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N91-27289

Program 4 The Effect of Temperature on the Fracture Toughness of Weldalite™ 049

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Objective

The objective of this research is to characterize the uncertain effect of temperature on the deformation and fracture behavior of Weldalite™ 049 from cryogenic to elevated temperatures. We will measure fracture resistance and emphasize the determination of fracture mechanisms, including slip plane cracking, high angle boundary delamination, subgrain boundary cracking, and microvoid coalescence. Microstructure will be controlled to produce either predominantly T_1 or $T_1 + \delta'$ (after Blankenship and Starke) and to examine the effect of dislocation-precipitate interaction on fracture toughness.

EFFECTS OF TEMPERATURE AND MICROSTRUCTURE ON THE FRACTURE OF WELDALITE™ 049

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LA^{2}ST Program Review

NASA Langley Research Center

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OBJECTIVE

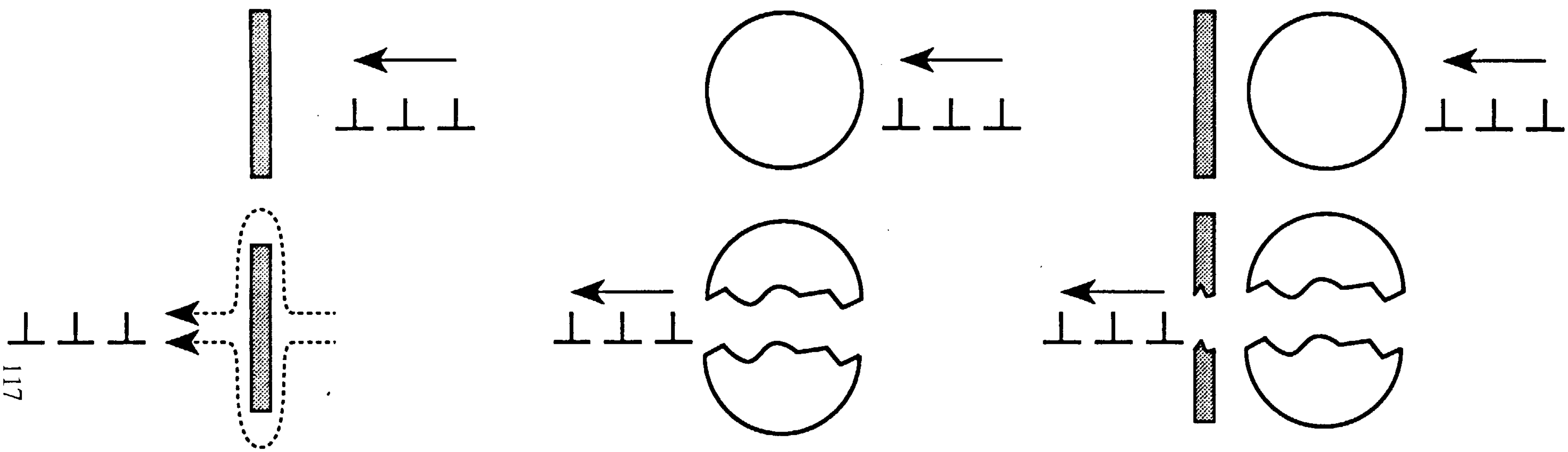
- To characterize the effect of precipitate slip interactions and temperature on the deformation and fracture behavior of Weldalite™ 049 from cryogenic to elevated temperatures.

APPROACH

- Limited fracture toughness data available as a function of temperature
- Test hypothesis of particle dislocation interactions involved with slip localization (Blankenship)
- Investigate the effect of temperature on slip localization and delamination (Wagner, Porr, Leng)

HYPOTHESIS

T_1 precipitate | δ' precipitate | T_1 & δ' precipitates



- Dislocations loop around T_1

⇓

Microvoid cracking

- Dislocations shear δ'

⇓

Slip plane cracking

- Dislocations shear δ' & T_1

⇓

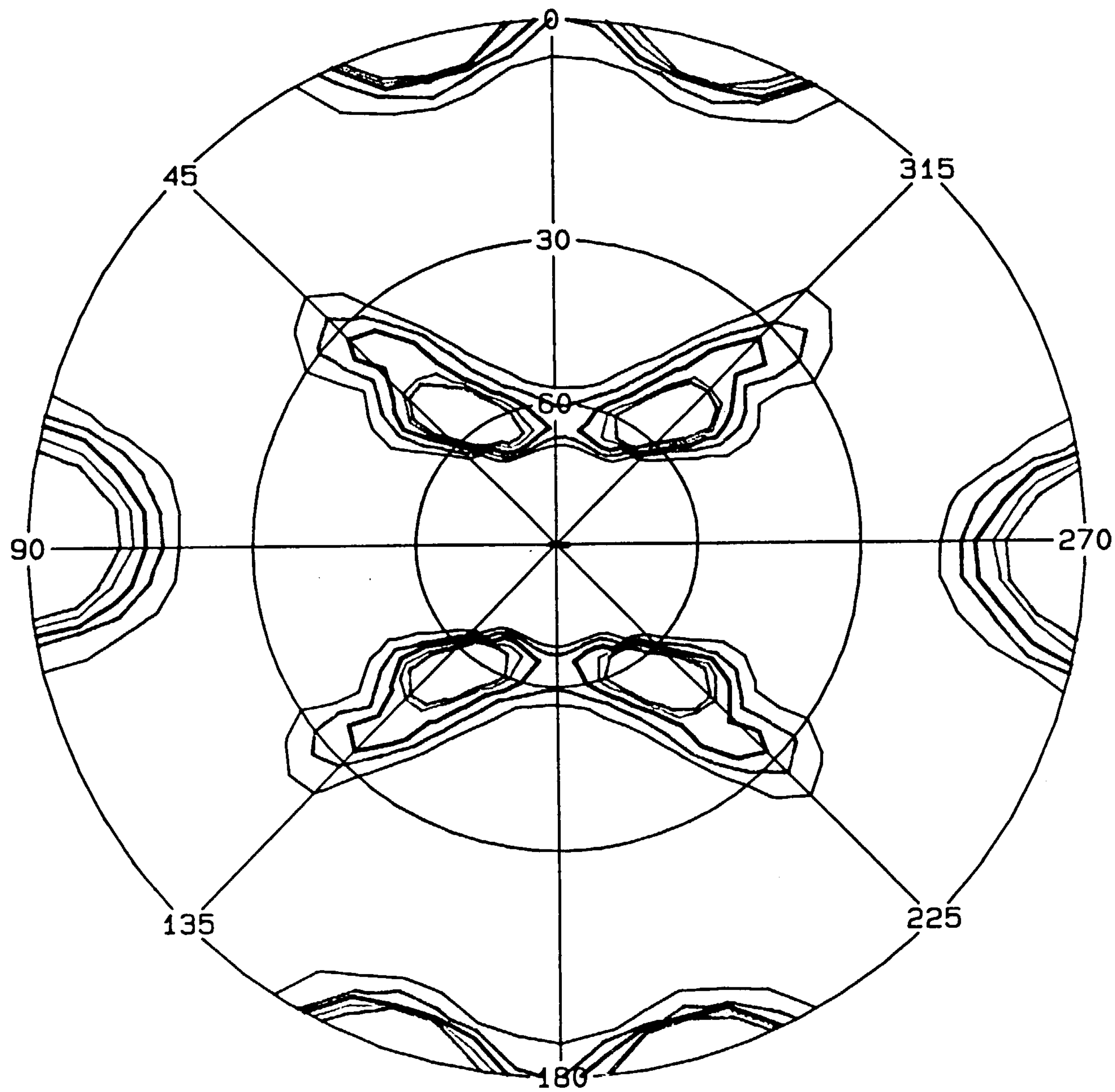
?

Temperature?

CHEMISTRY

	Si	Fe	Cu	Mn	Mg	Zn	Ag	Li	Zr	Ti	Al
X2095 alloy registration for Weldalite™ 049	0.12 max	0.15 max	3.9-4.6	0.10 max	0.25-0.6	0.25 max	0.25-0.6	1.0-1.6	0.04-0.18	0.10 max	Bal
Weldalite™ 049	—	0.08	4.64	—	0.37	0.17	0.35	1.53	0.17	—	Bal

(111) POLE FIGURE FOR WELDALITE™ 049

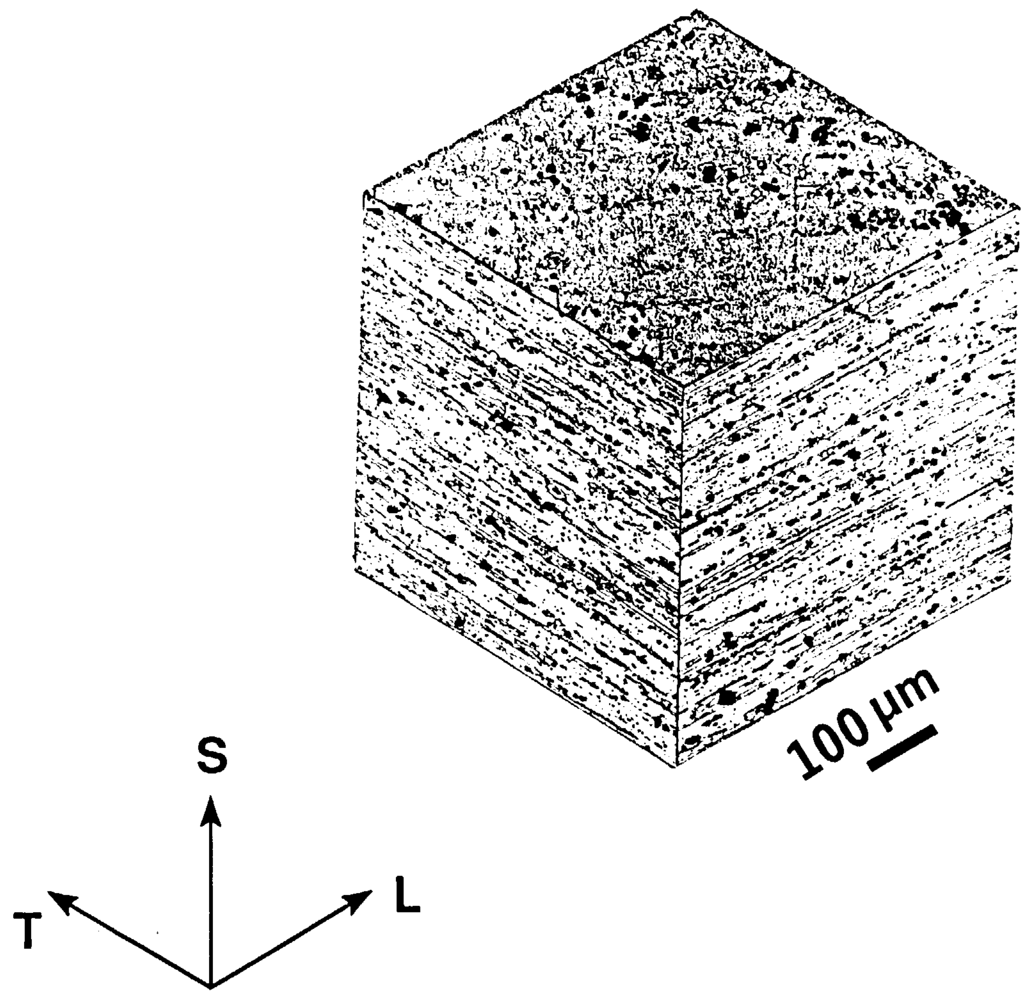


File: SY0: Z04840.PFG
Sample: WELDALITE 049-T3
T/2 (LACH)
2-MAY-91 07: 24: 46
H= 1 K= 1 L= 1

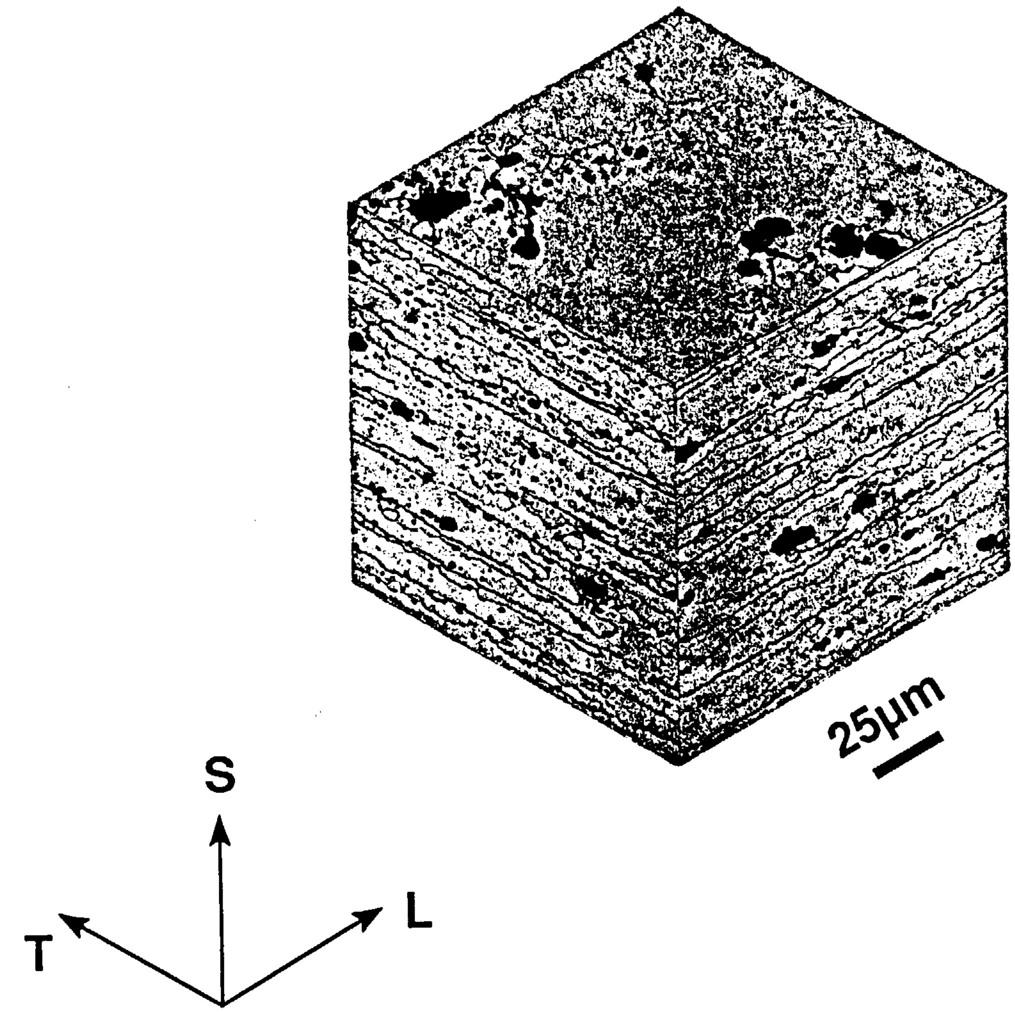
Plot Levels:

▭	2.6%	0.75
▭	4.4%	1.25
▭	7.0%	2.00
▭	10.5%	3.00
▭	14.0%	4.00

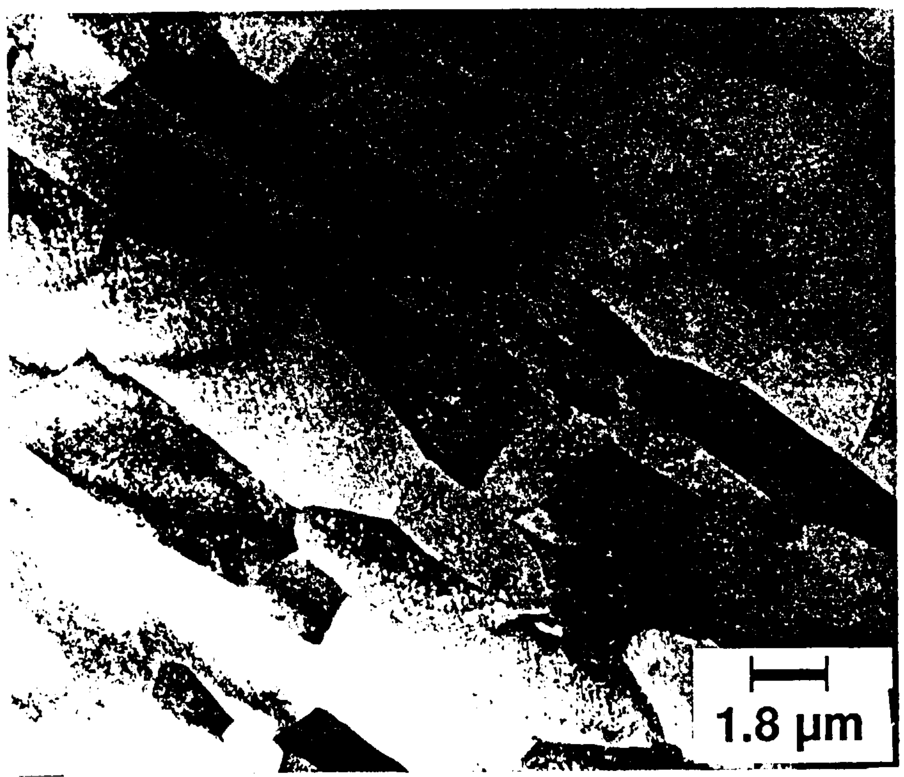
AS RECEIVED WELDALITE™ 049 (1.6% Li)



AS RECEIVED WELDALITE™ 049 (1.6% Li)



SUBGRAIN STRUCTURE OF WELDALITE™ 049 (1.6% Li)



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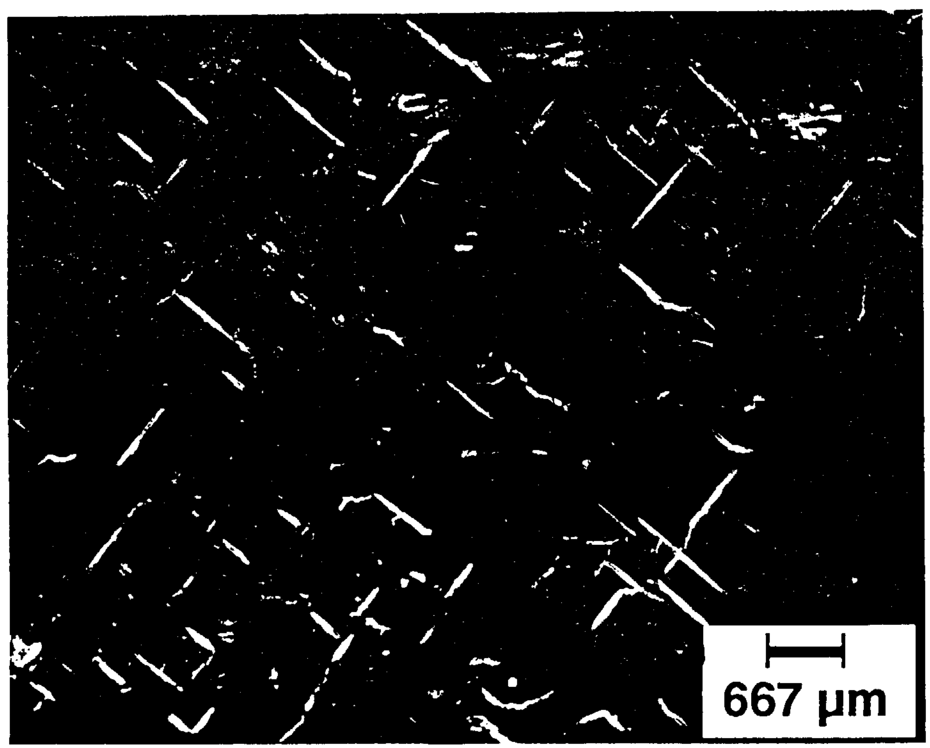
AGED AT 145°C FOR 72 HOURS



Precipitates

δ' (Al_3Li)

θ' (Al_2Cu)

T_1 (Al_2CuLi)

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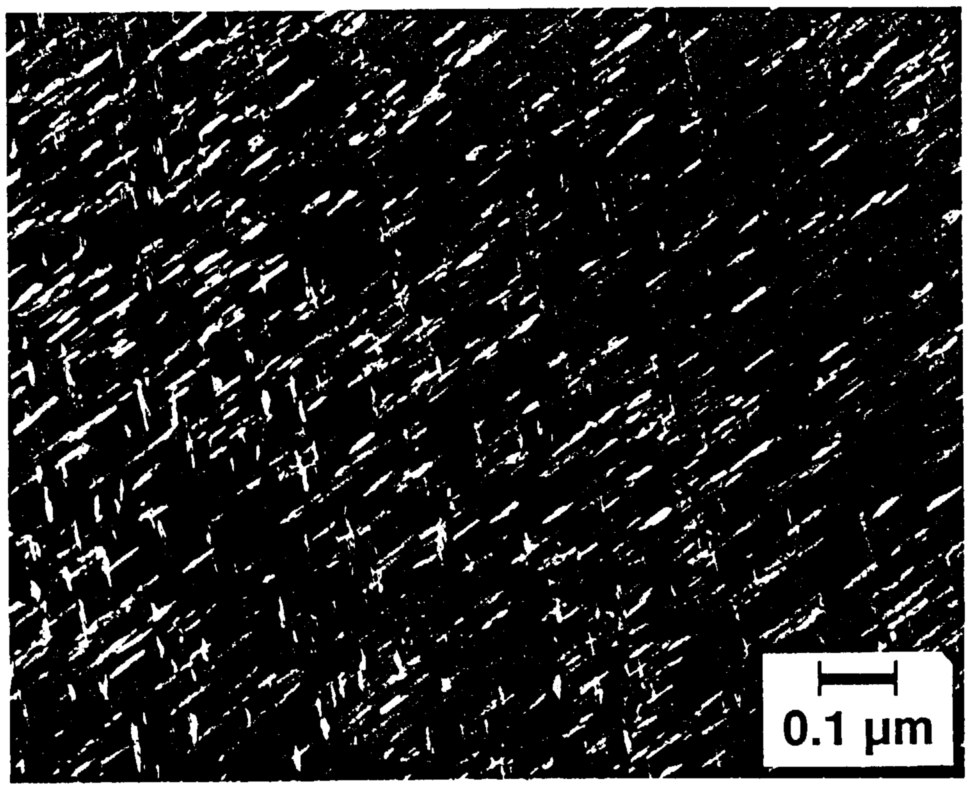
-T8 TEMPER

165°C for 24 hours



Precipitates

T_1 (Al_2CuLi)

S' (Al_2CuMg)

θ' (Al_2Cu)

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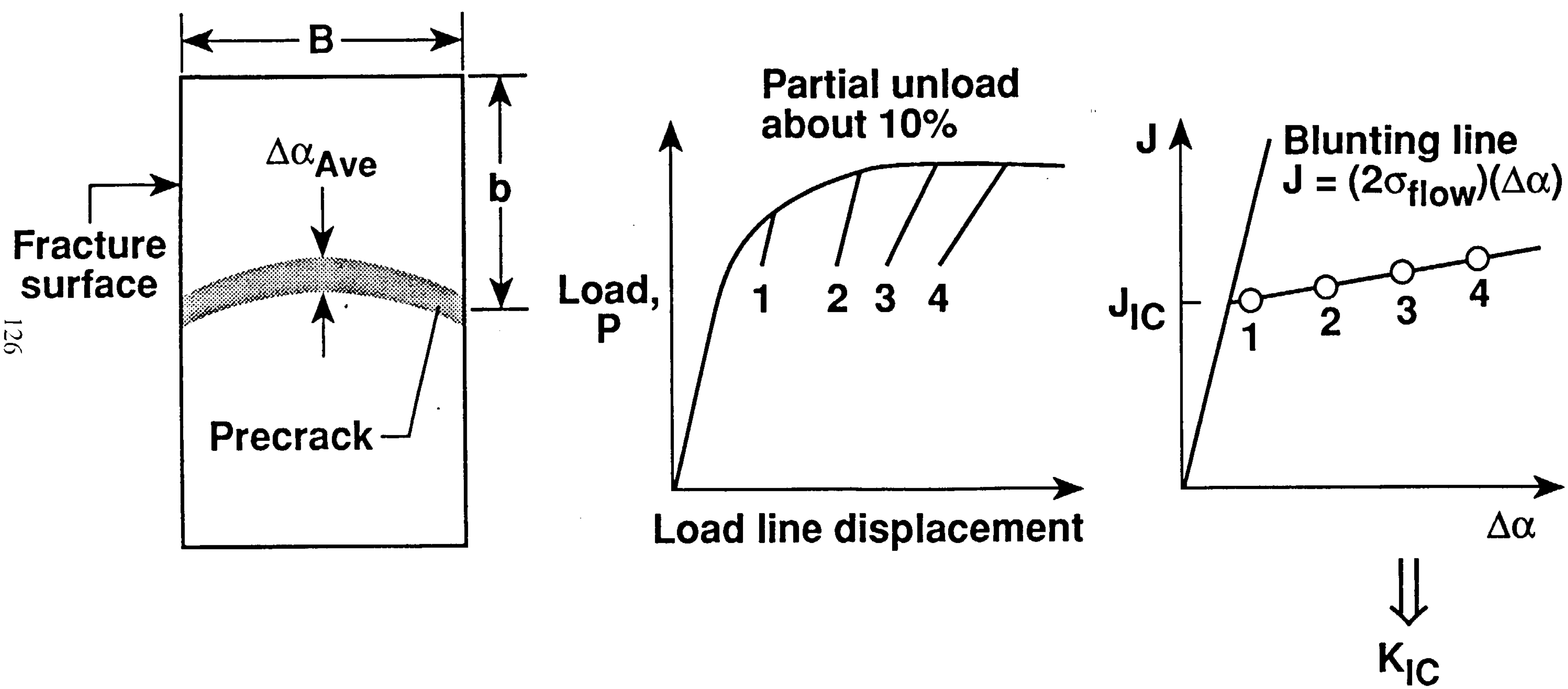
MECHANICAL PROPERTIES

Room Temperature

Temper	Yield strength, ksi	Ultimate strength, ksi	Percent elongation
145°C 24 hours	83 83	89 88	10.0 9.0
145°C 68 hours	91 89	94 91	7.1 8.4
165°C 24 hours	89 88	92 92	6.4 7.6

TEST PROCEDURE TO DETERMINE J_{IC} AND K_{IC}



TEST MATRIX

Temperature, °C

Weldalite™ 049	-190	-100	25	75	145	165	225
Non shearable T_1 165°C/24 hrs R_B 92 T_1 (s', θ')	T_R PE_R JA_R	T JA	T_R (T) PE_R (PE_R) JA_R (JA_R)	(T) (JA)		(T_R) (PE_R) (JA_R)	(T) (JA)
Shearable 145°C/24 hrs R_B 90 δ', GPZ/θ', T_1	T_R PE JA	JA	T_R (T) PE (PE) JA (JA)	(JA)	(T) (PE) (JA)		(JA)

T = Tensile
PE = plane strain
JA = Plane stress

R = Replication
( ) = Tested at UVA

SUMMARY

- 0.5" Weldalite™049 T-3 plate obtained
- Material characterization and heat treatments selected (Blankenship)
- NASA and UVA compact tension specimens machined and heat treated
- Fracture testing equipment developed and on-line (Wagner, Porr)
- Ready to begin experiments

QUESTIONS

- Does precipitate-dislocation interaction affect crack initiation and growth toughnesses for Weldalite™049?

- What is the effect of temperature?

↙ Fracture mechanics data ↘ Microscopic behavior