AD-A171 665 DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES(U) 1/1
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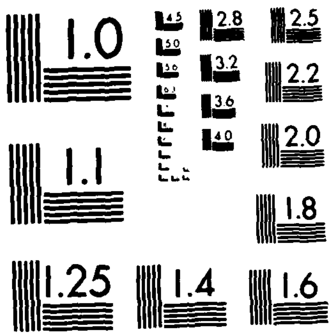

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QUARTERLY LETTER REPORT

Damping Characteristics of Metal Matrix Composites

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I. Contract Information

1.a. Title: Damping Characteristics of Metal Matrix Composites

1.b. ONR Contract Number N00014-85-C-0857

1.c. Principal Investigator: Mohan S. Misra, Martin Marietta Aerospace, Denver CO

1.d. ONR Scientific Officer: Dr. Steven G. Fishman

1.e. Period Covered: 4/10/86 - 8/10/86

II. Research Description

II.a. Description of Research

Metal matrix composite (MMC) with enhanced material damping can be potential structural materials to significantly improve the stability control and reliability of space structures. The objectives of the present investigation are: i) to identify the mechanism and source of damping in MMC (P55 Gr/6061 Al) by using in-situ characterization techniques; ii) to determine the role of microstructural parameters, e.g., fiber volume, fiber orientation and interfiber spacing, and iii) to define the role of fiber matrix interfaces.

II.b. Tests in Progress

II.b.1. Analytical Modeling

Damping in structural metals depends on stress level and thermal histories. In the stress amplitude dependent region, damping arises due to yielding of the material and attendant hysteretic effects under cyclic loading. For perfectly bonded composites, an analytical model has been developed to predict non-linear material damping behavior (i.e., in stress amplitude dependent damping region) of unidirectional Gr/Al composites. Damping test data obtained at 50 vacuum level in flexural (cantilever beam) mode, and also in extensional (tension-tension) mode was correlated with the model. The average predicted values in flexural mode are lower than measured values, and these differences have been attributed to parasitic losses (clamping effects) and residual stresses in fiber and matrix. Whereas, by using a matrix residual stress level of 6ksi and endurance limit of 15ksi, reasonable agreement has been obtained between predicted and measured values in the extensional mode. In essence, model analysis and data correlation indicate residual stresses adjacent to the fiber matrix interface significantly affect material damping.

II.b.2. In-Situ Damping Tests

(i) Moire Interferometry

Dynamic measurements conducted at Idaho National Engineering Laboratory by using 2400-l/mn grating on the free edge of a single-ply and three-ply Gr/Al [0°] specimens, do detect relative movement between the fiber and matrix. During flexural mode, this test technique detected in-plane displacement fields, indicating that localized matrix plasticity at intermediate stress level may be responsible for vibrational energy dissipation. Moire interferometry patterns are being analyzed to determine damping by computing the total strain energy and dissipation energy from hysteresis loops.

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(ii) Stress Pattern Analysis by Measurement of Thermal Emission (SPATE-8000 Stress Analyzer)

This technique was evaluated to measure stress and thermal gradients over a selected area of Gr/Al composites. These gradients can be identified in the matrix region between fibers, and quantified by appropriate calibration technique.

Preliminary SPATE analysis showed that during tension-tension cycling stress concentration factor of the order of 2.7 have been estimated in [0°] composites in localized regions, which can be attributed to void formation or debonding. Whereas, in [90°] Gr/Al composite, bands indicating high and low stress regions were observed presumably between the precursor wires; and stress concentration factors as high as 7 have been estimated. The region and magnitude of stress gradient may provide an indication of the site and extent of energy dissipation in metal matrix composites under cyclic stress loading conditions.

(iii) Acoustic Emission (AE)

Three types of precursor wires; as-fabricated, 25% shear deformed, and 50% shear deformed were tested in tension to record their AE characteristics. The amplitude distribution histograms showing accumulated events until tensile failure, indicated two distinct peaks for as-fabricated precursor wires as compared to single peaks in shear deformed wires. These peaks may correspond to a specific mechanism, such as debonding, fiber breakage or fiber pull out, etc., responsible for characteristic AE signal. A complete analysis for determining the AE source is in progress, while on the basis of present results, it can be concluded that:

1) in as-fabricated precursor wire the failure mechanism (second peak) is triggered by a primary mechanism which is high energy event detectable at low stress levels,

2) absence of high energy events peak in shear deformed suggests that damage (e.g., interfacial debonding) introduced during shear deformation, allows propagation of flaws at lower levels, leading to final failure.

(iv) Transmission Electron Microscopy (TEM)

Microstructural characteristics, such as second phase precipitates, dislocation substructure, nature of CVD coating on fibers, etc., adjacent to the fiber matrix interfaces can be revealed by analytical transmission electron microscopy. Prior to conducting in-situ damping measurements by using a deformation stage, test techniques were established to prepare thin specimens by ion milling; and analyze precipitate morphology and dislocation substructure.

TEM images of Gr/Al composites reveal the following details:

(i) Good bond at the fiber matrix interface

(ii) Three types of precipitate morphologies, blocky, lath and cuboidal types, with similar composition

(iii) CVD coating (Ti-B) much more adherent to aluminum matrix

(iv) Tangled dislocation structure near the interface

In addition, weak beam imaging technique is being used to determine dislocation densities in specimens cycled at different stress amplitude levels during (flexural and extensional mode) damping measurements.

Interface structure was also examined in diffusion bonded Gr/Mg composites, revealing a linear dislocation substructure, which bears a crystallographic orientation in the matrix region.

In a related study on damping measurement, of Gr/Al composites, test data analysis showed that dislocation damping as proposed by Granato-Lucke model may be the operative mechanism in the stress amplitude dependent region; and it can be verified by dislocation density measurements using TEM quantitative image analysis. Furthermore, differences in dislocation structure and densities in Gr/Al and Gr/Mg composites may also provide the basis of their characteristic damping behavior.

II.c. Presentation

SDIO/IST Advanced Composites program review at Woodshole, MA, June 3, 1986.

"Dislocation Damping in Gr/Al Composites", S.P. Rawal, J.H. Armstrong, and M.S. Misra, to be presented the TMS/AIME Annual Meeting, Denver, CO, March 1987

II.d. Technical Papers

"Interfacial Characterization and Damping in Metal Matrix Composites", S.P. Rawal, J.H. Armstrong and M.S. Misra to be presented at 11th Annual Conference on Composites and Advanced Ceramic Materials, Cocoa Beach, FL, January 1987.

II.e. Publications

None

II.f. Participants

Analytical Modeling: Material Science Corporation, Springhouse, PA
Damping Tests: University of Texas A&M. College Station, TX
Acoustic Emission: University of Denver, CO

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