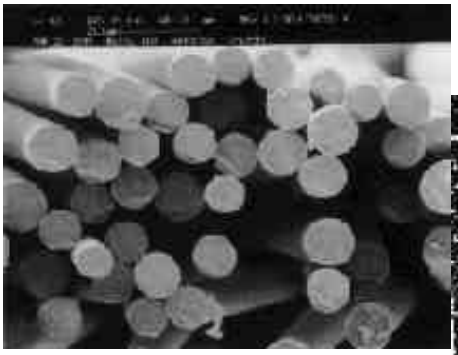
3M

Aluminum Matrix Composites

Typical Properties Data Sheet

Introduction

3M is developing two compositions of Continuous Fiber Reinforced Aluminum Matrix Composites (CFAMC). These composites are reinforced with Nextel™ 610 Ceramic Fiber.



Nextel™ 610 Ceramic Fiber forms the basis of the composite.

Typical fiber distribution in CFAMC.

Two compositions are in development

Pure Al / 60 vol% Al_2O_3

- Very high longitudinal strength (240 ksi) and moderate transverse strength (20 ksi)
- High stiffness
- Lightweight
- Good corrosion resistance
- Good electrical conductivity

Al - 2wt%Cu / 60 vol% Al_2O_3

- High longitudinal strength (220 ksi) and good transverse strength (40 ksi)
- High stiffness
- Lightweight

Applications

- Near net-shape components, continuous wires, rods, tubes, rings

- Near net-shape components

Contents

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Typical Properties

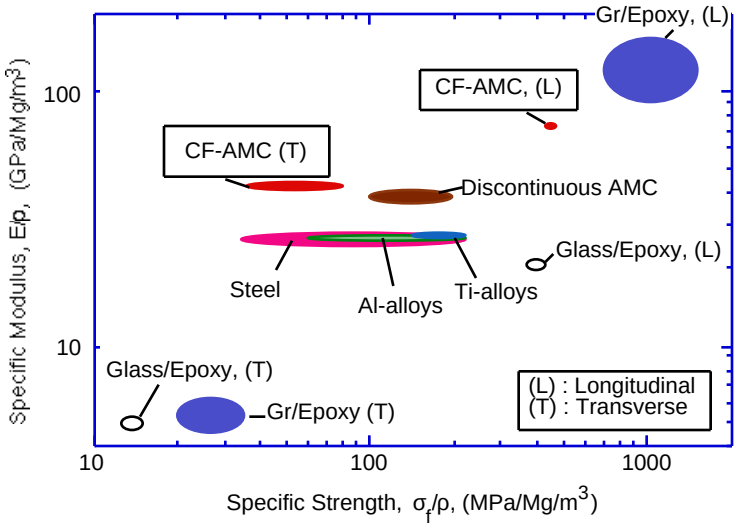
CFAMC System	Pure Al 60 vol% Al_2O_3	Al-2wt%Cu 60 vol% Al_2O_3
Longitudinal Young's Modulus, E_{11} (2)	35 Msi (240 GPa)	35 Msi (240 GPa)
Transverse Young's Modulus, E_{22}	19 Msi (130 GPa)	23 Msi (160 GPa)
Shear Modulus, G_{12} Measured parallel and across fibers	6.5 – 8.3 Msi (48 – 57 GPa)	6.5 – 8.2 Msi (45 – 46 GPa)
Longitudinal tensile strength S_{11T}	240 ksi (1600 MPa)	220 ksi (1500 MPa)
Longitudinal compressive strength $S_{11, LC}$	250 ksi (1700 MPa)	500 ksi (3400 MPa)
Shear strength S_{21} – S_{12} (at 2% strain)	10 ksi (70 MPa)	20 ksi (140 MPa)
Transverse strength S_{22} (at 1% strain)	20 ksi (120 MPa)	40 ksi (280 MPa)
Density	3.4 g/cc	3.4 g/cc
Coefficient of Thermal Expansion fiber direction (averaged 25 – 500°C)	7 ppm/°C	9*ppm/°C
Coefficient of Thermal Expansion transverse direction (averaged 25 – 500°C)	16 ppm/°C	16*ppm/°C

(1) The properties listed in this table are typical of composites loaded with 60 vol% Nextel™ 610 Ceramic Fibers. The data is based on averages.

(2) Index Notation
1 = fiber direction;
2 = transverse direction;
ij: i=direction normal to the plane in which stress is acting, j=stress direction;
S=ultimate strength unless specified

* *estimated*

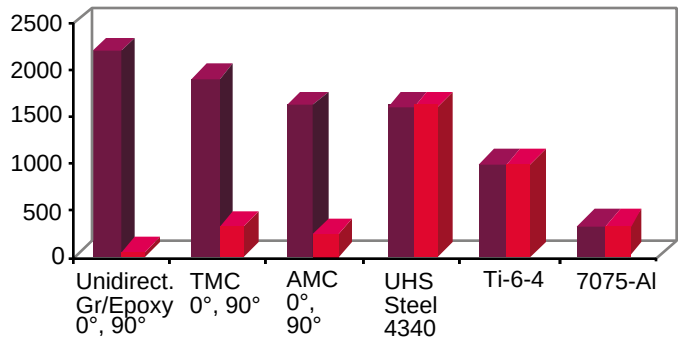
Unidirectional CFAMCs have a high longitudinal specific modulus and specific strength and good off-axis properties



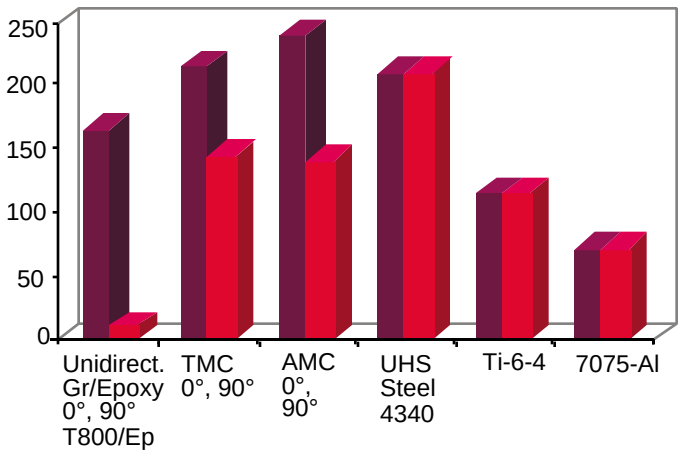
The longitudinal strength of 3M CFAMCs is equal to the strength of steel at 1/3 the weight.

Aluminum Matrix Composites

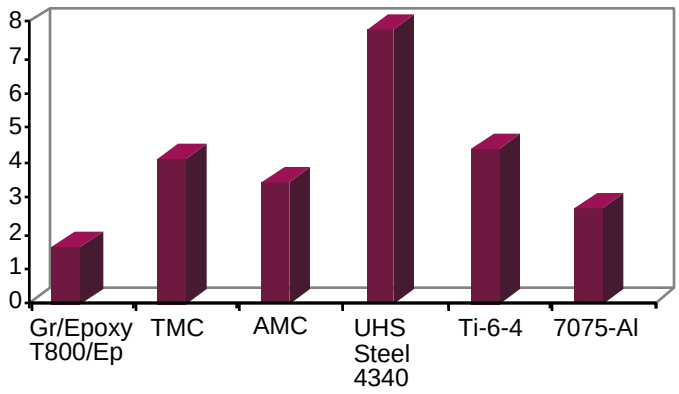
Materials comparison at room temperature



Modulus (GPa)

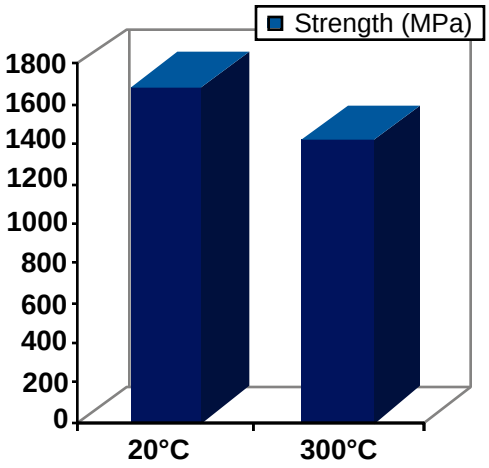


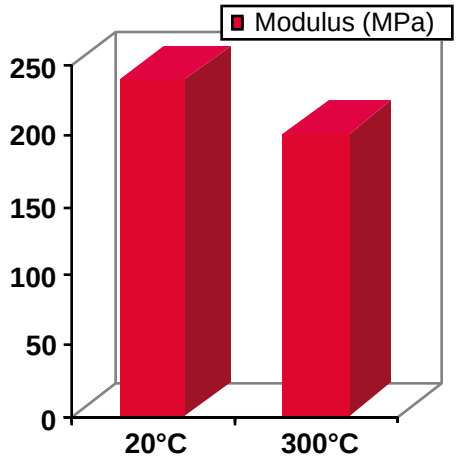
Density (g/cc)

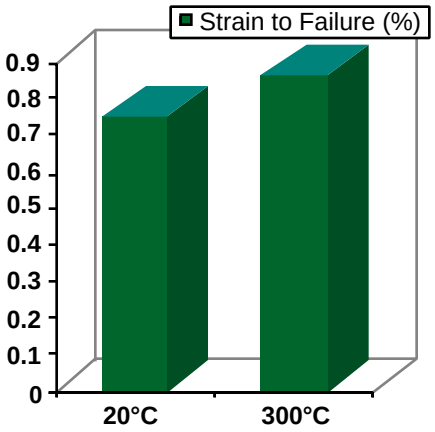


** Data obtained from:*
(1) "Practical Handbook of Materials Science," Editor C. T. Lynch, CRC Press, 1989
(2) "Cambridge Materials Selector, v 2.0" Granta Design Limited, 1994
(3) "Carbon Fiber Composites," D.D.L. Chung, Butterworth-Heineman, 1994

Properties at 300°C



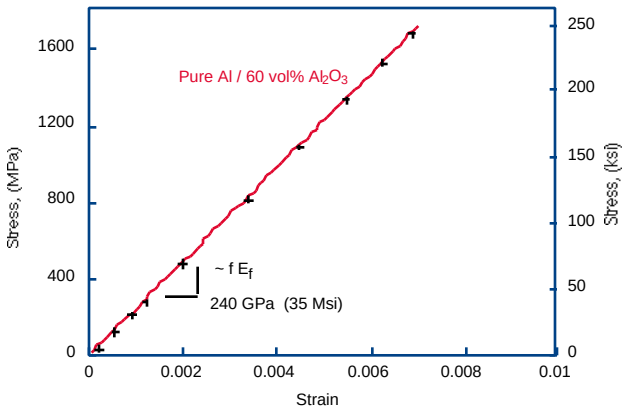




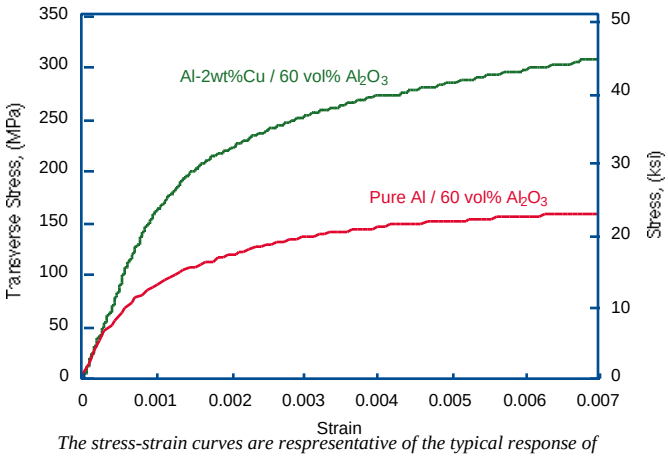
(Longitudinal)
(Strain Rate: $1.6\ 10^{-4}\ s^{-1}$)

Aluminum Matrix Composites

Typical longitudinal stress-strain response

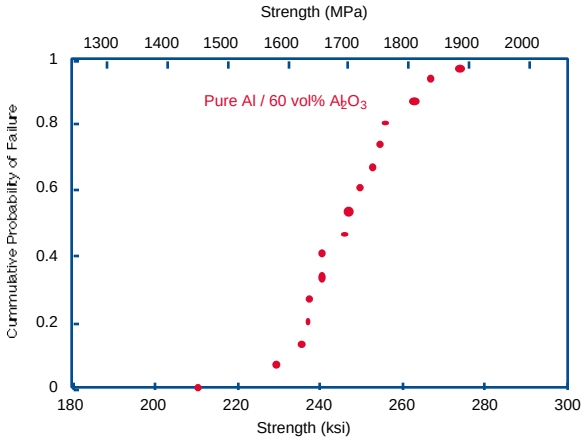


Typical transverse stress-strain response

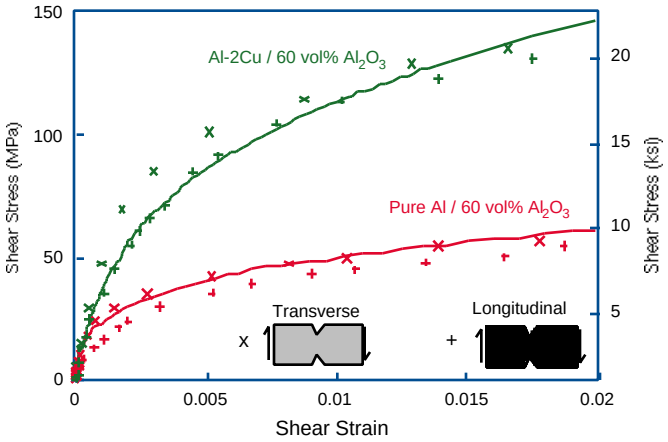


The stress-strain curves are respresentative of the typical response of 3M Aluminum Matrix Composites containing 55-65% Nextel™ 610 Ceramic Fibers. The curves are not indicative of the statistical scatter.

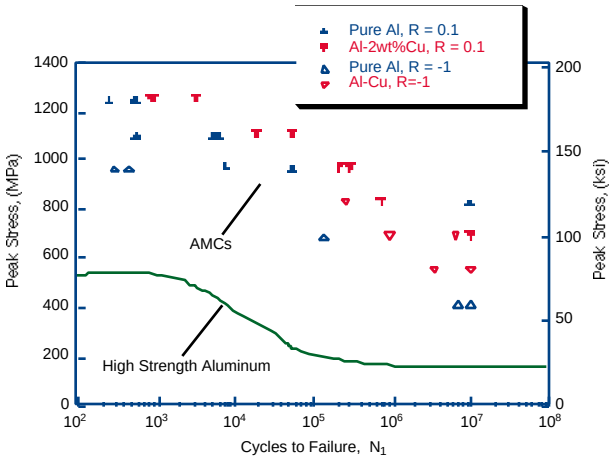
Typical ultimate tensile strength distribution

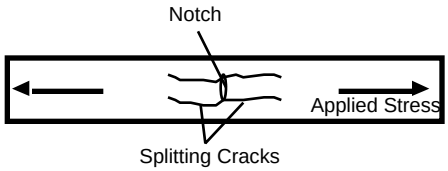


Typical shear stress-strain response



Typical longitudinal fatigue response: notched and un-notched

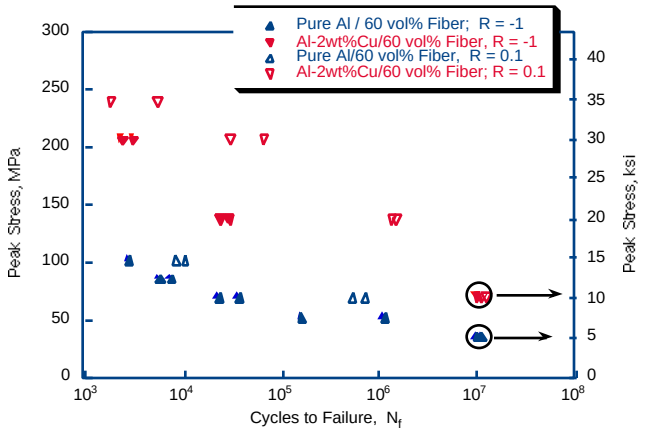




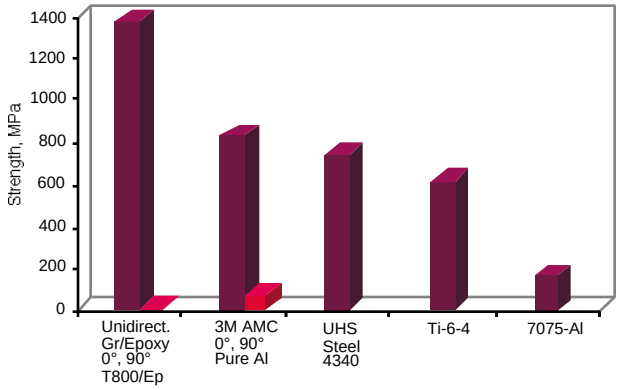
Notched and un-notched samples have a similar response. In the notched sample, the stress concentration is reduced by splitting at the root of the notch.

Aluminum Matrix Composites

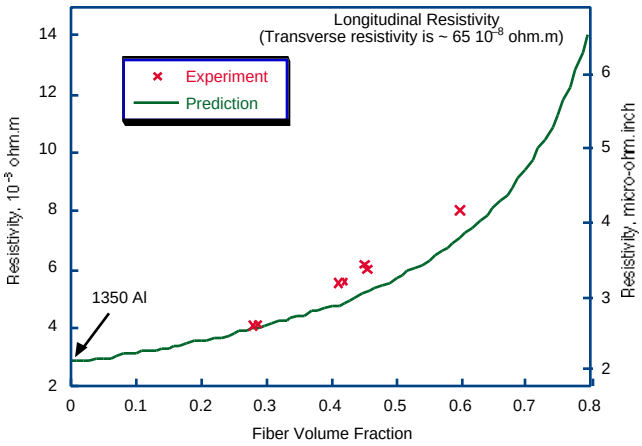
Typical transverse fatigue response



Materials comparison (fatigue strength)



Typical volume resistivity of pure Al/Al_2O3 composites



CFAMC corrosion damage

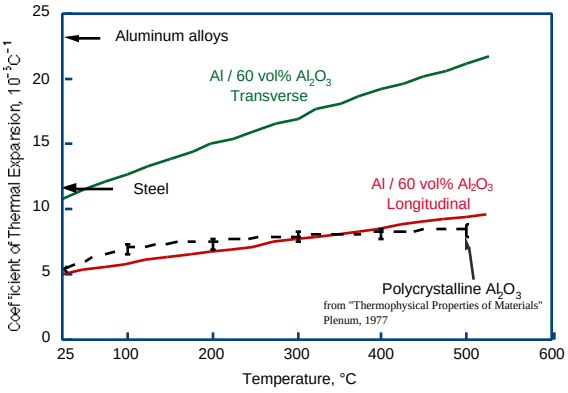
Corrosion damage of CFAMCs in salt water (1) is moderate and comparable to the unreinforced Matrix.

- Pure Al AMCs show good resistance in all three tests
- Al-2wt% Cu alloys have moderate resistance

(1) Tests:

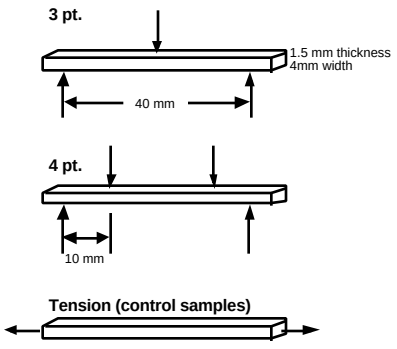
- *Acidified Synthetic Sea Water (fog) Test (SWAAT): ASTM G85-A3*
- *Salt Spray (fog) Test: ASTM B117-90 (2000 hrs)*
- *Immersion Corrosion Tests: ASTM B117*

CFAMC have a longitudinal CTE close to the fiber CTE



Typical bend strength

Al / 55 vol% Nextel™ 610



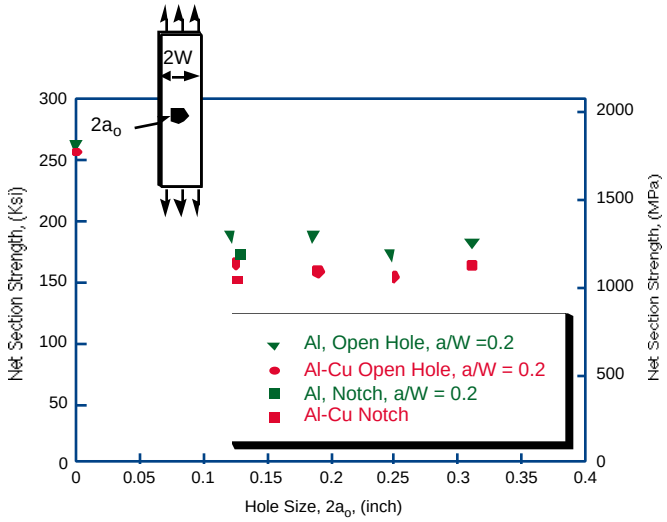
2290 MPa (330 ksi)

2070 MPa (290 ksi)

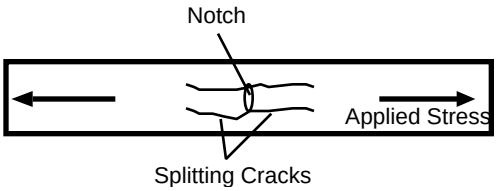
1855 MPa (270 ksi)

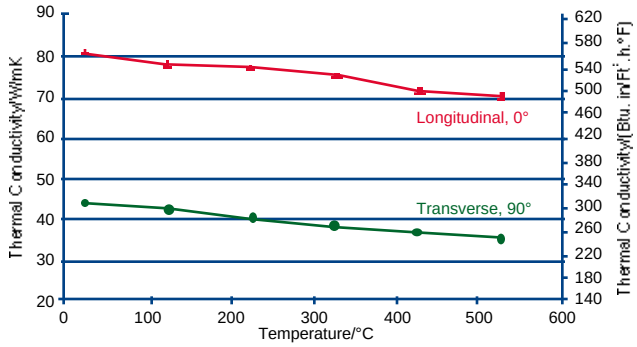
Aluminum Matrix Composites

Typical notch strength



AMCs have a reduced notch sensitivity due to "splitting" at the notch tip.





Notes

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Metal Matrix Composites Program

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