0.04505,	5.935,	0.1511,	0.00,	0.00347,	0.00000,		
10.0920,	0.04535,	6.123,	0.1511,	0.00,	0.00349,	0.00000,		
10.3016,	0.04565,	6.250,	0.1512,	0.00,	0.00352,	0.00000,		
10.4253,	0.04565,	6.325,	0.1512,	0.00,	0.00352,	0.00000,		
10.5125,	0.04655,	6.378,	0.1514,	0.00,	0.00359,	0.00000,		
10.8163,	0.04745,	6.563,	0.1514,	0.00,	0.00366,	0.00000,		
11.0672,	0.04775,	6.715,	0.1515,	0.00,	0.00368,	0.00000,		
11.1980,	0.04805,	6.794,	0.1515,	0.00,	0.00370,	0.00000,		
11.3311,	0.04835,	6.875,	0.1516,	0.00,	0.00373,	0.00000,		
11.4453,	0.04865,	6.944,	0.1516,	0.00,	0.00375,	0.00000,		
11.5125,	0.04865,	6.985,	0.1517,	0.00,	0.00375,	0.00000,		
11.6302,	0.04925,	7.057,	0.1517,	0.00,	0.00380,	0.00000,		
11.7763,	0.04925,	7.145,	0.1518,	0.00,	0.00380,	0.00000,		
11.9459,	0.05045,	7.248,	0.1520,	0.00,	0.00389,	0.00000,		
12.2251,	0.05075,	7.417,	0.1521,	0.00,	0.00391,	0.00000,		
12.5054,	0.05225,	7.588,	0.1521,	0.00,	0.00403,	0.00000,		
12.8270,	0.05225,	7.783,	0.1522,	0.00,	0.00403,	0.00000,		
12.7598,	0.05225,	7.742,	0.1523,	0.00,	0.00403,	0.00000,		
12.6750,	0.05255,	7.690,	0.1523,	0.00,	0.00405,	0.00000,		
12.8046,	0.05285,	7.769,	0.1524,	0.00,	0.00407,	0.00000,		
12.8835,	0.05315,	7.817,	0.1526,	0.00,	0.00410,	0.00000,		
12.9742,	0.05345,	7.872,	0.1528,	0.00,	0.00412,	0.00000,		
13.0578,	0.05375,	7.923,	0.1529,	0.00,	0.00414,	0.00000,		
13.2934,	0.05465,	8.066,	0.1529,	0.00,	0.00421,	0.00000,		
13.2934,	0.05676,	8.066,	0.1531,	0.00,	0.00437,	0.00000,		
12.5254,	0.05676,	7.600,	0.1532,	0.00,	0.00437,	0.00000,		
12.1285,	0.05706,	7.359,	0.1532,	0.00,	0.00440,	0.00000,		
12.1886,	0.05706,	7.395,	0.1533,	0.00,	0.00440,	0.00000,		
12.2451,	0.05766,	7.430,	0.1533,	0.00,	0.00444,	0.00000,		
12.3723,	0.05826,	7.507,	0.1534,	0.00,	0.00449,	0.00000,		
12.4618,	0.05886,	7.561,	0.1535,	0.00,	0.00454,	0.00000,		
7.7633,	0.05976,	4.710,	0.1535,	0.00,	0.00461,	0.00000,		
5.2603,	0.06036,	3.192,	0.1536,	0.00,	0.00465,	0.00000,		
4.6219,	0.06096,	2.804,	0.1536,	0.00,	0.00470,	0.00000,		
4.5607,	0.06156,	2.767,	0.1538,	0.00,	0.00474,	0.00000,		
4.4300,	0.06276,	2.688,	0.1539,	0.00,	0.00484,	0.00000,		
4.1967,	0.06306,	2.546,	0.1539,	0.00,	0.00486,	0.00000,		
4.0330,	0.06366,	2.447,	0.1540,	0.00,	0.00491,	0.00000,		
3.9694,	0.06396,	2.408,	0.1540,	0.00,	0.00493,	0.00000,		
3.9034,	0.06456,	2.368,	0.1542,	0.00,	0.00498,	0.00000,		
3.8398,	0.06637,	2.330,	0.1544,	0.00,	0.00511,	0.00000,		
3.6832,	0.06667,	2.235,	0.1544,	0.00,	0.00514,	0.00000,		
3.5407,	0.06697,	2.148,	0.1545,	0.00,	0.00516,	0.00000,		
3.3063,	0.06697,	2.006,	0.1546,	0.00,	0.00516,	0.00000,		
3.1166,	0.06727,	1.891,	0.1547,	0.00,	0.00518,	0.00000,		
2.9953,	0.06787,	1.817,	0.1549,	0.00,	0.00523,	0.00000,		
2.7680,	0.06787,	1.679,	0.1549,	0.00,	0.00523,	0.00000,		

2.6820,	0.06787,	1.627,	0.1550,	0.00,	0.00523,	0.00000,		
2.7503,	0.06967,	1.669,	0.1554,	0.00,	0.00537,	0.00000,		
2.6467,	0.07027,	1.606,	0.1554,	0.00,	0.00542,	0.00000,		
2.4288,	0.07117,	1.474,	0.1555,	0.00,	0.00548,	0.00000,		
2.0518,	0.07207,	1.245,	0.1556,	0.00,	0.00555,	0.00000,		
1.9211,	0.07357,	1.166,	0.1557,	0.00,	0.00567,	0.00000,		
1.8245,	0.07538,	1.107,	0.1559,	0.00,	0.00581,	0.00000,		
1.7633,	0.07568,	1.070,	0.1560,	0.00,	0.00583,	0.00000,		
1.7020,	0.07748,	1.033,	0.1563,	0.00,	0.00597,	0.00000,		
1.5819,	0.07838,	0.960,	0.1564,	0.00,	0.00604,	0.00000,		
1.4841,	0.07868,	0.900,	0.1564,	0.00,	0.00606,	0.00000,		
1.4158,	0.07928,	0.859,	0.1566,	0.00,	0.00611,	0.00000,		
1.3039,	0.08078,	0.791,	0.1568,	0.00,	0.00623,	0.00000,		
1.2344,	0.08138,	0.749,	0.1568,	0.00,	0.00627,	0.00000,		
1.1743,	0.08198,	0.713,	0.1569,	0.00,	0.00632,	0.00000,		
1.0306,	0.08198,	0.625,	0.1570,	0.00,	0.00632,	0.00000,		
0.9211,	0.08198,	0.559,	0.1570,	0.00,	0.00632,	0.00000,		
0.9140,	0.08438,	0.555,	0.1576,	0.00,	0.00650,	0.00000,		
0.8587,	0.08468,	0.521,	0.1577,	0.00,	0.00653,	0.00000,		
0.8009,	0.08559,	0.486,	0.1580,	0.00,	0.00660,	0.00000,		
0.6785,	0.08649,	0.412,	0.1581,	0.00,	0.00667,	0.00000,		
0.5772,	0.08679,	0.372,	0.1582,	0.00,	0.00669,	0.00000,		

K-5-1

Width, Th	ick, Span,	Units	Code, CA	1 -	16	
2.7	0, 2.20000	00, 10	.00000000	0,		
3533.597	0000, 0.50	00000,	0	0, 0.	00000000,	0.00000000, 0.00000000, 0.0000
NEXT IS:	Load, Disp	, Stre	ss, Time,	,Temp	, Axial,	Transverse, CHS 1 - 16
0.9729,	0.00000,	1.117,	0.0583,	0.00,	0.00000,	0.00000,
0.9140,	0.00000,	1.049,	0.0588,	0.00,	0.00000,	0.00000,
0.8622,	0.00000,	0.990,	0.0598,	0.00,	0.00000,	0.00000,
0.8504,	0.00030,	0.976,	0.0599,	0.00,	0.00004,	0.00000,
0.7986,	0.00030,	0.917,	0.0606,	0.00,	0.00004,	0.00000,
0.7326,	0.00030,	0.841,	0.0616,	0.00,	0.00004,	0.00000,
0.6678,	0.00030,	0.767,	0.0625,	0.00,	0.00004,	0.00000,
0.6408,	0.00060,	0.735,	0.0631,	0.00,	0.00008,	0.00000,
0.5866,	0.00060,	0.673,	0.0644,	0.00,	0.00008,	0.00000,
0.6184,	0.00090,	0.710,	0.0648,	0.00,	0.00012,	0.00000,
0.7220,	0.00090,	0.829,	0.0649,	0.00,	0.00012,	0.00000,
0.9234,	0.00120,	1.060,	0.0650,	0.00,	0.00016,	0.00000,
1.2827,	0.00150,	1.472,	0.0650,	0.00,	0.00020,	0.00000,
1.4064,	0.00150,	1.614,	0.0651,	0.00,	0.00020,	0.00000,
1.4653,	0.00180,	1.682,	0.0652,	0.00,	0.00024,	0.00000,
1.5171,	0.00270,	1.741,	0.0655,	0.00,	0.00036,	0.00000,
1.7138,	0.00360,	1.967,	0.0656,	0.00,	0.00048,	0.00000,
1.9505,	0.00450,	2.239,	0.0656,	0.00,	0.00059,	0.00000,
2.1849,	0.00511,	2.508,	0.0657,	0.00,	0.00067,	0.00000,
2.2509,	0.00511,	2.584,	0.0658,	0.00,	0.00067,	0.00000,
2.2697,	0.00541,	2.605,	0.0659,	0.00,	0.00071,	0.00000,
2.3027,	0.00571,	2.643,	0.0660,	0.00,	0.00075,	0.00000,
2.3652,	0.00571,	2.715,	0.0662,	0.00,	0.00075,	0.00000,
2.3475,	0.00601,	2.695,	0.0662,	0.00,	0.00079,	0.00000,
2.3769,	0.00631,	2.728,	0.0663,	0.00,	0.00083,	0.00000,
2.5348,	0.00721,	2.910,	0.0663,	0.00,	0.00095,	0.00000,
2.6455,	0.00751,	3.037,	0.0664,	0.00,	0.00099,	0.00000,
2.7279,	0.00781,	3.131,	0.0665,	0.00,	0.00103,	0.00000,
2.8269,	0.00811,	3.245,	0.0665,	0.00,	0.00107,	0.00000,
2.8834,	0.00841,	3.310,	0.0666,	0.00,	0.00111,	0.00000,
2.8858,	0.00871,	3.312,	0.0667,	0.00,	0.00115,	0.00000,
2.8387,	0.00901,	3.258,	0.0670,	0.00,	0.00119,	0.00000,
2.8787,	0.00931,	3.304,	0.0671,	0.00,	0.00123,	0.00000,
2.9694,	0.00961,	3.408,	0.0671,	0.00,	0.00127,	0.00000,
3.1308,	0.01171,	3.594,	0.0672,	0.00,	0.00155,	0.00000,
3.3652,	0.01201,	3.863,	0.0672,	0.00,	0.00159,	0.00000,
3.5666,	0.01381,	4.094,	0.0673,	0.00,	0.00182,	0.00000,
3.7409,	0.01381,	4.294,	0.0673,	0.00,	0.00182,	0.00000,
3.6867,	0.01411,	4.232,	0.0675,	0.00,	0.00186,	0.00000,
3.7362,	0.01441,	4.289,	0.0676,	0.00,	0.00190,	0.00000,
3.8304,	0.01471,	4.397,	0.0676,	0.00,	0.00194,	0.00000,
3.9188,	0.01562,	4.498,	0.0677,	0.00,	0.00206,	0.00000,
4.1084,	0.01592,	4.716,	0.0678,	0.00,	0.00210,	0.00000,
4.1932,	0.01622,	4.813,	0.0678,	0.00,	0.00214,	0.00000,
4.1402,	0.01622,	4.752,	0.0679,	0.00,	0.00214,	0.00000,

4.1060,	0.01652,	4.713,	0.0681,	0.00,	0.00218,	0.00000,		
4.1567,	0.01682,	4.771,	0.0681,	0.00,	0.00222,	0.00000,		
4.2497,	0.01712,	4.878,	0.0682,	0.00,	0.00226,	0.00000,		
4.3004,	0.01712,	4.936,	0.0682,	0.00,	0.00226,	0.00000,		
4.2627,	0.01742,	4.893,	0.0684,	0.00,	0.00230,	0.00000,		
4.3440,	0.01772,	4.986,	0.0685,	0.00,	0.00234,	0.00000,		
4.4559,	0.01862,	5.115,	0.0685,	0.00,	0.00246,	0.00000,		
4.6408,	0.01952,	5.327,	0.0686,	0.00,	0.00258,	0.00000,		
4.7951,	0.02072,	5.504,	0.0687,	0.00,	0.00274,	0.00000,		
4.9341,	0.02072,	5.664,	0.0687,	0.00,	0.00274,	0.00000,		
4.9588,	0.02102,	5.692,	0.0688,	0.00,	0.00277,	0.00000,		
4.9494,	0.02132,	5.681,	0.0689,	0.00,	0.00281,	0.00000,		
5.0542,	0.02222,	5.801,	0.0689,	0.00,	0.00293,	0.00000,		
5.2156,	0.02282,	5.987,	0.0690,	0.00,	0.00301,	0.00000,		
5.3298,	0.02342,	6.118,	0.0691,	0.00,	0.00309,	0.00000,		
5.4959,	0.02402,	6.308,	0.0691,	0.00,	0.00317,	0.00000,		
5.5913,	0.02432,	6.418,	0.0692,	0.00,	0.00321,	0.00000,		
5.5854,	0.02462,	6.411,	0.0693,	0.00,	0.00325,	0.00000,		
5.6608,	0.02492,	6.498,	0.0694,	0.00,	0.00329,	0.00000,		
5.6549,	0.02553,	6.491,	0.0695,	0.00,	0.00337,	0.00000,		
5.9470,	0.02673,	6.826,	0.0697,	0.00,	0.00353,	0.00000,		
6.0460,	0.02703,	6.940,	0.0697,	0.00,	0.00357,	0.00000,		
6.0766,	0.02763,	6.975,	0.0698,	0.00,	0.00365,	0.00000,		
6.2121,	0.02793,	7.130,	0.0699,	0.00,	0.00369,	0.00000,		
6.2874,	0.02823,	7.217,	0.0699,	0.00,	0.00373,	0.00000,		
6.2792,	0.02853,	7.208,	0.0700,	0.00,	0.00377,	0.00000,		
6.2816,	0.02883,	7.210,	0.0701,	0.00,	0.00381,	0.00000,		
6.4488,	0.03033,	7.402,	0.0702,	0.00,	0.00400,	0.00000,		
6.7951,	0.03183,	7.800,	0.0703,	0.00,	0.00420,	0.00000,		
7.0589,	0.03183,	8.103,	0.0703,	0.00,	0.00420,	0.00000,		
7.0483,	0.03213,	8.090,	0.0704,	0.00,	0.00424,	0.00000,		
7.0366,	0.03243,	8.077,	0.0705,	0.00,	0.00428,	0.00000,		
7.1332,	0.03303,	8.188,	0.0705,	0.00,	0.00436,	0.00000,		
7.2792,	0.03363,	8.355,	0.0706,	0.00,	0.00444,	0.00000,		
7.4736,	0.03483,	8.578,	0.0706,	0.00,	0.00460,	0.00000,		
7.6208,	0.03514,	8.747,	0.0707,	0.00,	0.00464,	0.00000,		
7.5525,	0.03544,	8.669,	0.0709,	0.00,	0.00468,	0.00000,		
7.6290,	0.03574,	8.757,	0.0711,	0.00,	0.00472,	0.00000,		
7.6538,	0.03664,	8.785,	0.0712,	0.00,	0.00484,	0.00000,		
7.9235,	0.03874,	9.095,	0.0712,	0.00,	0.00511,	0.00000,		
8.2097,	0.03904,	9.423,	0.0713,	0.00,	0.00515,	0.00000,		
8.1485,	0.03934,	9.353,	0.0714,	0.00,	0.00519,	0.00000,		
8.1308,	0.03964,	9.333,	0.0716,	0.00,	0.00523,	0.00000,		
8.2297,	0.04024,	9.446,	0.0716,	0.00,	0.00531,	0.00000,		
8.2910,	0.04084,	9.517,	0.0717,	0.00,	0.00539,	0.00000,		
8.4217,	0.04204,	9.667,	0.0718,	0.00,	0.00555,	0.00000,		
6.6620,	0.04234,	7.647,	0.0719,	0.00,	0.00559,	0.00000,		
5.2344,	0.04234,	6.008,	0.0719,	0.00,	0.00559,	0.00000,		
5.0048,	0.04234,	5.745,	0.0720,	0.00,	0.00559,	0.00000,		

4.9906,	0.04264,	5.728,	0.0721,	0.00,	0.00563,	0.00000,		
5.0236,	0.04294,	5.766,	0.0722,	0.00,	0.00567,	0.00000,		
5.0601,	0.04354,	5.808,	0.0722,	0.00,	0.00575,	0.00000,		
5.1708,	0.04474,	5.935,	0.0723,	0.00,	0.00591,	0.00000,		
5.2356,	0.04565,	6.010,	0.0724,	0.00,	0.00603,	0.00000,		
5.1296,	0.04565,	5.888,	0.0724,	0.00,	0.00603,	0.00000,		
5.0036,	0.04595,	5.743,	0.0725,	0.00,	0.00606,	0.00000,		
4.9270,	0.04595,	5.655,	0.0725,	0.00,	0.00606,	0.00000,		
4.9364,	0.04625,	5.666,	0.0727,	0.00,	0.00610,	0.00000,		
4.6208,	0.04625,	5.304,	0.0728,	0.00,	0.00610,	0.00000,		
4.4311,	0.04625,	5.086,	0.0728,	0.00,	0.00610,	0.00000,		
4.3440,	0.04655,	4.986,	0.0729,	0.00,	0.00614,	0.00000,		
4.2709,	0.04685,	4.902,	0.0730,	0.00,	0.00618,	0.00000,		
4.3063,	0.04895,	4.943,	0.0730,	0.00,	0.00646,	0.00000,		
4.2215,	0.04955,	4.846,	0.0731,	0.00,	0.00654,	0.00000,		
4.0530,	0.05015,	4.652,	0.0731,	0.00,	0.00662,	0.00000,		
3.9470,	0.05195,	4.531,	0.0733,	0.00,	0.00686,	0.00000,		
3.8587,	0.05255,	4.429,	0.0734,	0.00,	0.00694,	0.00000,		
3.7256,	0.05285,	4.276,	0.0735,	0.00,	0.00698,	0.00000,		
3.6255,	0.05315,	4.161,	0.0735,	0.00,	0.00702,	0.00000,		
3.5713,	0.05345,	4.099,	0.0736,	0.00,	0.00706,	0.00000,		
3.5183,	0.05345,	4.038,	0.0736,	0.00,	0.00706,	0.00000,		
3.4794,	0.05405,	3.994,	0.0738,	0.00,	0.00714,	0.00000,		
3.5065,	0.05435,	4.025,	0.0738,	0.00,	0.00717,	0.00000,		
3.4241,	0.05435,	3.930,	0.0739,	0.00,	0.00717,	0.00000,		
3.3911,	0.05495,	3.892,	0.0739,	0.00,	0.00725,	0.00000,		
3.3911,	0.05526,	3.892,	0.0740,	0.00,	0.00729,	0.00000,		
3.3404,	0.05706,	3.834,	0.0741,	0.00,	0.00753,	0.00000,		
3.0954,	0.05736,	3.553,	0.0741,	0.00,	0.00757,	0.00000,		
2.7727,	0.05766,	3.183,	0.0742,	0.00,	0.00761,	0.00000,		
2.6396,	0.05796,	3.030,	0.0742,	0.00,	0.00765,	0.00000,		
2.5501,	0.05826,	2.927,	0.0743,	0.00,	0.00769,	0.00000,		
2.4782,	0.05886,	2.845,	0.0744,	0.00,	0.00777,	0.00000,		
2.4523,	0.05976,	2.815,	0.0744,	0.00,	0.00789,	0.00000,		
2.2839,	0.06006,	2.622,	0.0745,	0.00,	0.00793,	0.00000,		
2.1955,	0.06036,	2.520,	0.0746,	0.00,	0.00797,	0.00000,		
2.1284,	0.06096,	2.443,	0.0747,	0.00,	0.00805,	0.00000,		
2.0542,	0.06126,	2.358,	0.0748,	0.00,	0.00809,	0.00000,		
2.0754,	0.06156,	2.382,	0.0749,	0.00,	0.00813,	0.00000,		
1.9564,	0.06156,	2.246,	0.0750,	0.00,	0.00813,	0.00000,		
1.8410,	0.06216,	2.113,	0.0750,	0.00,	0.00821,	0.00000,		
1.8269,	0.06366,	2.097,	0.0751,	0.00,	0.00840,	0.00000,		
1.7798,	0.06426,	2.043,	0.0751,	0.00,	0.00848,	0.00000,		
1.6066,	0.06426,	1.844,	0.0752,	0.00,	0.00848,	0.00000,		
1.5147,	0.06426,	1.739,	0.0752,	0.00,	0.00848,	0.00000,		
1.4770,	0.06486,	1.695,	0.0753,	0.00,	0.00856,	0.00000,		
1.4712,	0.06517,	1.689,	0.0754,	0.00,	0.00860,	0.00000,		
1.4476,	0.06577,	1.662,	0.0755,	0.00,	0.00868,	0.00000,		
1.4252,	0.06607,	1.636,	0.0756,	0.00,	0.00872,	0.00000,		

1.3793,	0.06667,	1.583,	0.0756,	0.00,	0.00880,	0.00000,		
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1.3169,	0.06727,	1.512,	0.0758,	0.00,	0.00888,	0.00000,		
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1.3098,	0.06877,	1.503,	0.0761,	0.00,	0.00908,	0.00000,		
1.3180,	0.06967,	1.513,	0.0761,	0.00,	0.00920,	0.00000,		
1.3098,	0.07087,	1.503,	0.0762,	0.00,	0.00935,	0.00000,		
1.2909,	0.07117,	1.482,	0.0763,	0.00,	0.00939,	0.00000,		
1.2262,	0.07117,	1.407,	0.0763,	0.00,	0.00939,	0.00000,		
1.1637,	0.07117,	1.336,	0.0764,	0.00,	0.00939,	0.00000,		
1.1520,	0.07147,	1.322,	0.0764,	0.00,	0.00943,	0.00000,		
1.1437,	0.07177,	1.313,	0.0766,	0.00,	0.00947,	0.00000,		
1.2014,	0.07297,	1.379,	0.0766,	0.00,	0.00963,	0.00000,		
1.2085,	0.07357,	1.387,	0.0767,	0.00,	0.00971,	0.00000,		
1.1802,	0.07508,	1.355,	0.0767,	0.00,	0.00991,	0.00000,		
1.1272,	0.07568,	1.294,	0.0768,	0.00,	0.00999,	0.00000,		
1.0813,	0.07598,	1.241,	0.0769,	0.00,	0.01003,	0.00000,		
1.0530,	0.07658,	1.209,	0.0769,	0.00,	0.01011,	0.00000,		
1.0624,	0.07718,	1.220,	0.0770,	0.00,	0.01019,	0.00000,		
1.0483,	0.07778,	1.203,	0.0770,	0.00,	0.01027,	0.00000,		
0.9988,	0.07808,	1.146,	0.0772,	0.00,	0.01031,	0.00000,		
0.9176,	0.07838,	1.053,	0.0772,	0.00,	0.01035,	0.00000,		
0.8881,	0.07898,	1.019,	0.0773,	0.00,	0.01043,	0.00000,		
0.8622,	0.07928,	0.990,	0.0773,	0.00,	0.01046,	0.00000,		
0.8422,	0.07988,	0.967,	0.0774,	0.00,	0.01054,	0.00000,		
0.8481,	0.08048,	0.973,	0.0775,	0.00,	0.01062,	0.00000,		
0.7903,	0.08108,	0.907,	0.0775,	0.00,	0.01070,	0.00000,		
0.7362,	0.08138,	0.845,	0.0776,	0.00,	0.01074,	0.00000,		
0.7161,	0.08168,	0.822,	0.0776,	0.00,	0.01078,	0.00000,		
0.7067,	0.08198,	0.811,	0.0777,	0.00,	0.01082,	0.00000,		
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0.5654,	0.08559,	0.649,	0.0782,	0.00,	0.01130,	0.00000,		
0.5677,	0.08589,	0.652,	0.0782,	0.00,	0.01134,	0.00000,		
0.5501,	0.08619,	0.631,	0.0783,	0.00,	0.01138,	0.00000,		
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0.5324,	0.08829,	0.611,	0.0785,	0.00,	0.01165,	0.00000,		
0.5265,	0.08889,	0.604,	0.0786,	0.00,	0.01173,	0.00000,		
0.5465,	0.08949,	0.627,	0.0787,	0.00,	0.01181,	0.00000,		
0.5206,	0.08979,	0.598,	0.0787,	0.00,	0.01185,	0.00000,		
0.5053,	0.09009,	0.580,	0.0788,	0.00,	0.01189,	0.00000,		
0.4853,	0.09069,	0.557,	0.0788,	0.00,	0.01197,	0.00000,		

0.4488,	0.09159,	0.515,	0.0789,	0.00,	0.01209,	0.00000,		
0.4358,	0.09249,	0.500,	0.0790,	0.00,	0.01221,	0.00000,		
0.4111,	0.09309,	0.473,	0.0790,	0.00,	0.01225,	0.00000,		

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Laminated Matrix Composites

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LAMINATED MATRIX COMPOSITES

OBJECTIVE

The objective of this project is to fabricate two types of ceramic composite samples: (1) "toothpick"-like samples consisting of multiple thin (0.25 μm) layers of alternating carbon and silicon carbide deposited onto 2" long SiC monofilament fibers, and (2) disk-shaped samples containing a laminated C+SiC matrix where the reinforcement material is carbon particulate. The latter sample type has several variants, i.e., differing layer thicknesses and two of the samples types are to have a SiC, rather than the laminated, matrix. One of the SiC matrix samples has a carbon interface coating while the other has no interface coating.

PROCEDURE AND EQUIPMENT

Task I- "Toothpick" Samples:

The chemical vapor deposition experiments were conducted in a water-cooled, resistively heated vertical furnace pictured in Figure 1. This system has a single reagent gas entry line that allows the connection of a multitude of different reagent sources. For these particular sources, four gas lines were connected to the injector. All four gas lines were metered with mass flow controllers calibrated to the individual gases. The gas line entered the furnace through a water-cooled gas injector at the base of the furnace. The gas injector served as an interface with the heated reaction chamber and provides thermal protection against premature decomposition of the gases. Another gas line feeds argon outside the reaction chamber to prevent an accumulation of reagents outside the reaction chamber, such as on the heating element or stainless steel furnace walls.

The reaction chamber is actually a three piece object constructed of machined graphite. The lower portion is an inverted cone with a small cylindrical nozzle on its base that connects with the gas injector. A tight seal is ensured there by the mounting the gas injector on springs external to the furnace. Above the inlet nozzle is a graphite gas diffuser plate set mid-way up the cone. This supports the samples to be coated and works to manipulate incoming gases into desired directions. In these experiments, the diffuser plate had a large central hole over which the similarly-pierced carbon felt sample holder (see Figure 2) was placed and a multitude of smaller holes radiating outward. The diffuser plate was held in position with carbon cement. Over this cone was a straight cylinder which serves to keep the reagent gases from depositing on the heating elements or attacking the stainless steel walls of the furnace; the cone and cylinder are merely screwed together with integral threading. Above the cylinder was the final piece of the reaction chamber, a thick disk, which directed the exhaust gases to the scrubber. The reaction chamber is capped with a centrally pierced lid that allows the introduction of a thermocouple or, in these experiments, visual inspection of the samples during the run.

Temperature control of the furnace was achieved via an optical pyrometer which was linked directly to the power control unit of the furnace. The pyrometer sighted on the outside surface of the graphite reaction chamber. Power is fed into the furnace to the graphite heating element via two large, water-cooled cables at the base of the furnace.

Propylene and argon, the reagent and diluent for the deposition of graphite respectively, are simply controlled by the valves on their high pressure storage tanks, their mass flow controllers, and an on-off valve that isolated them from the gas line headed for the injector. The addition of the on-off valve allowed not only selective leak testing of portions of the line prior to an experiment but provided protection against decomposition products of methyltrichlorosilane (MTS) which include hydrogen chloride. The MTS was in a "bubbler" where the hydrogen carrier gas was injected into the base of the bubbler. Valves were included on both the carrier gas injection line and the outflow line to allow isolation of the MTS from the external atmosphere when it was not in use and to maintain MTS at its operating pressure if, as in these experiments, different pressures were used on each reagent gas. Connecting to the MTS outflow line was the hydrogen diluent line, which mixed and diluted the MTS vapor as it moved toward the furnace. The MTS portion of the gas system was isolated from the injection line with an on-off valve and had access to a relief line that connected directly to the scrubber. The MTS is normally stored under argon at atmospheric pressure to prevent infiltration by atmospheric gases between experiments and for these reduced pressure runs had to be bled down without filling the reaction chamber with this silicon carbide forming material. The relief line enabled that operation to be conducted safely and without contamination of the furnace. Figure 1 is a representation of the furnace.

The sample holder consisted of a simple 30-35 mm flat torus formed out of carbon felt with a razor blade. The hole in its center fit around the central hole of the diffuser plate in the reaction chamber. The sample holder in practice had an octagonal perimeter and a square center hole. The holder, as taken from the roll of felt, was about 4-5 mm thick. Sample fibers were imbedded in the holder oriented approximately vertically. In practice the difficulty of aligning these fibers perfectly vertically was extremely difficult, especially with the production experiments that embedded over ten fibers in the holder. Fibers with an outward tilt were noted to be more likely to aquire nodules, or anomalous deposits perpendicular to the shaft of the fiber, and thus later experiments were run with fibers intentionally leaning slightly inward, which seemed to reduce the amount of nodules that developed. Fibers were typically 6.35 cm (TPB-10) to 7.62 cm long (TPB-11, TPB-12) in production runs, though earlier condition-optimization experiments used fibers 5 cm to 15 cm long. Figure 2 represents the sample holder.

The series of condition-optimization experiments refined data on optimum flow rates, operating pressures, and flow periods. The production runs were all at 1200°C and all used pressures of 25 torr for the deposition of carbon and 300 torr for SiC deposition. This pressure for SiC deposition enhanced uniformity yet avoided conditions where pyrophoric exhaust products might form. The production runs also used a set flow rate of 25 standard cubic centimeters per minute (sccm) of propylene diluted with 975 sccm of argon to deposit carbon and 50 sccm of MTS and 950 sccm of diluent hydrogen to deposit silicon carbide. The initial production experiment (TPB-10) used 60 five-minute propylene and 60 three-minute MTS cycles, a total of 120 deposition cycles. As the accompanying photomicrographs demonstrate, this produced a coating that was slightly too thick. The second production experiment (TPB-11) used 50 four-minute propylene cycles and 50 one hundred and fifty second MTS cycles. TPB-12 ran 20 total cycles at TPB-10's conditions. The weight of uncoated fibers provided by Knolls Atomic Power Laboratory is .00047 g per centimeter of length.

RESULTS

The majority of micrographs taken are from the initial production experiment, TPB-10. This was used as a baseline for further production runs and data gleaned from photomicrographs of later experiments. Two sets of micrographs were made and thus different identification systems were used.

The first series of micrographs was used to quickly aquire data about the thickness of layers using fracture surfaces. Samples were cut with a razor blade and mounted on carbon felt for observing in a scanning electron microscope.

Figure 3 shows a 300X magnification micrograph of a top section of sample 8 from run TPB-10. It only demonstrates basic features comparable to other micrographs, namely the silicon carbide core monofilament and its core carbon monofilament, and the outer thickness of the deposited graphite and silicon carbide coating. As can be seen down its length, the finished fiber is very nodular. The delamination visible between the deposit and core fiber was due to the sectioning of the fiber by a razor blade. Figure 4 is of the side of the sample piece of sample 8 as in photo 1, but focuses on a nodule and a small one at that - most nodules are considerably larger than the diameter of the fiber.

Figure 5 is a 1000X micrograph of the top of a middle section of sample 8 from experiment TPB-10. It not only captures delamination (again due to the razor blade sectioning) but hints of the multi-layered structure of the deposit. Near the core monofilament substrate, this micrograph shows that the layers are very regular and smooth but within 9.5 μm there is a sharp transformation to an irregular layering. Individual layers appear to be about 0.4 μm to 0.9 μm thick in this micrograph. Figure 6 shows part of the rough layer seen in figure 5 that clearly demonstrates the layering of the sample. Layers in this micrograph appear to be about 0.35 μm thick judging from measurements of the width of the shading bands in the lower left corner of the micrograph rather than the sharply defined ridges in the center and upper right (which may include multiple layers).

Figure 7 is a view of the top of the top section of sample 16 at 1000X magnification. Like figure 5, it shows the transition from smooth deposition to rough deposition. In the lower right corner this micrograph captures an excellent example of fracture following the layers rather than transversing through them. Layers appear to be approximately 0.7 μm thick as measured near the center of the micrograph. Figure 8 is an end-on view of a middle section of sample 16. It fractured badly when cut, but demonstrates a tightly held interface layer on the monofilament and irregular outer deposit.

This first series of micrographs also demonstrated a variation in overall coating thickness that varied by position along the length of a sample. The top of sample 8 had an overall thickness of 49 to 53 μm, not counting the delaminated area. The middle of sample 8 had a coating thickness of 60 to 65 μm. The top of sample 16 had a thickness of 33 to 38 μm while its middle had a coating thickness of 50-55 μm. Therefore, the middle of the samples appears to be more heavily coated than the top.

The second series of micrographs were of samples from the three production runs. These samples were mounted in epoxy and polished. These micrographs are labeled as (sample)(position)(experiment). For example, micrograph 8M10 is a micrograph of the middle of sample 8 from experiment TPB-10.

The micrograph of 8M10 shown in figure 9 captures trends that are apparent in most micrographs of the second set. The core silicon carbide-carbon monofilament appears harder than the coating or surrounding epoxy matrix and rises above the surface of epoxy. The deposited layers start out circular near the monofilament and then there is a region where the layers are less circular, more irregular. The region near the substrate and the outermost deposit appear dark and smooth. Figure 10 is a magnification of the inner layers near the monofilament, taken in the lower left boxed-in area of figure 9. The layers near the monofilament appear to be about 0.5 μm thick. Figure 11 is of the upper boxed-in area of figure 9. It aims to capture part of the rough middle layer and the smooth outer region. Layering is visible, but harder to differentiate apparently because, for the most part, the silicon carbide layers are just very thin lines between thicker carbon layers. Figure 12 of 8M10 is a magnification of the boxed in area of figure 11. Individual layers are apparent here. For the region show in figure 12, the carbon layers appear to be about 0.3 μm thick but the thin silicon carbide layers appear to be only 0.05 μm.

Figure 13 is an overview of the middle of sample 16 of experiment TPB-10. Like figure 9, it shows the monofilament, a smooth inner coating near the monofilament, an irregular middle region, and a smooth outer region. Figure 14 is an overview of the middle of sample 28 from experiment TPB-10. It demonstrates features similar to figures 13 and 9. The hint of elongation from top to bottom is the result of the sample being mounted and polished at a slight angle.

Figure 15 is an overview of the bottom section of sample 28. While showing features similar to figures 14, 13, and 9, the coating is noticeably thinner than its predecessors. Figure 16 is of the bottom section of sample 28 of experiment TPB-10. It shows layering like figure 11 and the layers appear to be 0.23 μm thick. Figure 17 is a low magnification overview of 16B10. Figure 18 is a somewhat lightly exposed close-up of the layering of the interface (average layer thickness: 0.33 μm) and middle region (average layer thickness: 0.28 μm) as taken from the boxed-in area of figure 17. Figure 11 shows similar but better defined features.

Figure 19 is a low magnification overview of 15M12. The coating is only very close to the monofilament and does not demonstrate the usual smooth inner layers/rough middle region/smooth outer layers that previous overviews showed. Figure 20 is a magnification of the boxed-in area of figure 19 of experiment 12, the experiment where only 20 total layers were deposited (using the same deposition conditions as experiment 10). Figure 20 captures the entire thickness of the deposited coating as well as some epoxy mounting matrix (in the upper left corner). The monofilament is in the lower left corner. Note that the bright band immediately beside the monofilament is actually the well-illuminated side of the monofilament, not a deposited coating layer.

Figure 21 is a lower magnification overview of the middle of sample 11 of experiment 11. It differs from previous overview photos in that it does demonstrate a smooth interface but quickly falls into something between the usual rough middle region and smooth outer layer. It is also a rather thin coating compared to previous overall coating thicknesses. Figure 22 examines the boxed-in portion of figure 21. The bright object in the lower right corner is the monofilament. Figure 23, a magnification of the boxed-in portion of figure 22, shows the layering of this area (coating thickness: about 0.25 μm for carbon and .05 μm for silicon carbide). The layers are thinner than in previous figures, as expected for the lower cycle times than seen in TPB-10.

One of the notable features captured in figures 23, 22, 18, 16, 12, 11, and 10 are large white bands or grains. We believe the white areas to be silicon carbide. They are often much thicker than surrounding carbon layers and certainly thicker than the very thin silicon carbide layers.

Trends are apparent in the samples from experiment TPB-10. The first series of micrographs showed that the coating in the middle was thicker than at the top of the samples; this holds true in the second series of photographs as well: From experiment 10, the middle sections of the 3 samples (8, 16, 28) have overall thicknesses between 51.3 μm and 61.7 μm. The bottom of the samples are only 24.5 μm to 38 μm (from samples 16 and 28). The bottom sections are even thinner than the top as noted in the first series of micrographs. Experiment 11 shows a thinner midsection than experiment 10's samples; the middle of sample 11 has only about a 26 μm coating., but experiment 11 was run with shorter and fewer flow cycles than experiment 10. Experiment 12 used one sixth the number of flow cycles than experiment 10. Thus, as expected, the middle section of sample 15 from experiment 12 was one sixth as thick as for samples from experiment 10 (8.3 μm to 10 μm).

Beyond microscopic studies of deposition microstructures, it was possible to study weight gains of individual samples. The samples, as previously noted, were mounted in a rough circle on a piece of carbon felt. As figure 2 shows, the felt had an orientation notch. This notch served to indicate a starting point for the numbering of samples in an experiment, which was always in a clockwise manner from the notch which itself was always at the "top" of the holder. Samples in a run were thus tracked from mounting to removal and could be weighed before and after an experiment was completed. Long duration experiments (TPB-10 and -11) often were weighed after a run with the loss of their bottom 6 mm or so of length. This loss was due to the solidification of the felt with carbon and silicon carbide and resultant bonding to the embedded samples. During removal, the bottom portions simply snapped off in the felt in many cases.

Weight gains in TPB-11 were notably lower than those of TPB-10, as was expected. It should be noted experiment TPB-10 produced samples that had far more nodular external formations than TPB-11, resulting in an upwardly skewed average weight gain as shown in tables 1 and 2. Experiment TPB-12's average weight gain was approximately one-fifth that of TPB-11, per tables 2 and 3. This in turn shows an approximately linear relationship between the number of deposition cycles and weight gains (noting that TPB-11 and TPB-12 only had slightly different deposition times for either type of layer).

FIGURES

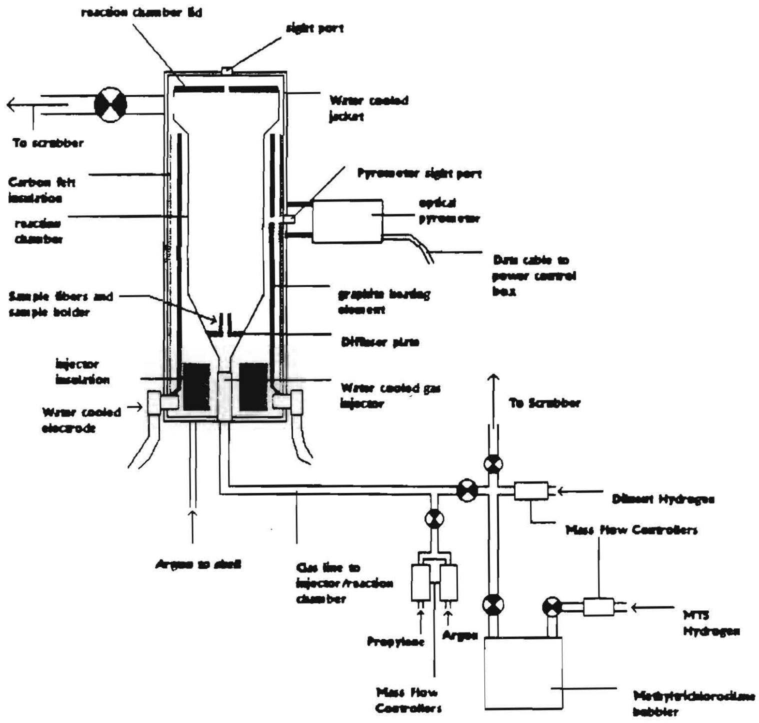

Figure 1: The CVD furnace and reagent delivery system.

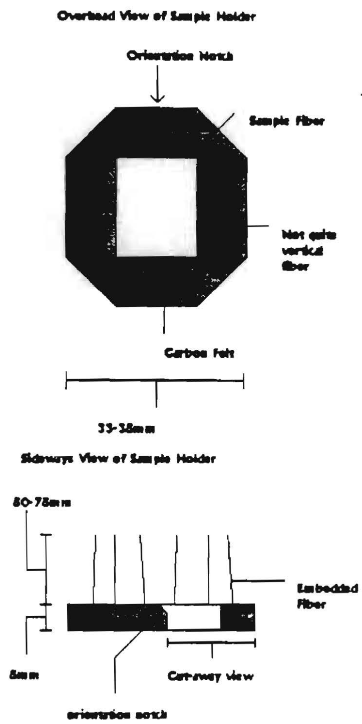

Figure 2: The sample holder, overhead and sideways views.

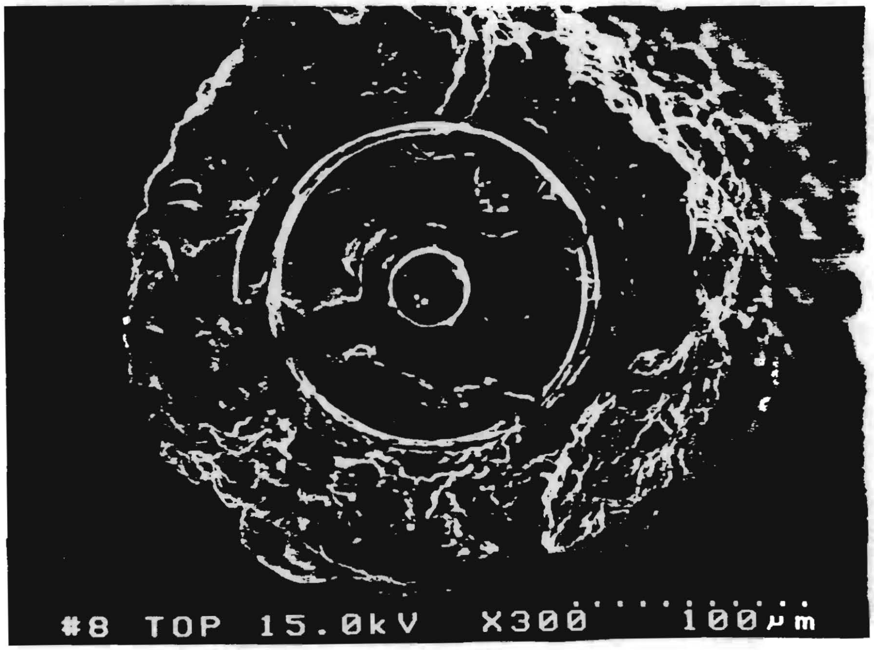

Figure 3: Top of sample from experiment TPB-10

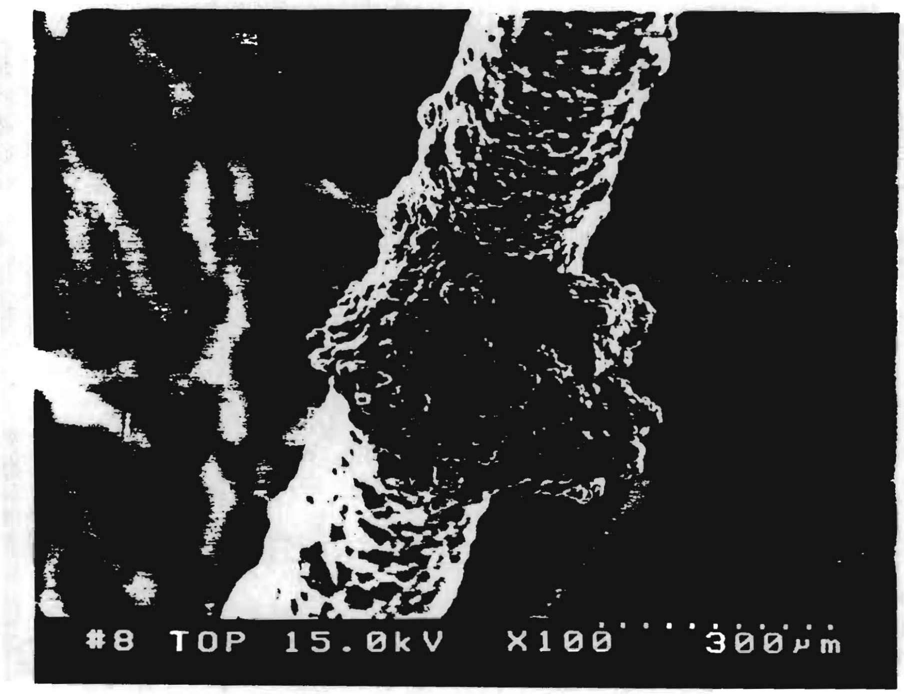

Figure 4: Top of sample 8, experiment TPB-10, side view.

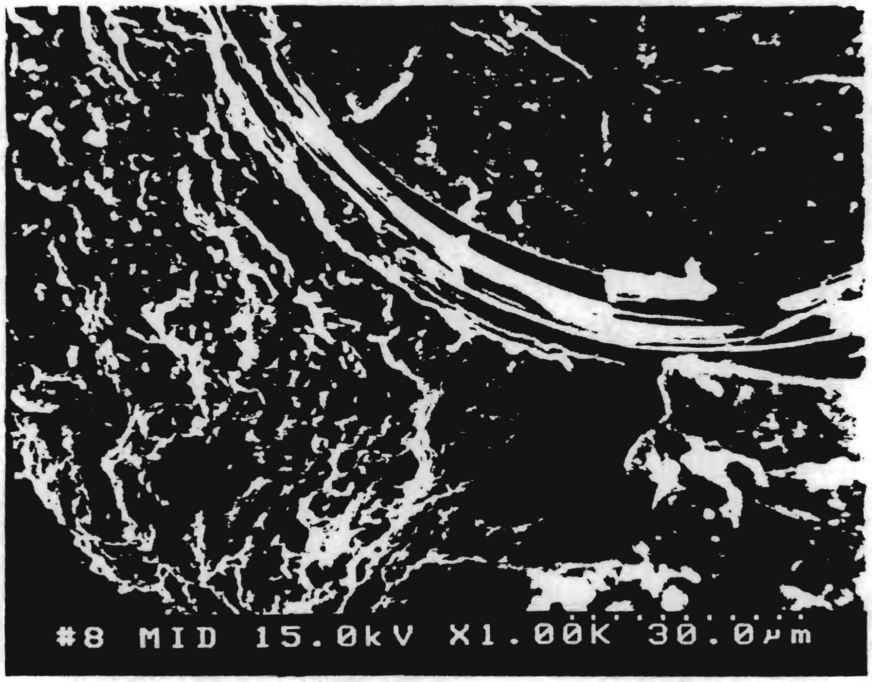

Figure 5: Middle section of sample, experiment TPB-10.

Figure 6: Middle section of sample 8, experiment TPB-10.

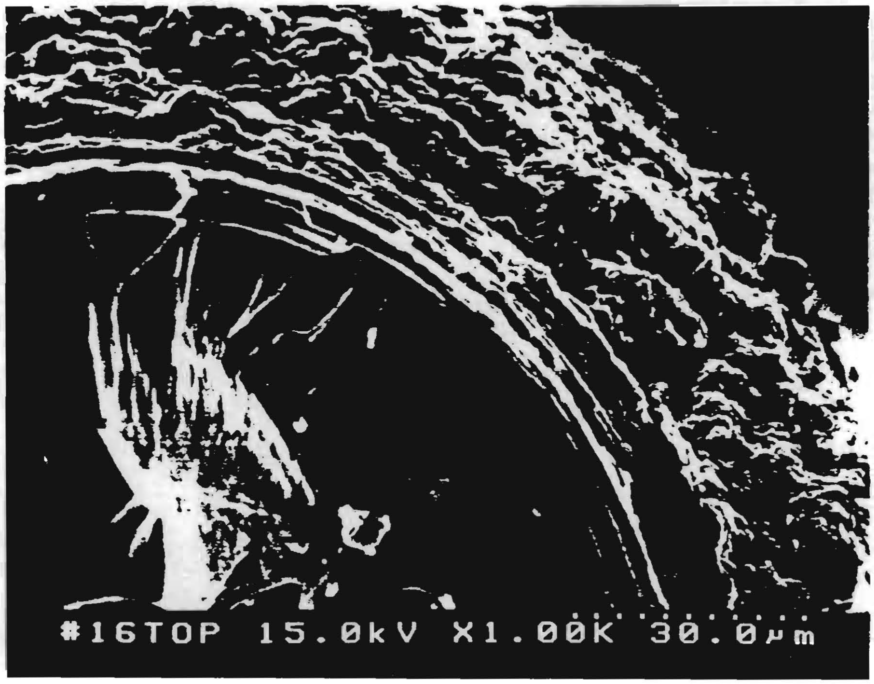

Figure 7: Top of sample 16, experiment TPB-10.

Figure 8: Middle section of sample 16, experiment TPB-10.

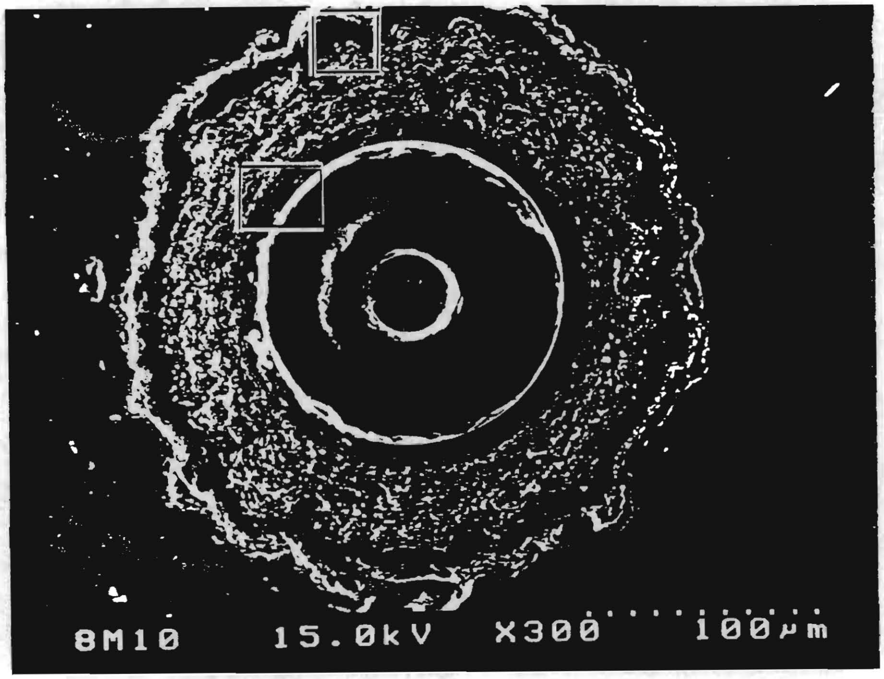

Figure 9: Middle section of sample 8, experiment TPB-10, first micrograph of second series. Overview.

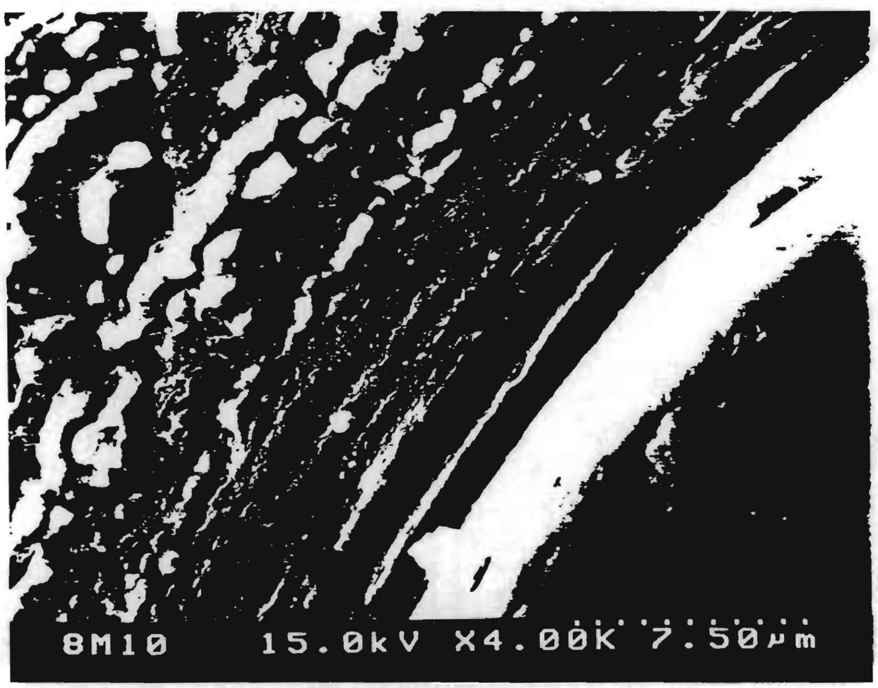

Figure 10: Middle section of sample 8, experiment TPB-10.

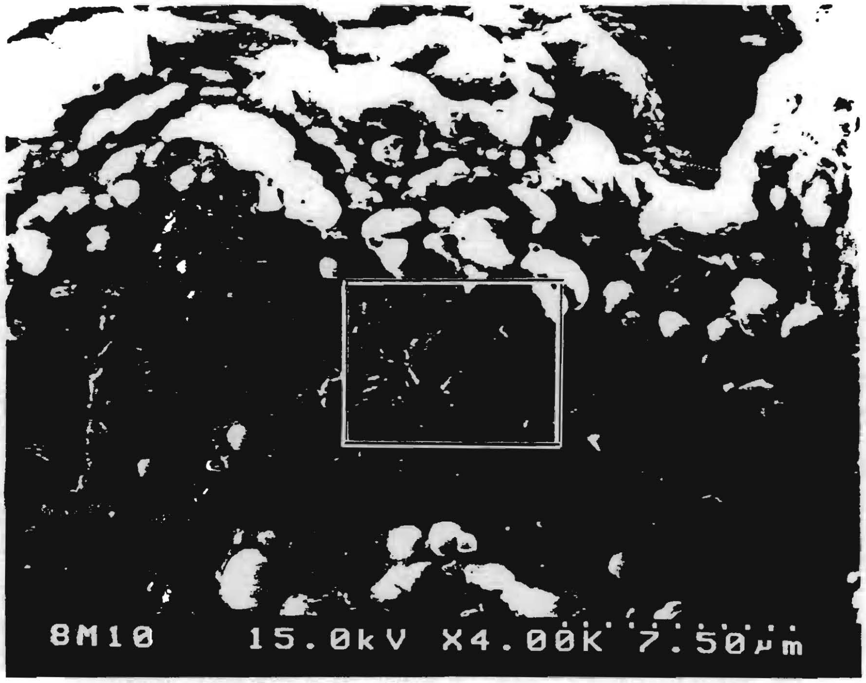

Figure 11: Middle section of sample 8, experiment TPB-10.

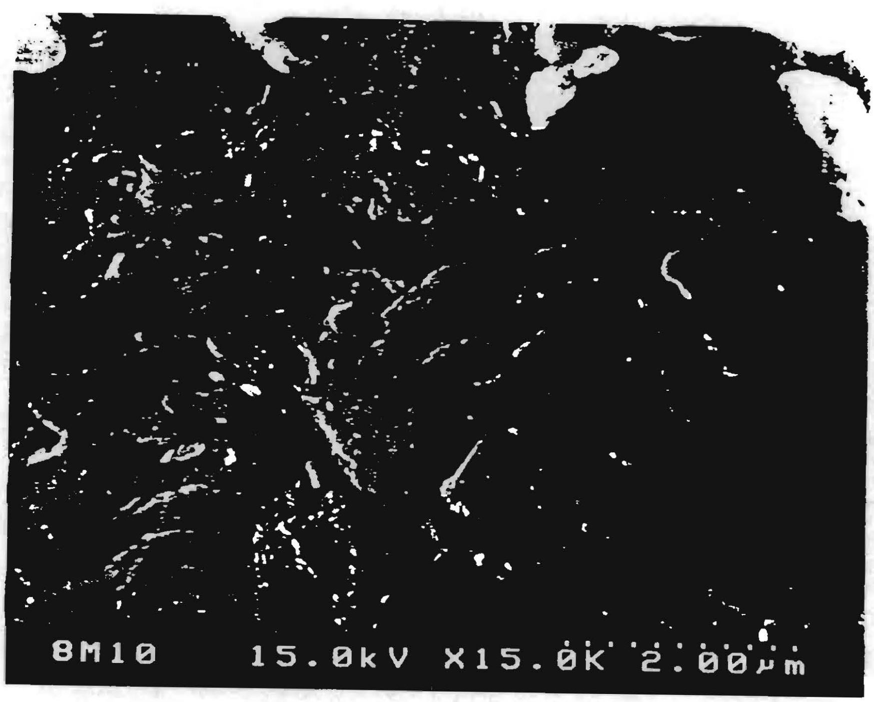

Figure 12: Middle section of sample 8, experiment TPB-10.

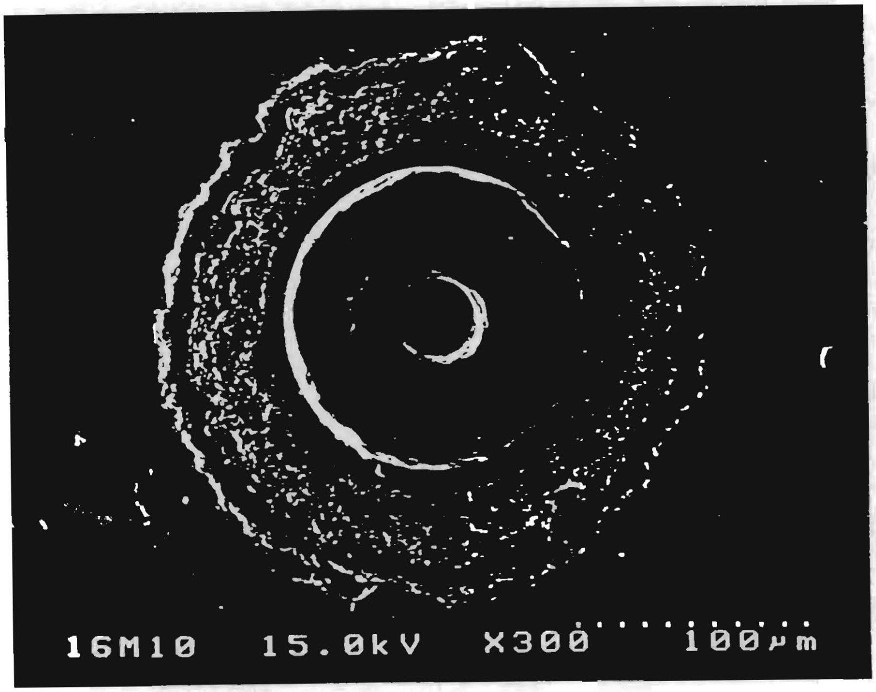

Figure 13: Middle section of sample 16, experiment TPB-10, overview.

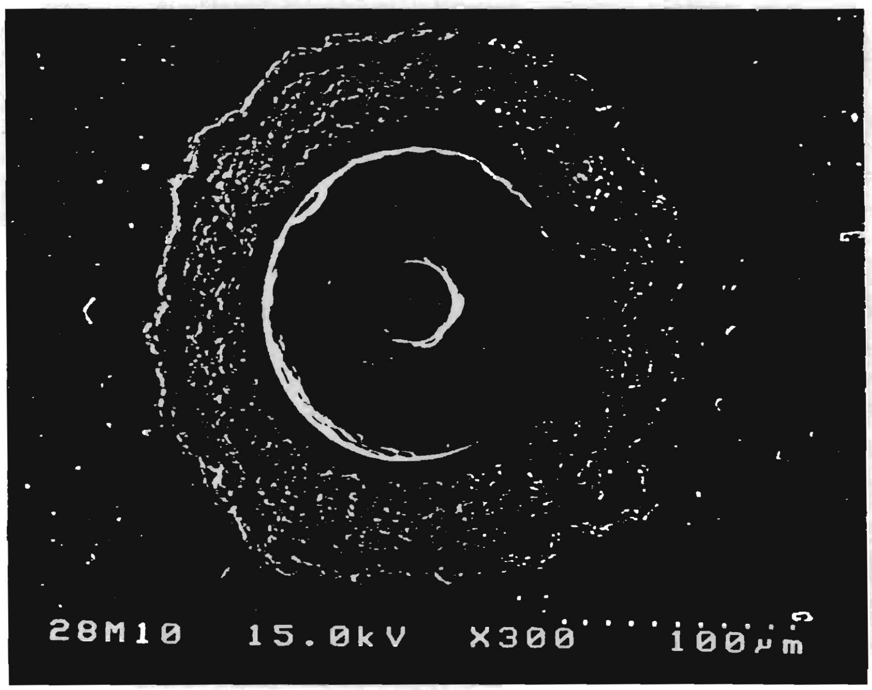

Figure 14: Middle section of sample 28, experiment TPB-10, overview.

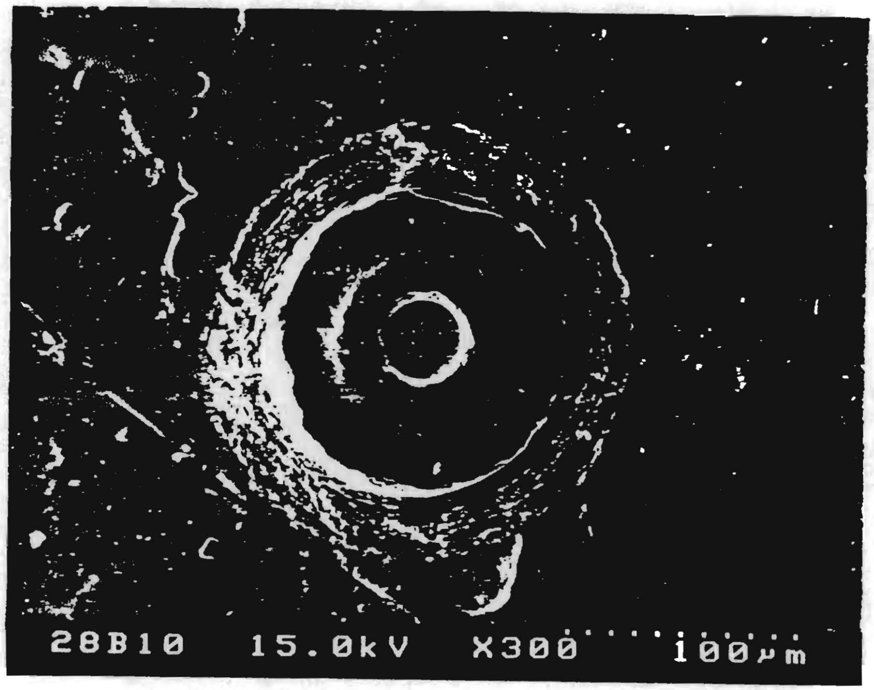

Figure 15: Overview of the bottom section of sample 28 of experiment TPB-10.

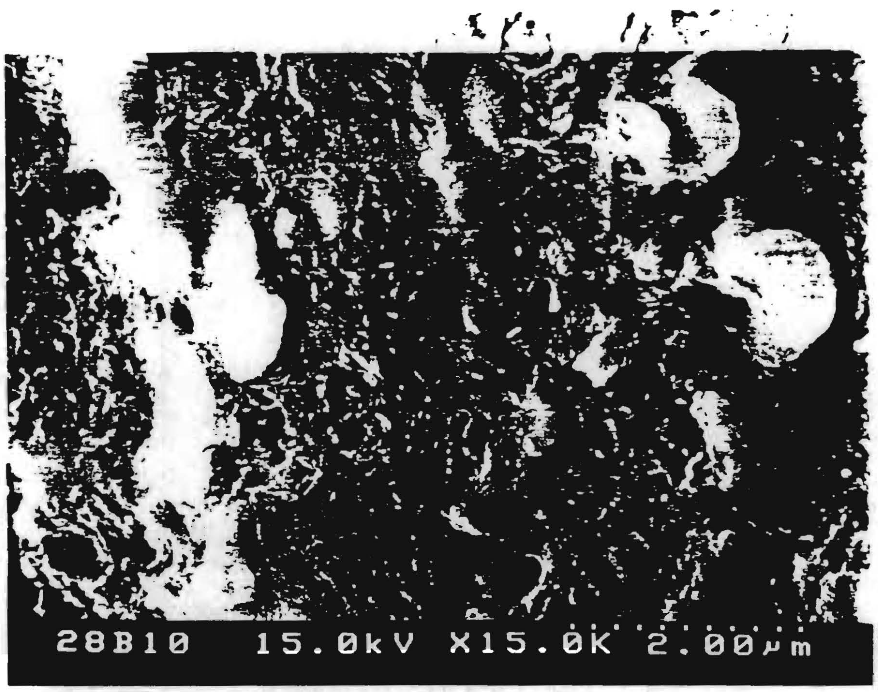

Figure 16: Bottom section of sample 28 of experiment TPB-10.

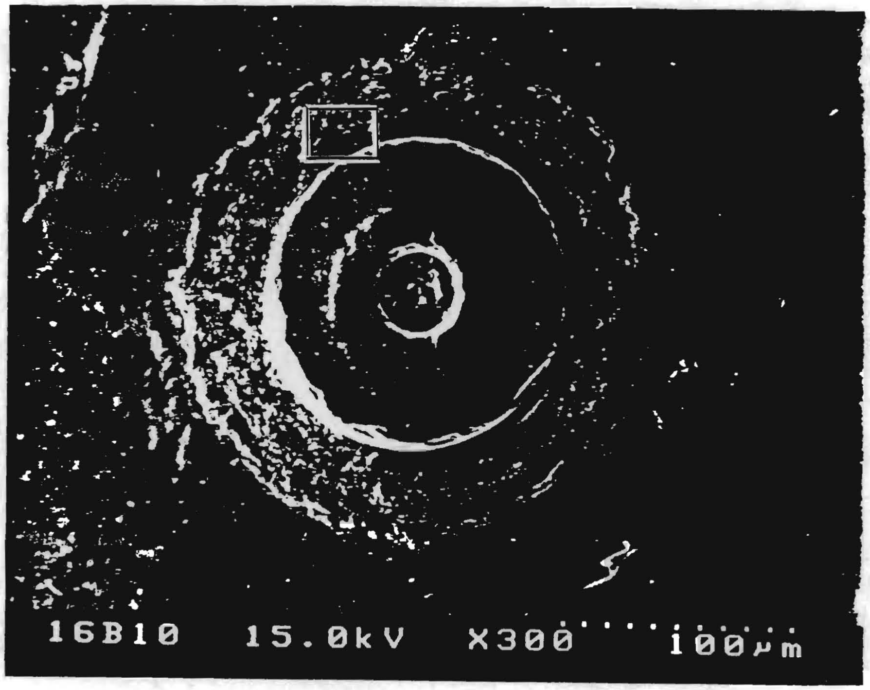

Figure 17: Bottom section of sample 16, experiment TPB-10, overview.

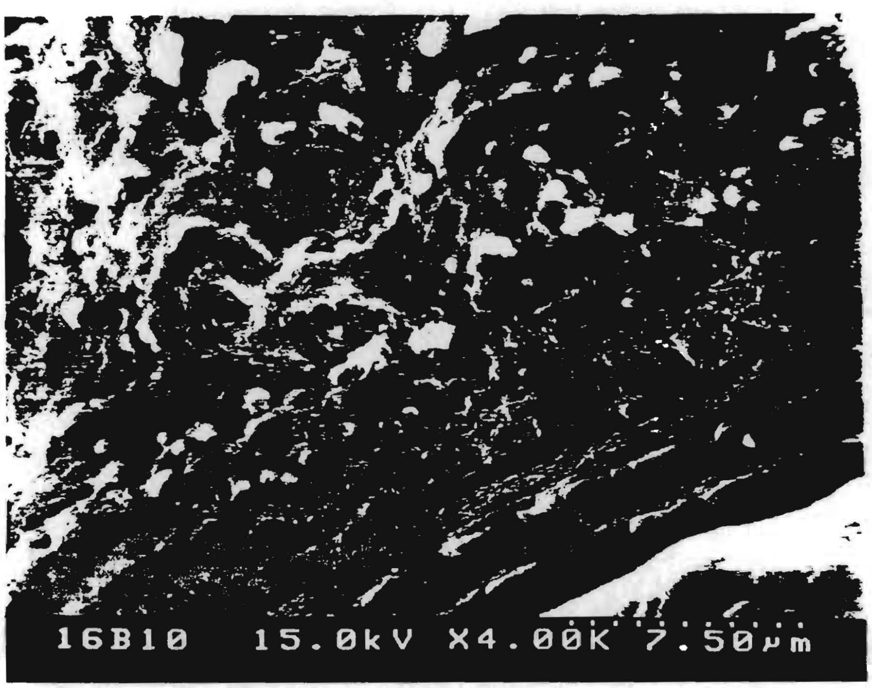

Figure 18: Bottom section of sample 16, experiment TPB-10.

Figure 19: Middle section of sample 15, experiment 12, overview.

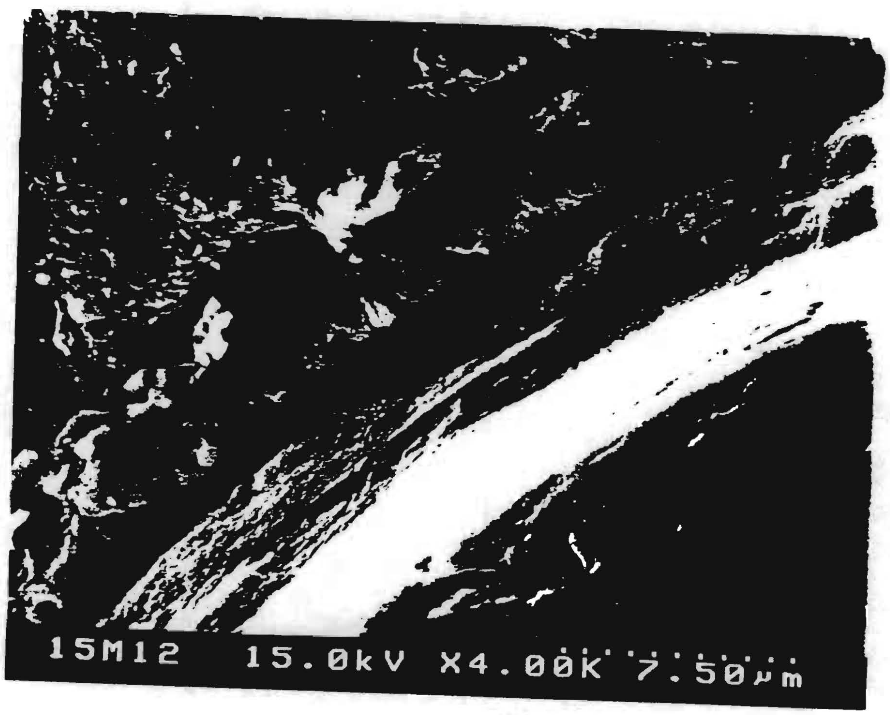

Figure 20: Middle section of sample 15, experiment TPB-12.

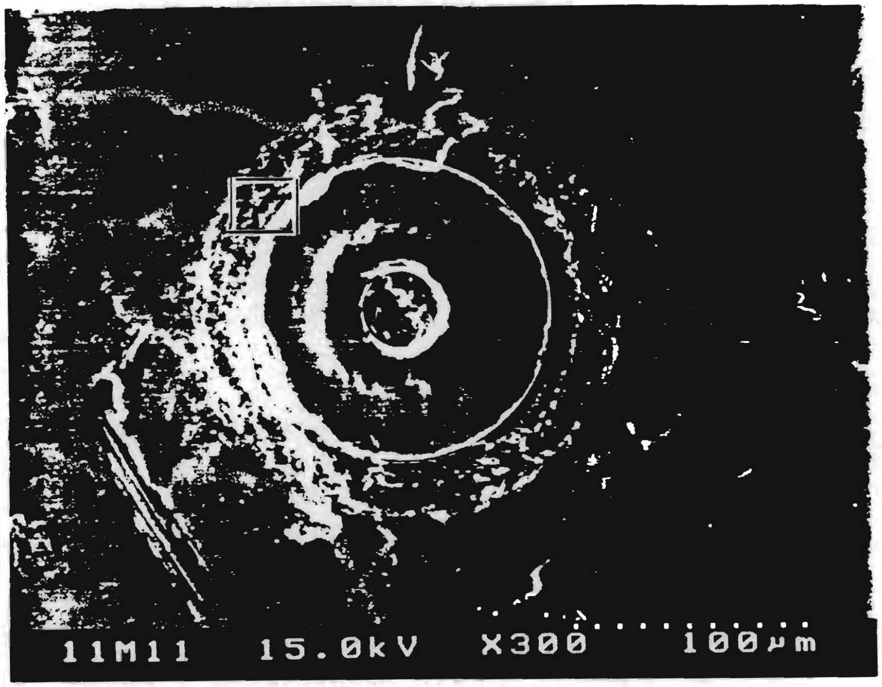

Figure 21: Middle section of sample 11, experiment TPB-11, overview.

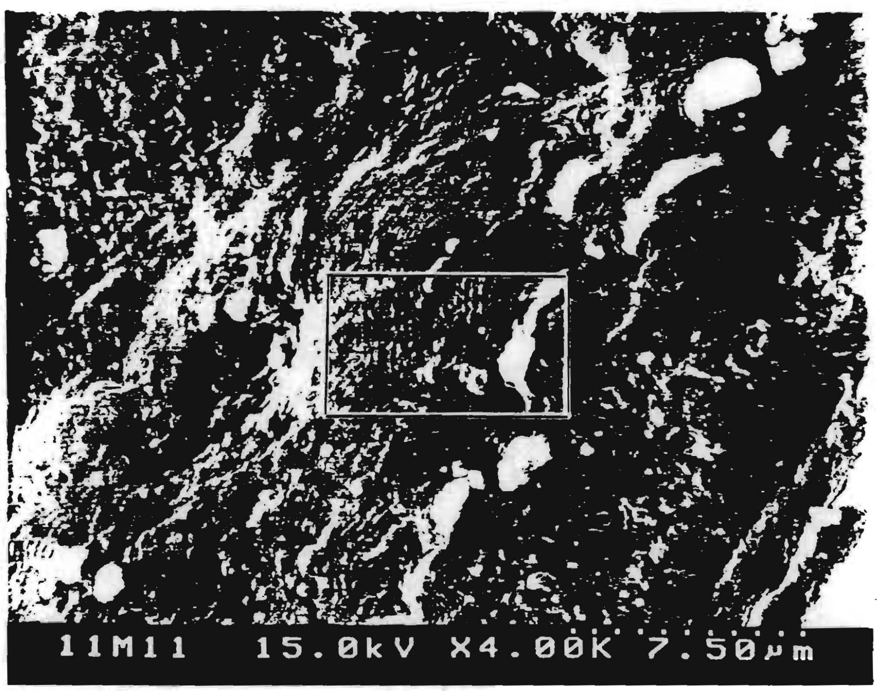

Figure 22: Middle section of sample 11, experiment TPB-11.

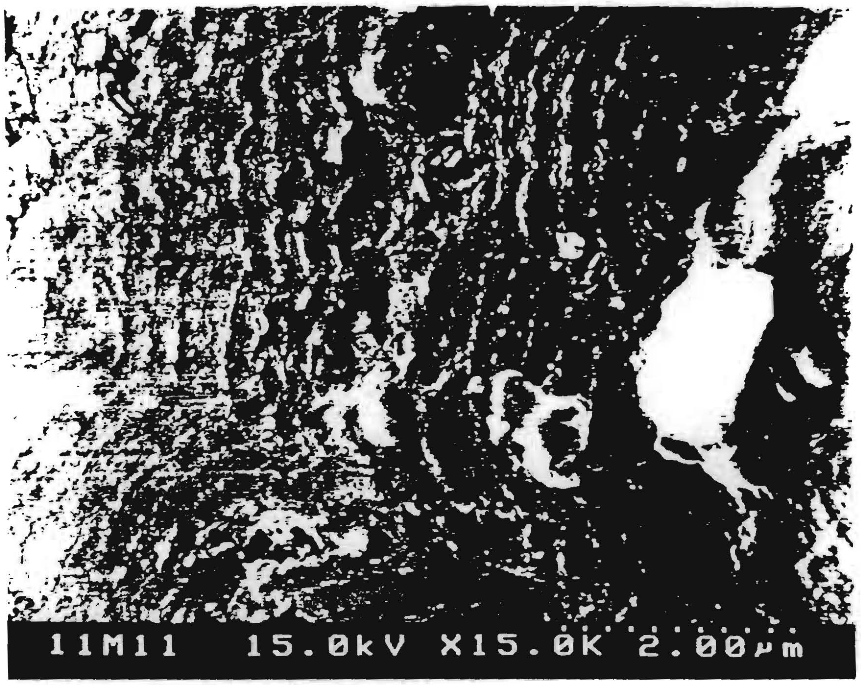

Figure 23: Middle section of sample 11, experiment TPB-11.

TABLES

EXPERIMENT TPB-10

Sample	Init Wt	Final Wt	Loss	Nodules
1	0.0029	0.0112	y	h
2	0.0033	0.0079	n	h
3	0.0029	0.0064	y	m
4	0.003	0.0062	y	l
5	0.003	0.0111	y	h
6	0.0031	0.0077	y	m
7	0.0031	0.0097	y	h
8	0.0031	0.0081	y	h
9	0.0032	0.0065	y	m
10	0.0031	0.0076	y	m
11	0.0029	0.0071	y	m
12	0.0031	0.01	y	h
13	0.0033	0.0067	y	l
14	0.0029	0.0087	n	h
15	0.0031	0.0072	y	m
16	0.0035	0.0065	y	m
17	0.0029	0.0086	y	h
18	0.0029	0.0079	y	h
19	0.003	0.0124	y	h
20	0.0031	0.0062	y	l
21	0.0029	0.0067	y	l
22	0.0027	0.0065	y	m
23	0.0031	0.0107	y	h
24	0.003	0.0065	y	l
25	0.0031	0.0087	y	h
26	0.0029	0.0062	y	m
27	0.0031	0.0116	y	h
28	0.0032	0.006	y	m
29	0.0032	0.0058	y	m
30	0.0034	0.0054	y	l
31	0.0032	0.0059	y	m
32	0.0031	0.0068	y	m
average	0.003072	0.007828		
avg. gain		0.004756		

Loss is a yes/no field for whether or not a portion of the bottom of the sample was broken off during removal from the carbon felt holder.

Nodules describes roughly how much nodular development a sample developed on its length: (n) none, (l) light, (m) moderate, (h) heavy

Table 1: Deposition data from experiment TPB-10

EXPERIMENT TPB-11

Sample	Init Wt	Final Wt	Loss	Nodules
1	0.0037	0.0057	n	n
2	0.0037	0.0051	y	n
3	0.0036	0.0054	n	n
4	0.0036	0.0059	n	n
5	0.0034	0.0046	y	n
6	0.0034	0.0051	y	n
7	0.0037	0.0061	n	n
8	0.0035	0.0059	n	n
9	0.0034	0.0047	y	n
10	0.0038	0.0064	y	m
11	0.0039	0.0051	y	n
12	0.0037	0.0061	y	n
13	0.0037	0.0054	y	n
14	0.0037	0.006	y	n
15	0.0037	0.0056	y	n
16	0.0038	0.0054	y	n
17	0.0036	0.005	y	n
18	0.0036	0.0065	y	m
19	0.0035	0.0054	n	n
20	0.0036	0.0073	n	m
21	0.0036	0.0063	y	l
22	0.0038	0.0073	n	m
23	0.0034	0.006	n	n
24	0.0036	0.0056	n	n
25	0.0037	0.0075	n	m
26	0.0038	0.0058	y	n
27	0.0036	0.0048	n	n
28	0.0036	0.0048	n	n
29	0.0035	0.0066	n	m
30	0.0035	0.005	n	n
31	0.0035	0.0076	n	m
32	0.0035	0.0072	n	m
33	0.0035	0.0081	n	h
34	0.0036	0.0057	n	n
average	0.003612	0.005912		
avg. gain		0.0023		

Table 2: Deposition data from experiment TPB-11.

EXPERIMENT TPB-12

Sample	Init Wt	Final Wt	Loss	Nodules
1	0.0037	0.0041	n	n
2	0.0038	0.0044	n	n
3	0.0036	0.0042	n	n
4	0.0036	0.0039	n	n
5	0.0036	0.0041	n	n
6	0.0037	0.004	n	n
7	0.0036	0.004	n	n
8	0.0035	0.0042	n	n
9	0.0036	0.0039	n	n
10	0.0037	0.0041	n	n
11	0.0036	0.004	n	n
12	0.0036	0.0041	n	n
13	0.0036	0.004	n	n
14	0.0037	0.0041	n	n
15	0.0037	0.0046	n	n
average	0.00364	0.004113		
avg. gain		0.000473		

Table 3: Deposition data from experiment TPB-12.

E25-A21-5
Formerly A-5398

LAMINATED MATRIX COMPOSITES

Monthly Progress Report

Period Covered June 15, 1997 to October 14, 1997

Prepared for:

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October 15, 1997

LAMINATED MATRIX COMPOSITES

Objective

The objective of this project is to fabricate two types of ceramic composite samples: 1) "toothpick"-like samples consisting of multiple thin ($0.25\,\mu m$) layers of alternating carbon and silicon carbide deposited onto 2" long SiC monofilament fibers, and 2) disk-shaped samples containing a laminated C+SiC matrix where the reinforcement is carbon particles. Fabrication of the first type of samples has been completed and the samples shipped. Fabrication of the disk samples is in progress. These latter samples are of several types, i.e. differing layer thicknesses, and two of the samples are to have a SiC, rather than the laminated matrix. One of the SiC matrix samples has a carbon interface coating, while the other has no interface coating.

Accomplishments

Our effort is currently focused on fabrication of the disk-shaped composite samples. To date, fabrication of five of the seven types of disk composites has been completed. These samples and the run conditions used are identified in Table I. Note that two samples (instead of the one required) were prepared from the "all SiC matrix" type material. The six successful runs are summarized on the next page.

Table I. Run Conditions for Disk Composites

Run Type	all SiC	all SiC	C int, SiC	Equal B	Equal A	Equal C
Run #	K-1	K-2	K-3	K-4	K-5	K-6
C cycle time (min)	n/a	n/a	1@10min	3	1.5	4.5
SiC cycle time (min)	n/a	n/a	completion	6	3	9
propylene flow (sccm)	n/a	n/a	200	200	200	200
C-diluent (H2) flow (sccm)	n/a	n/a	200	200	200	200
target MTS flow (sccm)	50	100	50	50	50	50
actual MTS flow (sccm)	53.0	96.2	48.1	42.2	42.5	43.5
MTS-diluent (H2) flow (sccm)	500	1000	500	500	500	500
total run time	8 hrs	7h, 45 m	11h, 10m	18h, 18m	17h, 19.5m	15h, 45m
# C layers	0	0	1	122	231	70
#SiC layers	1	1	1	122	231	70
final back pressure (psi)	0.1	9.2	10.0	9.5	10.7	9.5
average bottom temp (C)	1100	1100	1100	930	930	930

K-1 was an all SiC run. However, it was terminated early due to a lack of increase in back pressure. The total run time was 8 hours. Despite the fact that the run was terminated early, the sample had a relatively low porosity of 17%.

K-2 was another all SiC run. However, the flow rates of the MTS and the H_2 diluent were doubled, with the attempt at making the run time shorter. The run time was terminated at a back pressure of 9.2 psi. The reason for the early termination was the increase in system back pressure (above the preform) from 795 to 990 torr in the time span of only 8 minutes. The porosity was again 17%.

K-3 was a SiC run, with a single C interface layer between the reinforcement particles and the matrix. The temperature of the preform during the interface deposition was $930^{o}C$. During the SiC deposition, the temperature was increased to $1100^{o}C$.

K-4 was the first successful laminated matrix run. The target layer thickness was 0.30 μm, as specified by the equal B conditions.

K-5 was the equal A, or 0.15 μm layer thickness, run.

K-6 was the equal C, or 0.45 μm layer thickness run. The back pressure at termination was 9.5 psi. The reason this run was stopped early was because of the continuous and rapid increase in system pressure, which was 816 torr upon termination.

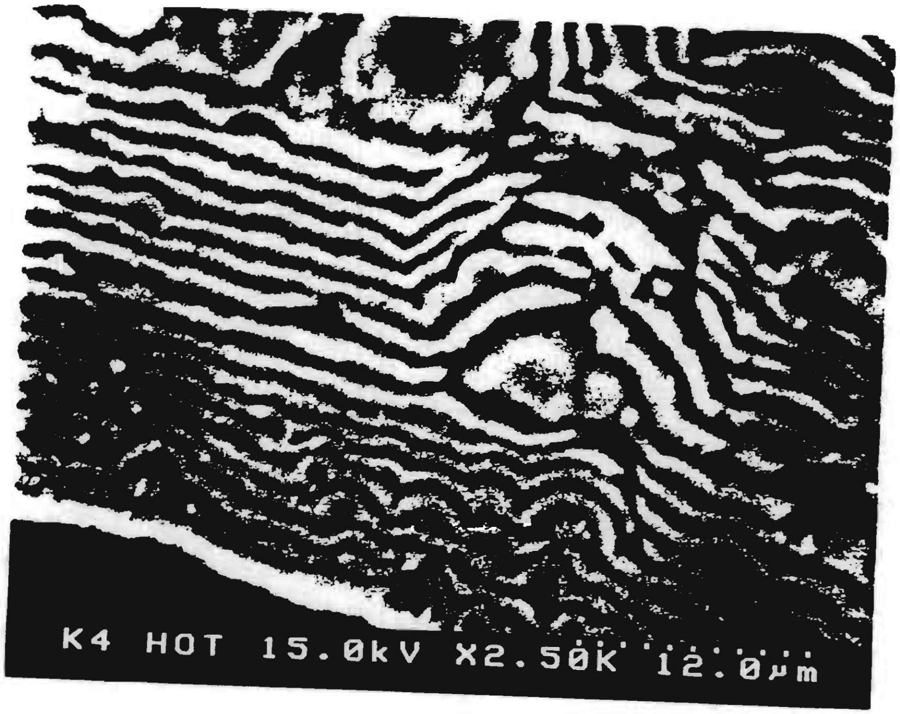
A polished cross section of Sample K-4 was thoroughly examined via SEM. Micrographs were taken in four areas, from the hot to the cold side of the sample. In each of the four areas, three pictures were taken. The first area was the region closest to the reinforcement particle. The second area was the region closest to the pore that was associated with the periphery of the coated particle. The final area was the area in between these two features. The information below provides further identification of each micrograph; a copy of each is attached. Note the desired layered microstructure was achieved. The layers are rather uniform in thickness and continuous. There is very little debris evident in the micrographs. Detailed measurements of layer thickness remain to be made.

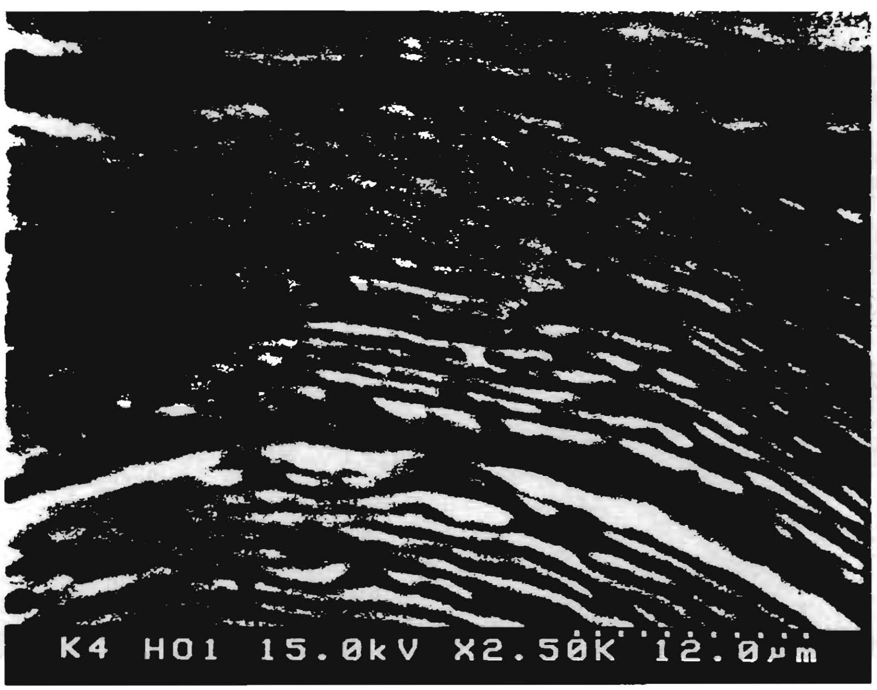
HOT region: Photos 1-3. Photo1 is the area closest to the reinforcement particle. The particle can be seen in the lower left hand corner. Photo 2 is the area between two particles. The dark line near the top of this micrograph is the region between two reinforcement particles. Photo 3 is from the area in between the two regions.

WARM region. Photos 4-6: Photo 4 is the area closest to the reinforcement particle. The particle can be seen in the lower left hand corner. Photo 6 is the area closest to the pore.. Photo 5 is the area in between the two regions. In all photos, the particle-to-pore area goes from left to right.

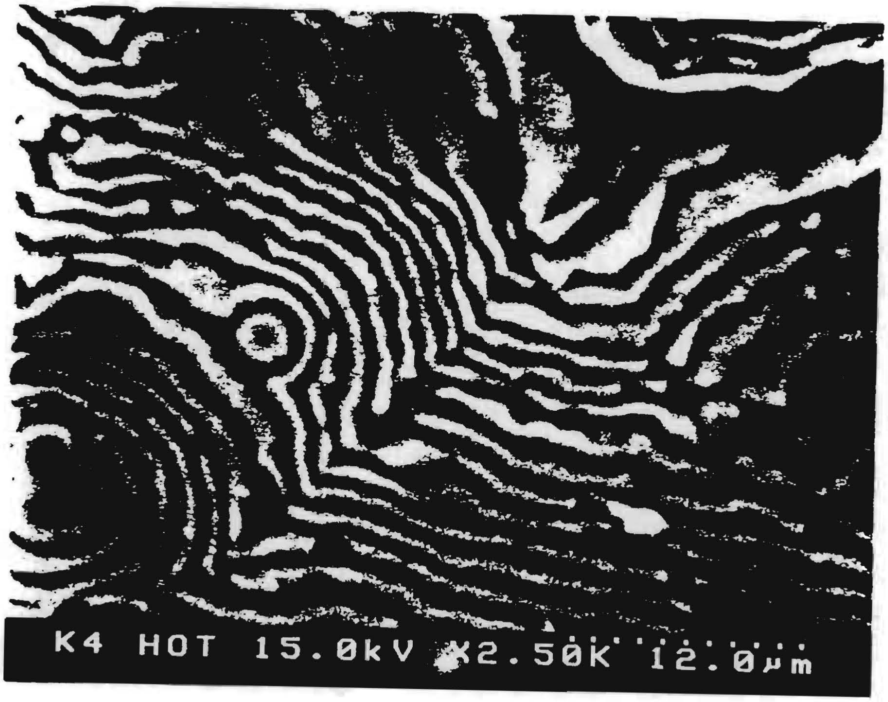
COOL region. Photos 7-9. Photo 7 is the region closest to the sphere. The particle can be seen at the bottom of the photo. Photo 8 is the region closest to the pore. The pore can be seen in the upper left hand corner of the photo. Photo 9 is the area between photos 7 and 8.

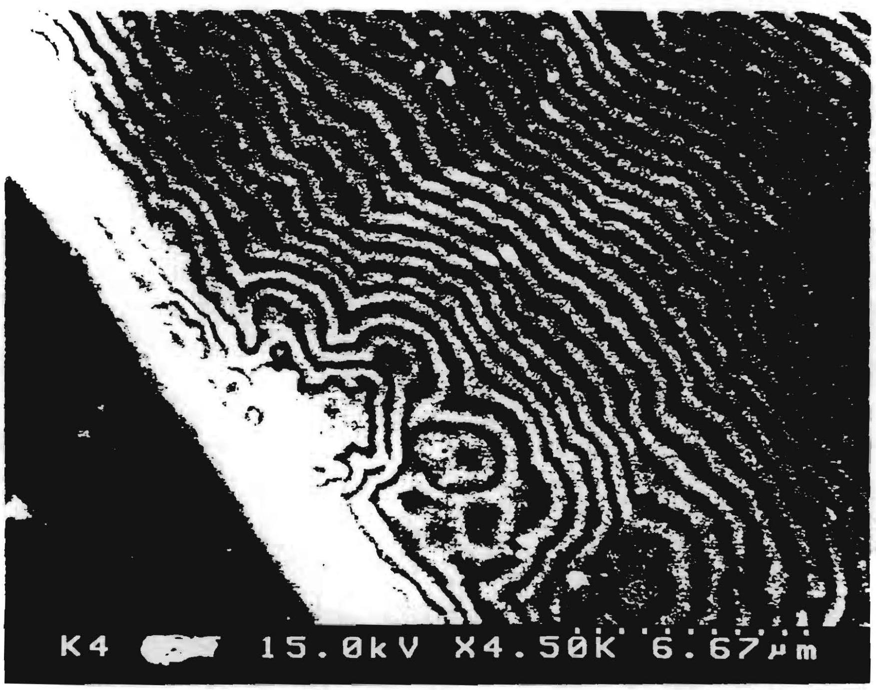
COLD region. Photos 10-12. Photo 10 is closest to the particle, which can be seen in the lower left hand region. Photo 11 is closest to the particle. Photo 12 is the area in between the two regions.



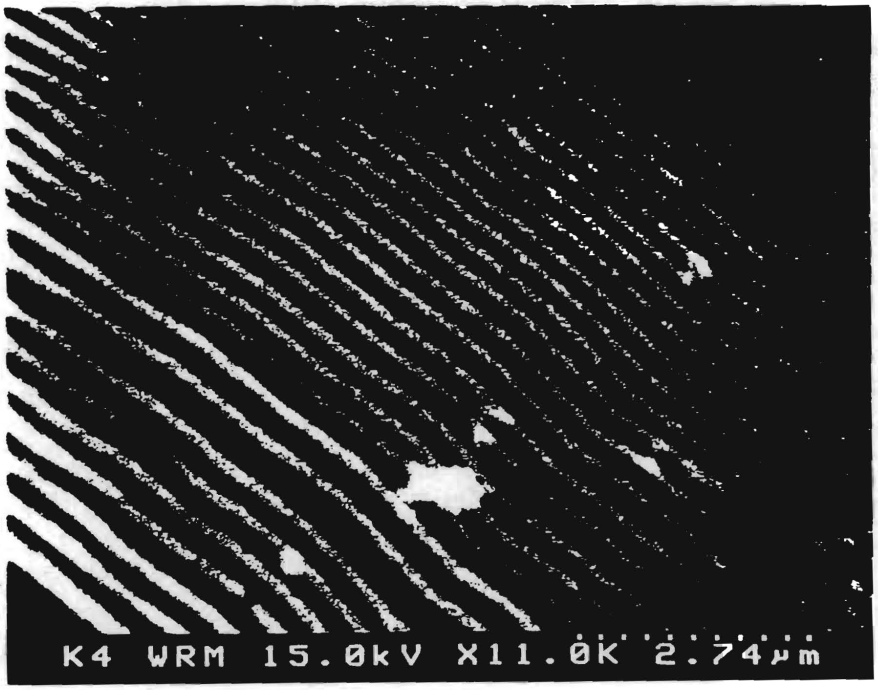


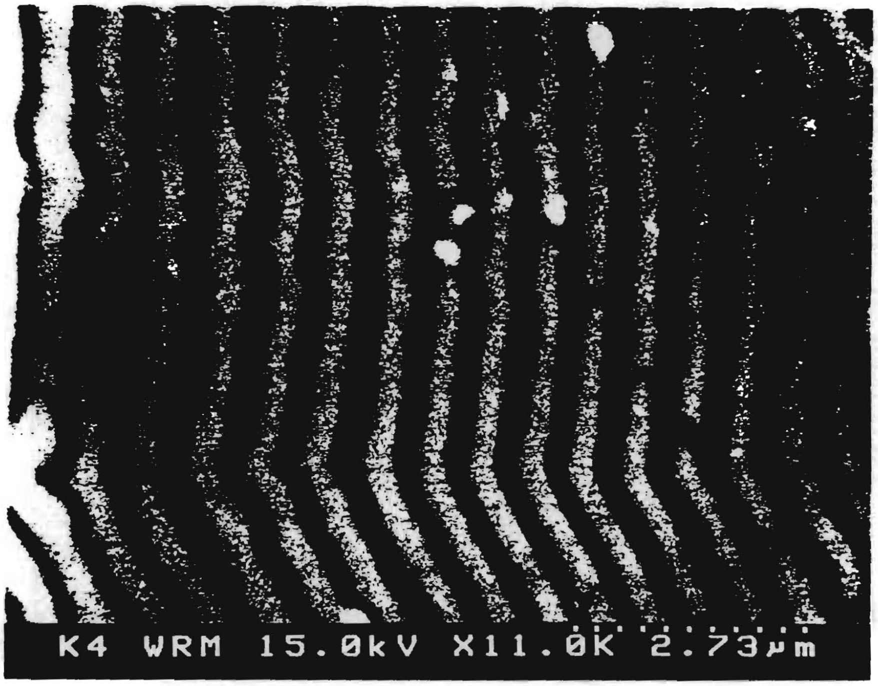
Sample K-4, Micrographs Nos. 1 and 2



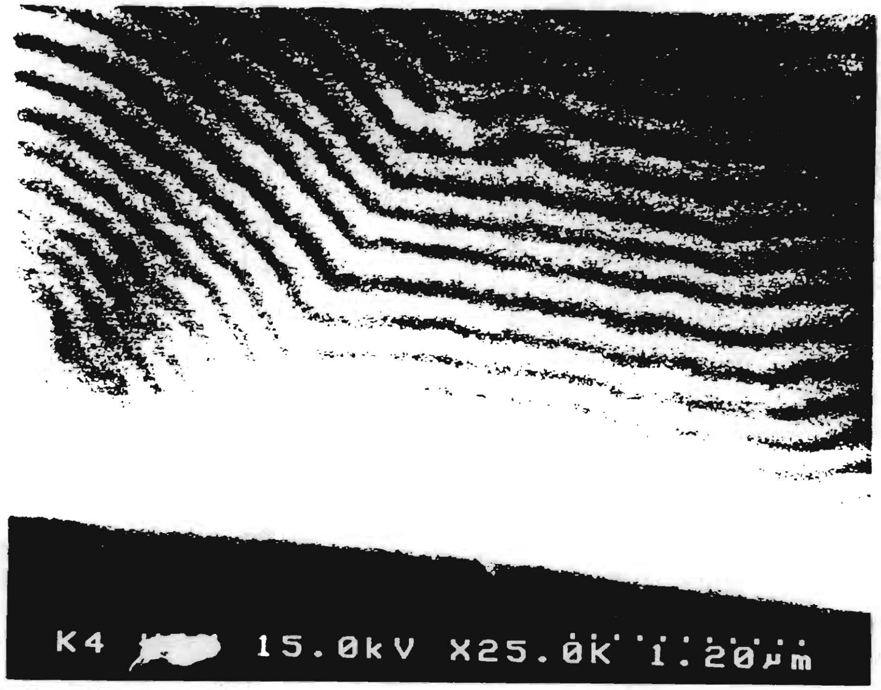


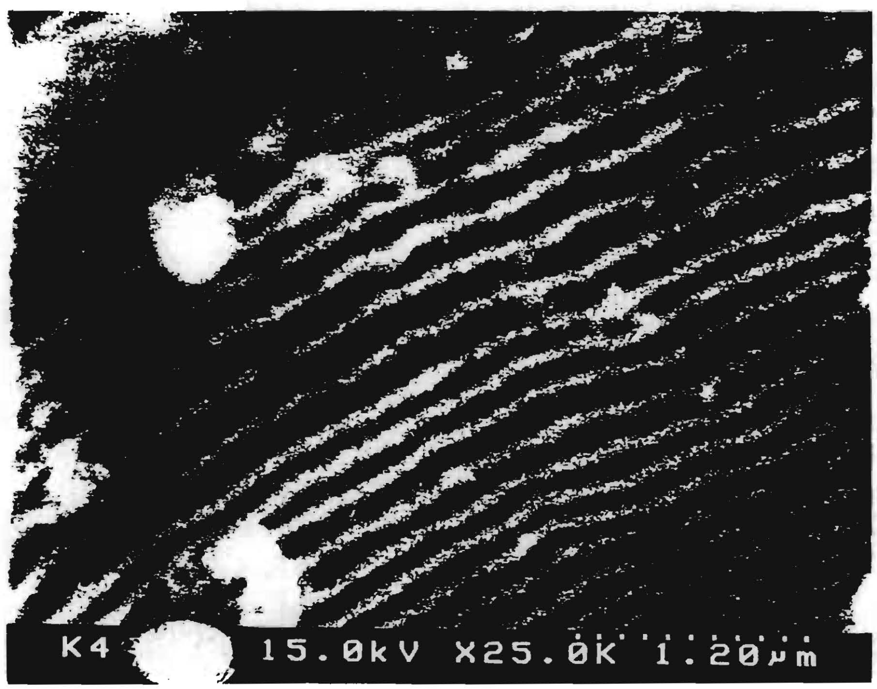
Sample K-4, Micrographs Nos. 3 and 4



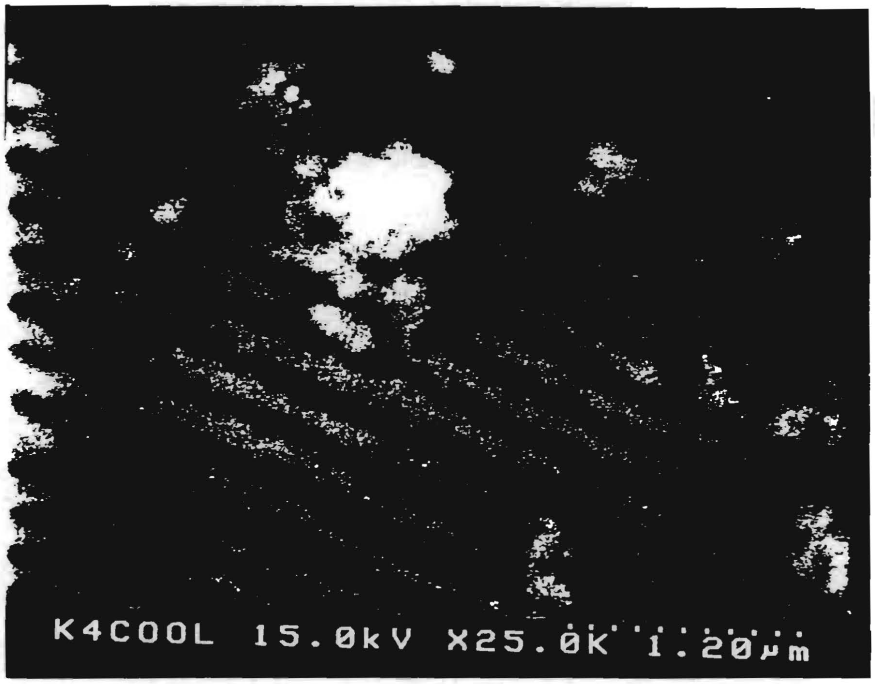


Sample K-4, Micrographs Nos. 5 and 6

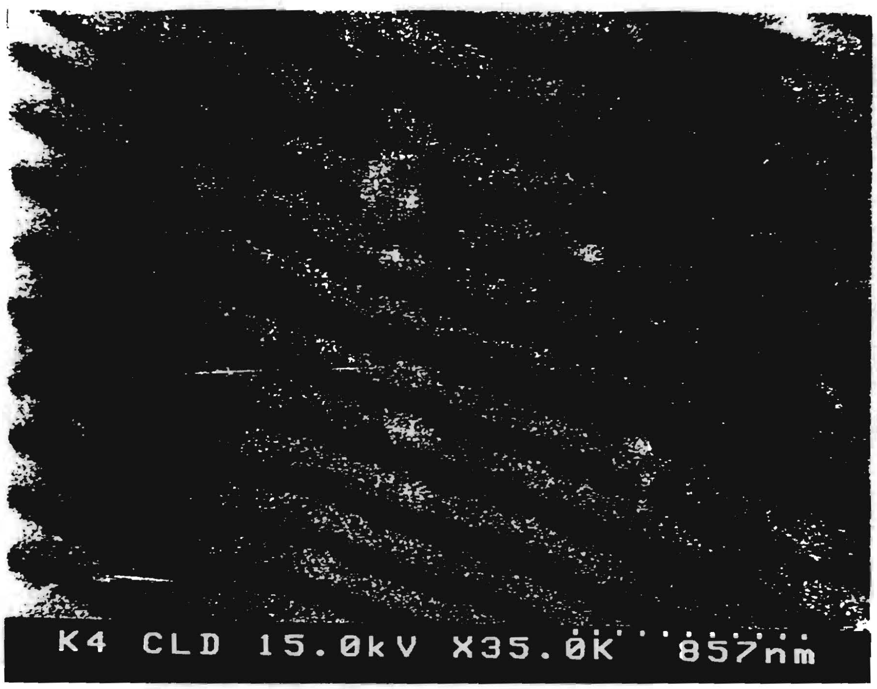




Sample K-4, Micrographs Nos. 7 and 8



Sample K-4, Micrographs Nos. 9 and 10



Sample K-4, Micrographs Nos. 11 and 12