10:59:48 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 09/25/96

Active

Project #: E-18-X52 Cost share #: Rev #: 1
Center # : 10/24-6-R8789-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: AQ-4922 Mod #: 01 Document : CONT
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA:
Main project #: PE #:

Project unit: MSE Unit code: 02.010.112
Project director(s):
THADHANI N N MSE (404)894-2651

Sponsor/division names: SANDIA NAT'L LABS / WESTERN ELECTRIC CO INC
Sponsor/division codes: 240 / 003

Award period: 951215 to 970930 (performance) 970930 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	5,291.00
Funded	0.00	5,291.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: PROPOSAL FOR MATERIAL SYNTHESIS ANALYSIS OF PRE-SHOCKED POWDER SAMPLES

PROJECT ADMINISTRATION DATA

OCA contact: Anita D. Rowland 894-4820

Sponsor technical contact	Sponsor issuing office
G.T. HOLMAN	JULIE A. MCBRIDE
(505)844-5847	(505)845-6052
SANDIA NATIONAL LABORATORY	SANDIA NATIONAL LABORATORY
ORGANIZATION 1152	PROCUREMENT ORGANIZATION 10232
MS 1421	P.O. BOX 5800
P.O. BOX 5800	ALBUQUERQUE, NM 87185-0212
ALBUQUERQUE, NM 87185	FAX: 505.844.1921

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : supplemental sheet
Equipment title vests with: Sponsor X GIT
GFP, REF. CLAUSE 6, PP. 14-15
Administrative comments -
MOD 01 APPROVES A ONE-YR NO-COST TIME EXTENSION

Georgia Institute of Technology
Office of Contract Administration
PROJECT CLOSEOUT - NOTICE

Closeout Notice Date 24-OCT-1997

Project Number E-18-X52 Doch Id 38470

Center Number 10/24-6-R8789-0A0

Project Director THADHANI, NARESH

Project Unit MSE

Sponsor SANDIA NAT'L LABS/WESTERN ELECTRIC CO INC

Division Id 4870

Contract Number AQ-4922 Contract Entity GTRC

Prime Contract Number

Title PROPOSAL FOR MATERIAL SYNTHESIS ANALYSIS OF PRE-SHOCKED POWDER SAMPLES

Effective Completion Date 30-SEP-1997 (Performance) 30-SEP-1997 (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	N	
Other	N	

Comments
USE SPONSOR FORM FOR PATENT REPORT.

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	Y
Georgia Tech Research Corporation	Y
Project File	Y

NOTE: Final Patent Questionnaire sent to PDPI

E-18-X52
1, 2

Georgia Tech

School of Materials Science and Engineering

Georgia Institute of Technology
Atlanta, Georgia 30332-0245
USA
FAX: 404•853•9140

September 24, 1995

G. T. Holman
Advanced Materials Physics Dept.,
Org. 1152, P.O. Box 5800
Sandia National Labs.,
Albuquerque, NM 87185

Dear Mr. Holman:

Enclosed please find our end-of-the-fiscal-year (final) report as part of our work under the Sandia Project No. AQ-4922. The report is entitled, "Strain Analysis of Shock-Compressed Alumina Powders," and documents much of the work on XRD line broadening analysis. We are currently preparing a publication for submittal to a journal, and will send you a copy of the same.

We thank you and the Sandia National Laboratories for support of this research effort.

Yours sincerely,

Naresh Thadhani
Associate Professor, MSE
Tel: (404) 894-2651

STRAIN ANALYSIS OF SHOCK-COMPRESSED ALUMINA POWDERS

End-of-the-fiscal-year (final) Report
Period: December 15, 1995 to September 30, 1996

Sandia National Laboratories Document No. AQ-4922
"Materials Synthesis Analysis of Pre-Shocked Powder Samples

Prepared by

V. Subramanian and N.N. Thadhani
School of Materials Science and Engineering,
Georgi Tech, Atlanta, GA 30332-0245

September 24, 1996

STRAIN ANALYSIS OF SHOCK-COMPRESSED ALUMINA POWDERS

Summary of Results

Microstructural characterization of the different Alumina (Al_2O_3) powders sent by Sandia, revealed powders of different morphology. The A14 and the Sumitomo Alumina powders were more coarse, with the Sumitomo powders also showing a faceted structure. In contrast, the A-15, A-35, and A-16 powders were fine with equiaxed morphology. XRD Line broadening analysis performed on the various powders indicated that the finer powders had some residual micro strain, possibly due to powder comminution process, while the coarse morphology powders were typically strain-free.

The shock-compressed alumina samples showed significant effects. The A-14, A-15, and A35 powders shocked with MB-B loading showed similar strain levels of up to $2.6x10^{-3}$. The A-14, A-16, and Sumitomo powders shocked with MBA-CB configuration showed different behaviors. The Sumitomo powders, which were practically strain-free in the as-received state showed much higher increases in strain (upon shock-loading) with increasing pressure.

In general, the strain values for all powders under different loading conditions are in the range of $1.6x10^{-3}$ to $4.4x10^{-3}$, which is similar to values obtained in previous studies on dynamically loaded Alumina. Such strain values correspond to dislocation densities similar to those attained in heavily cold-worked metallic materials. A more detailed publication is being prepared documenting the results of this study, a copy of which will be sent to the Sandia technical program monitor prior to submittal.

STRAIN ANALYSIS OF SANDIA Al_2O_3 USING X-RAY DIFFRACTION

The shocked samples were ground using a pestle and mortar to obtain powders which were used for the X-ray scans. Scans were done using a step size of 0.015° and a scan time of 5 seconds. The K-α_2 component was first stripped from the pattern. The peaks were then fit with a lorentzian function using the software "Genplot". The width of the peak at half the intensity (FWHM) was also obtained from the software. The broadening due to the instrument was obtained from a Si standard sample. The instrumental broadening was found to follow the equation

$\beta_{inst} = 9.024*10^{-6}(2\theta) + 1.458*10^{-3}$

where β_{inst} is the peak width due to instrumental broadening and θ is the diffraction angle. The instrumental broadening was subtracted from the FWHM of the sample peaks to obtain the true peak breadth (β). The peak breadth (β) is related to the strain (ε) and crystallite size (t) as given below

$\beta\cos\theta = 2\varepsilon\sin\theta + \lambda/t$, where λ is the wavelength.

The $\beta\cos\theta$ and $\sin\theta$ values were plotted for the samples and were linearly fit. The strain was obtained from the slope of the linear fit.

STRAIN

Powder	Starting Powder	M-B	M-CB	MBA-CB
Alcoa A-14	0.0001	0.00405	0.00685	0.007
Alcoa A-152SG	0.0018	0.00535		
Alcoa A-16SG	0.00055	0.0041		
Alcoa A-3500SG	0.00075	0.0044		

LIST OF FIGURES

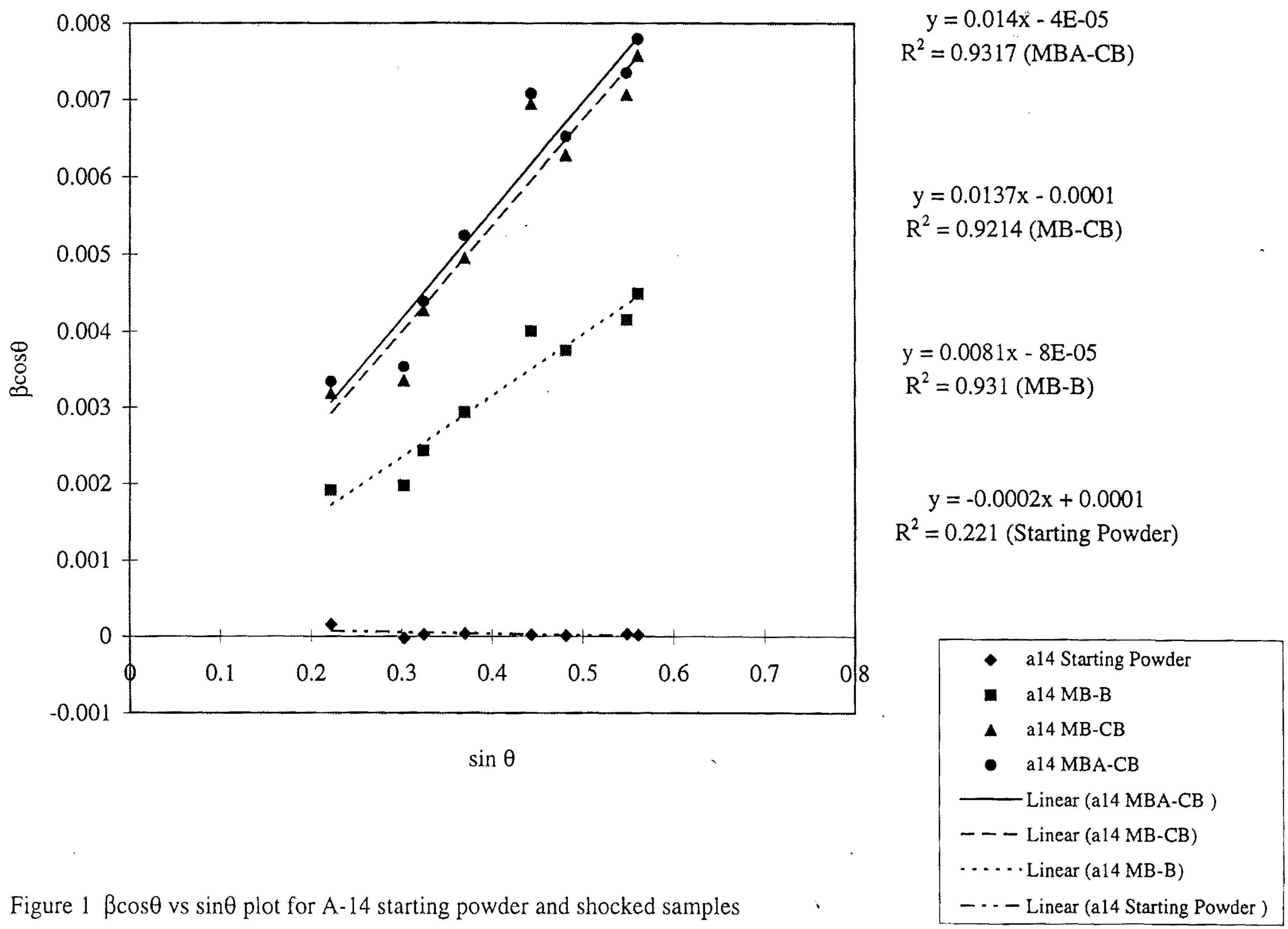


Figure 1 βcosθ vs sinθ plot for A-14 starting powder and shocked samples

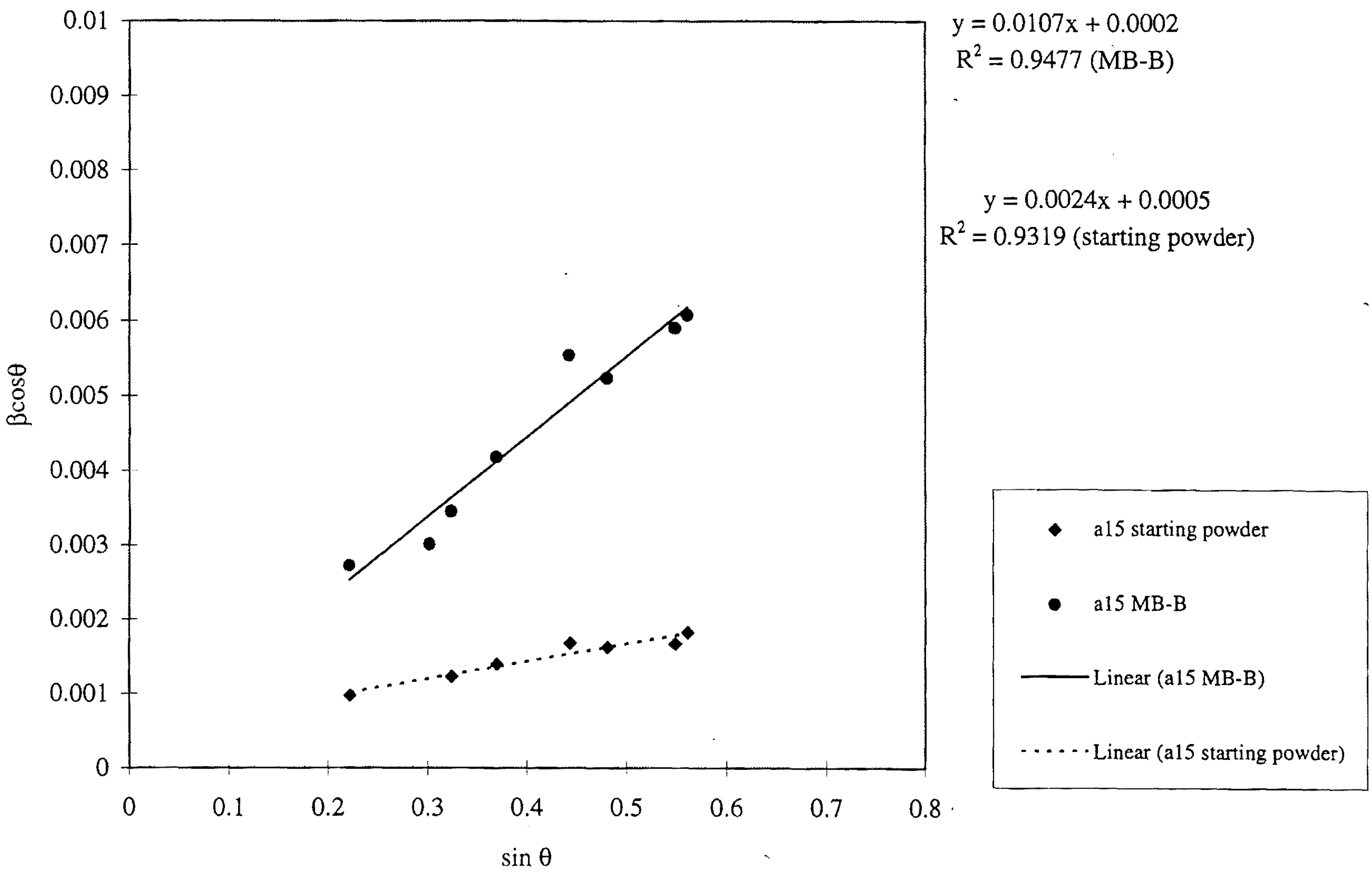


Figure 2 βcosθ vs sinθ plot for A-152SG starting powder and shocked sample (MB-B)

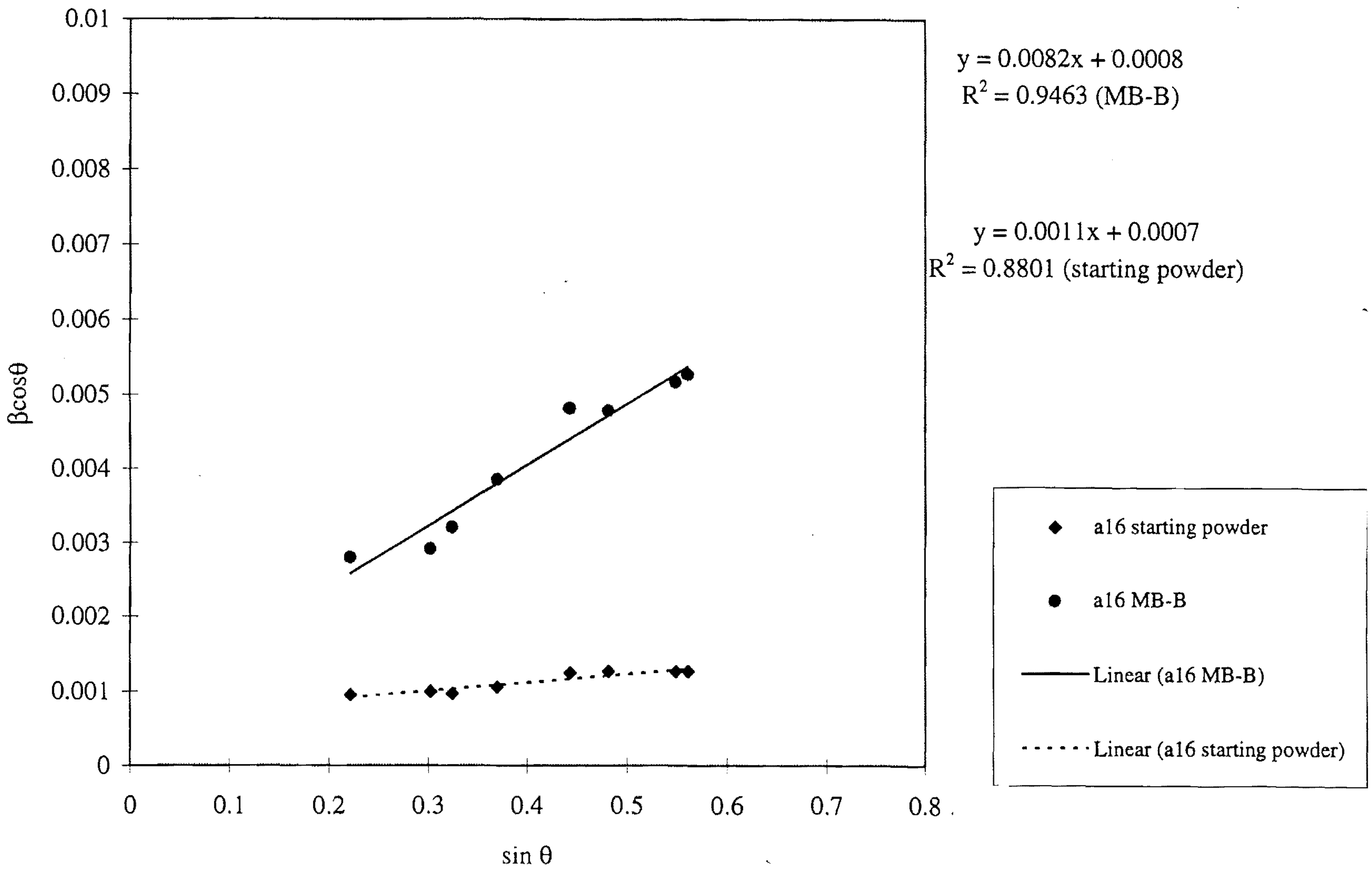


Figure 3 βcosθ vs sinθ plot for A-16SG starting powder and shocked sample (MB-B)

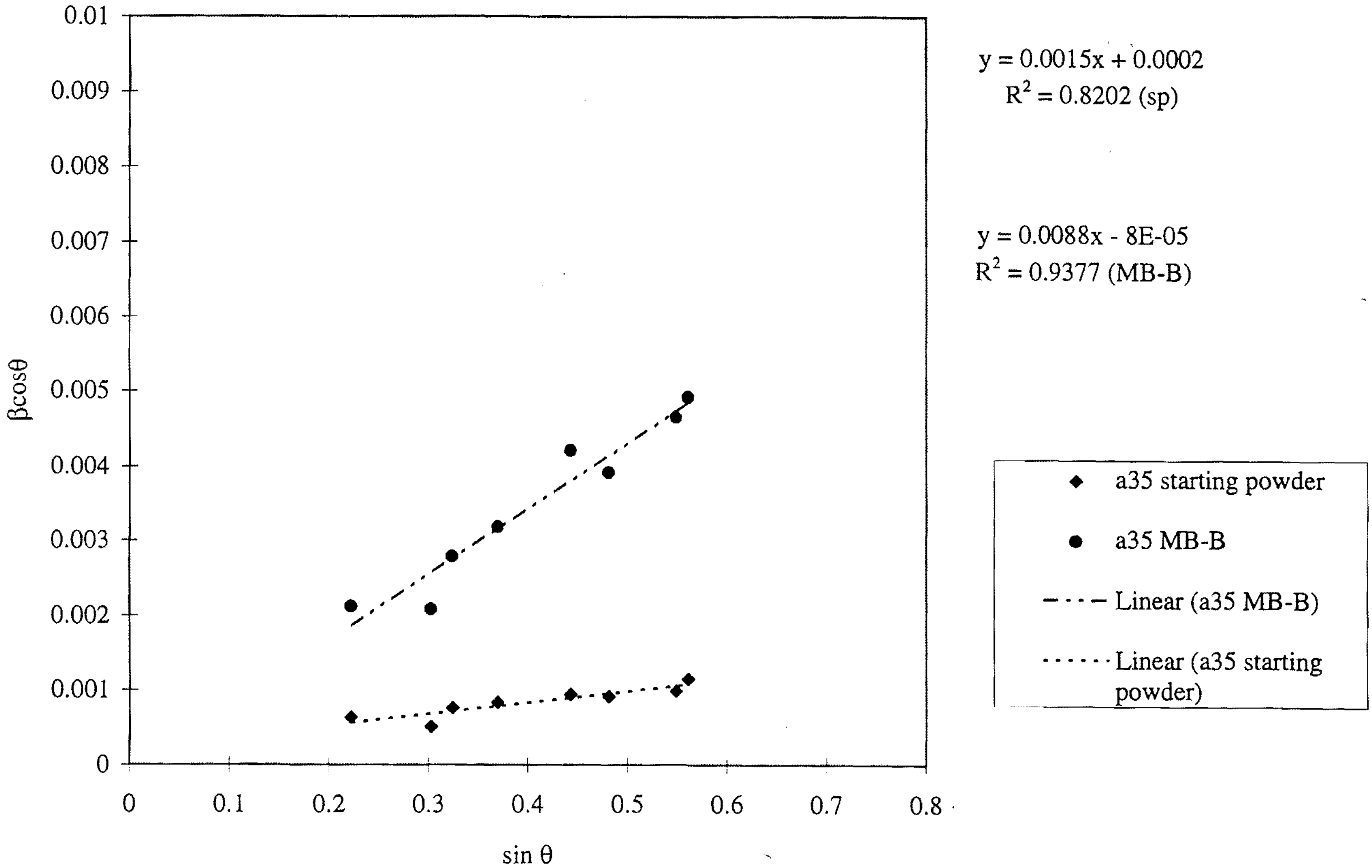


Figure 4 βcosθ vs sinθ plot for A-3500SG starting powder and shocked sample (MB-B)

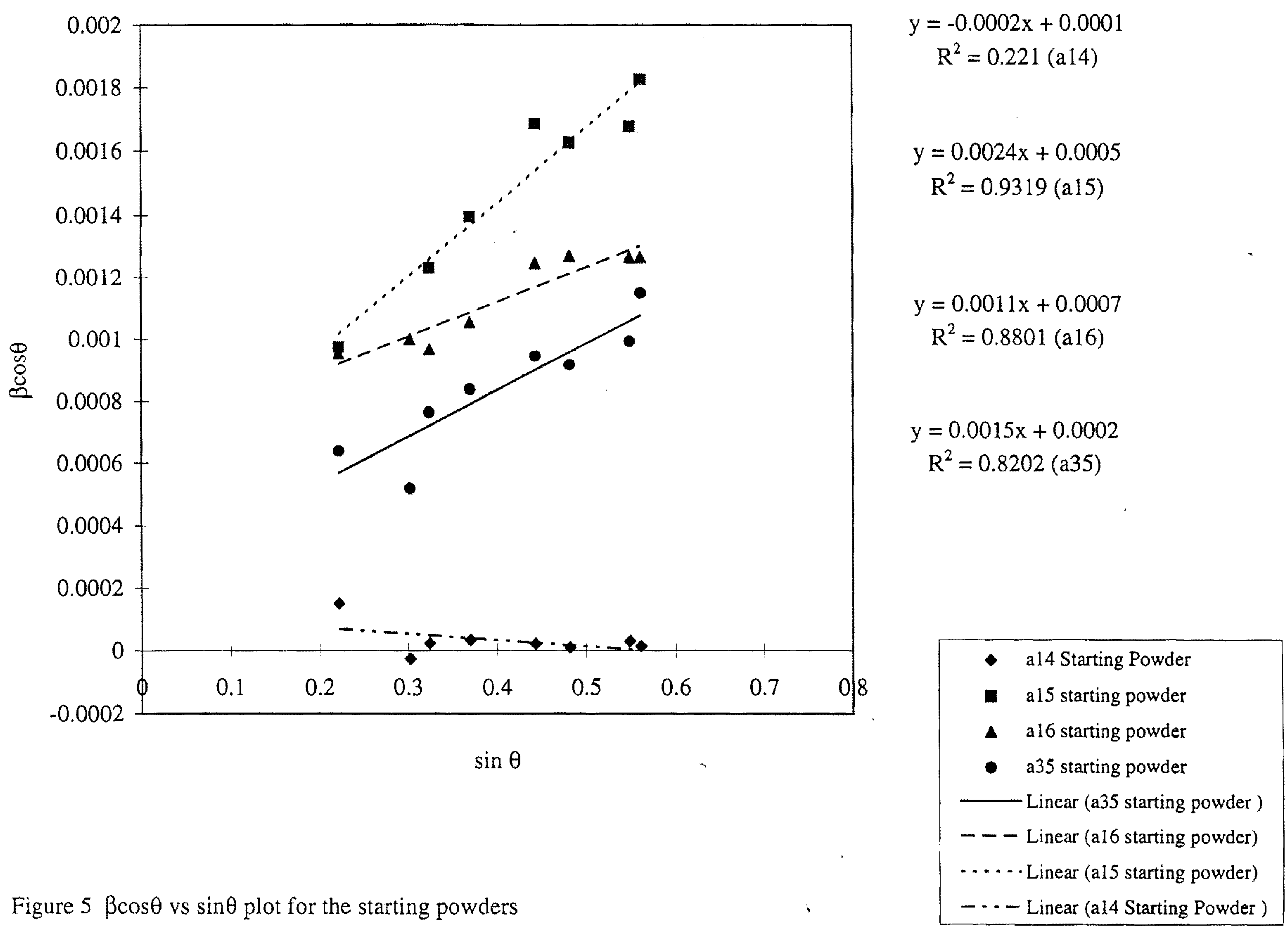


Figure 5 βcosθ vs sinθ plot for the starting powders

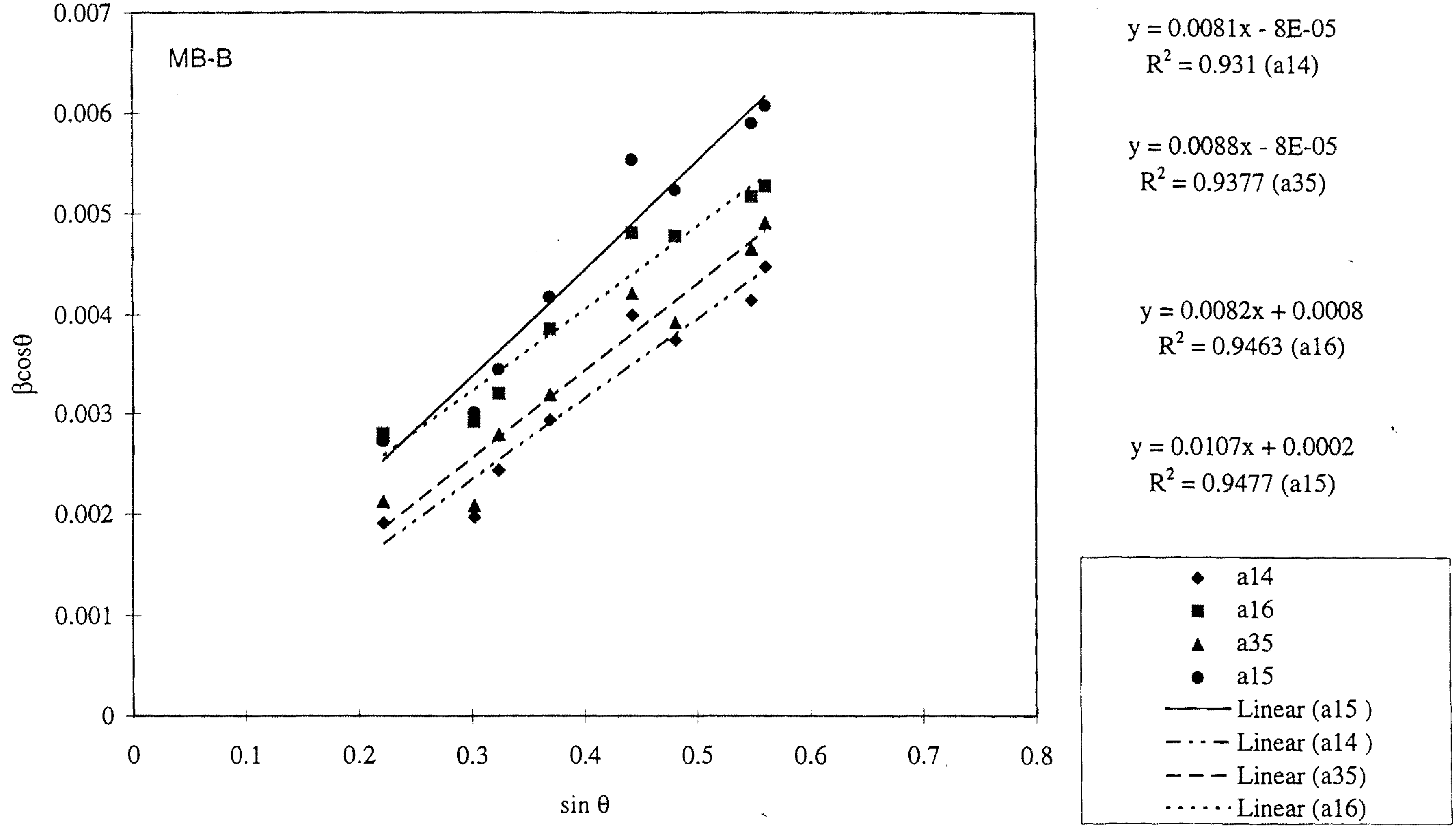


Figure 6 βcosθ vs sinθ plot for the MB-B shocked samples

STRAIN

Powder	Starting Powder	PB-B	MB-B	MB-CB	MBA-CB
Alcoa A-14	-0.0001		0.00405	0.00685	0.007
Alcoa A-152SG	0.0018		0.00535		
Alcoa A-16SG	0.00055	0.0033	0.0041		0.0082
Alcoa A-3500SG	0.00075		0.0044		
Sumimoto	-0.0001			0.00745	0.00875

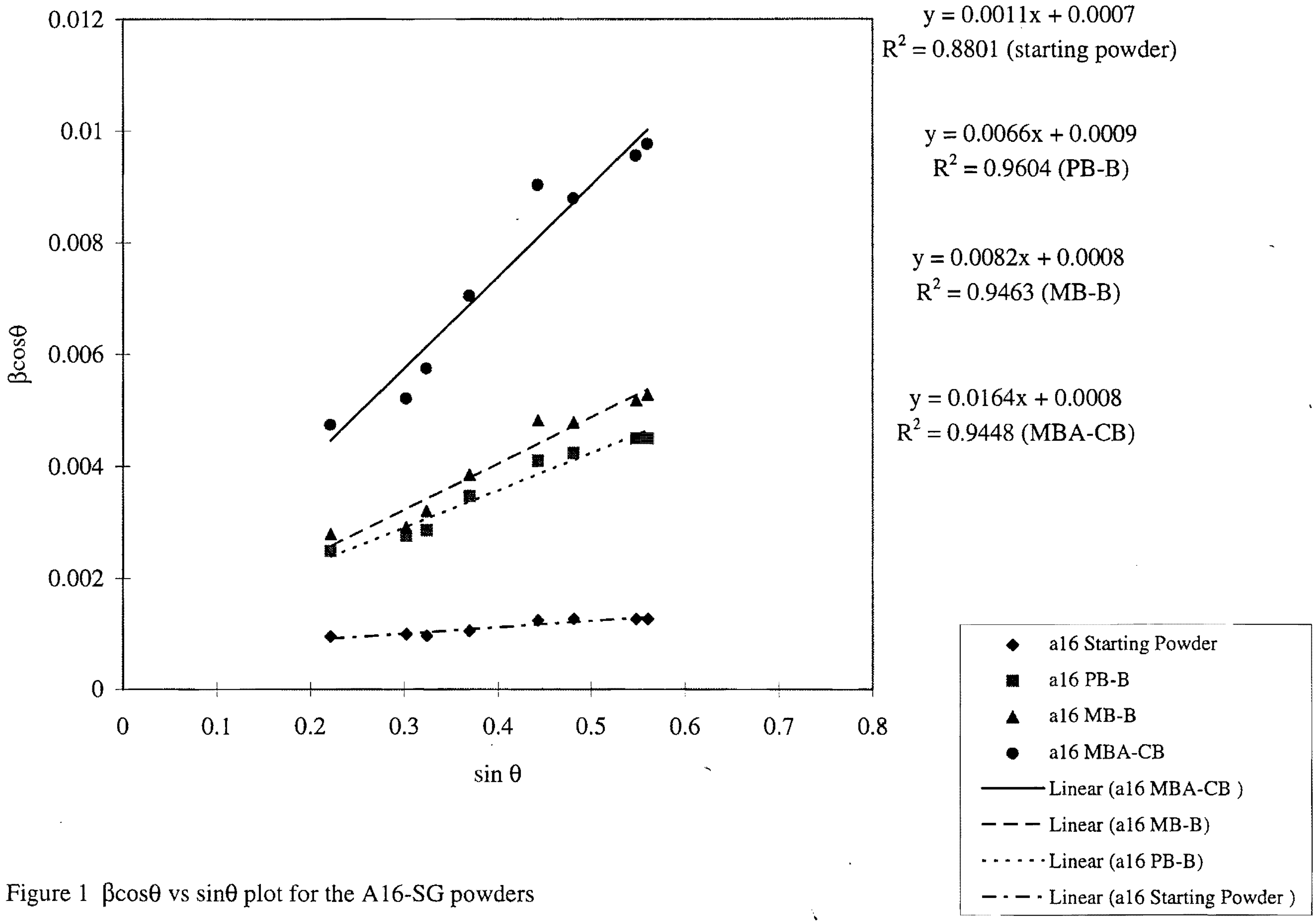


Figure 1 βcosθ vs sinθ plot for the A16-SG powders

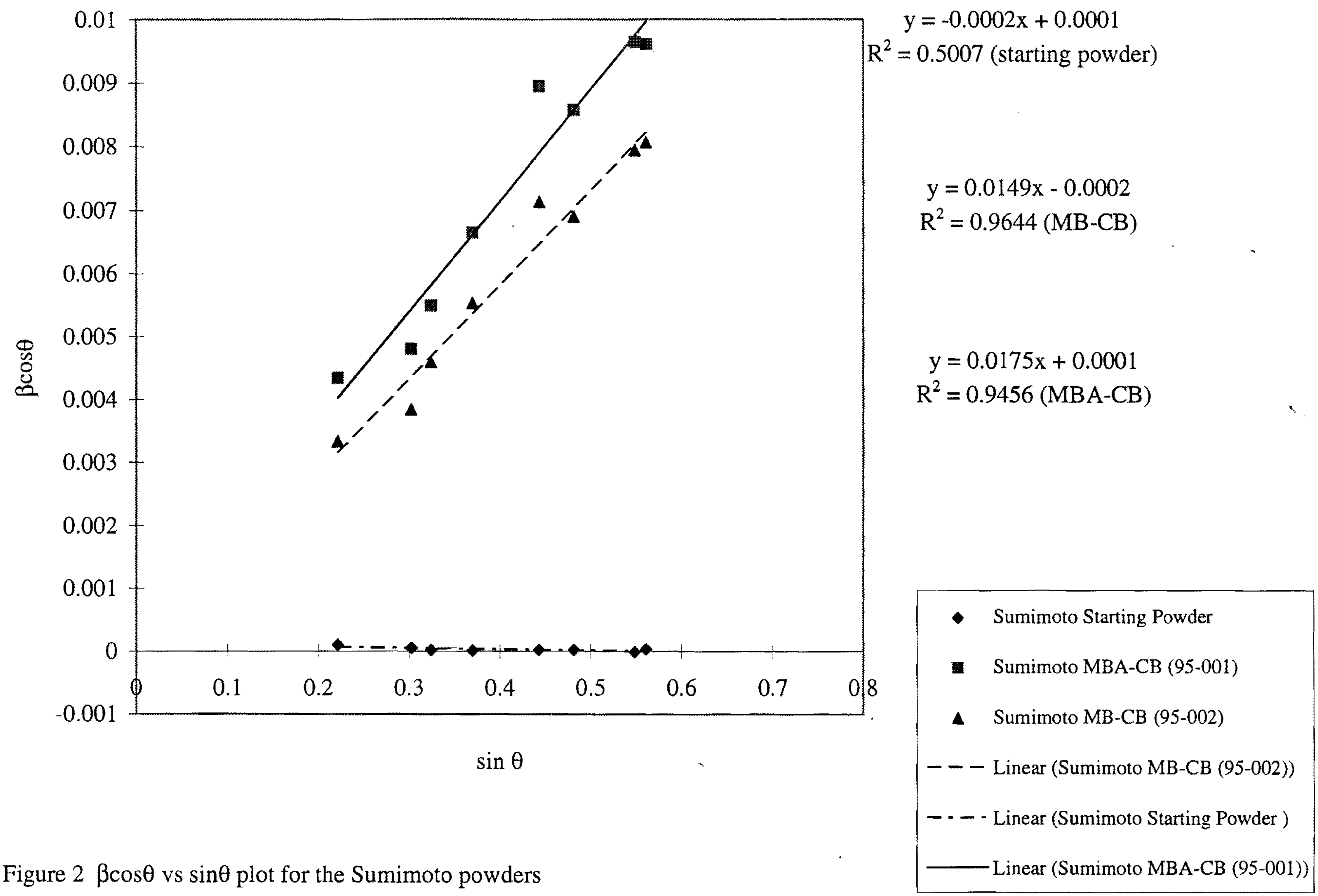
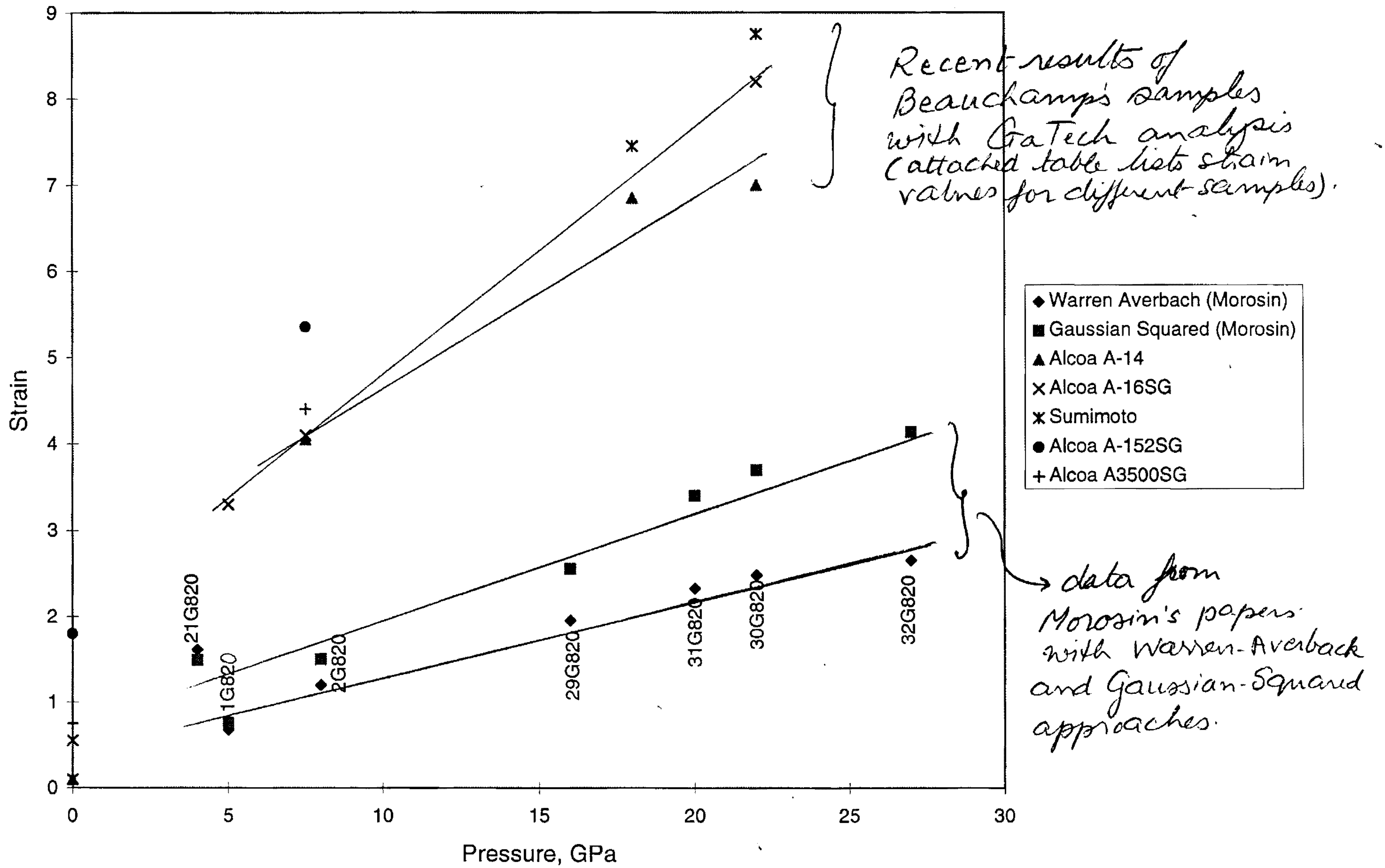


Figure 2 βcosθ vs sinθ plot for the Sumimoto powders


Strain
Pressure, GPa
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
21G820
1G820
2G820
29G820
31G820
30G820
32G820
Warren Averbach (Morosin)
Gaussian Squared (Morosin)
Alcoa A-14
Alcoa A-16SG
Sumimoto
Alcoa A-152SG
Alcoa A3500SG
Recent results of Beauchamp's samples with GaTech analysis (attached table lists strain values for different samples).
data from Morosin's papers with Warren-Averback and Gaussian-Squared approaches.