AD-A137 121 DETERMINING AND MODELING THE RESPONSE OF PIEZOREIISTANCE TRANDUCERS TO DYNAMIC LOADING(U) WSSHINGTON STATEUUNIV PULLMAN DEPT OF PHYSICS 1/1

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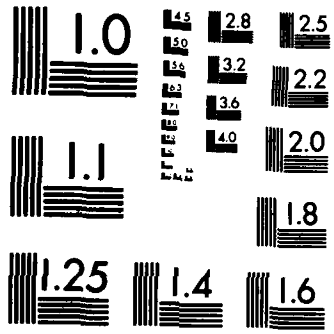
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Ytterbium (Yb)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The work of the past year has concentrated on experimental measurements and their analyses. The response of Yb foils, oriented parallel and perpendicular to the shock front, was obtained for well defined loading and unloading. The foils were embedded in a PMMA matrix and the longitudinal stress ranged between 0.1 and 2.0 GPa. Results have provided an empirical calibration for Yb under shock wave uniaxial strain loading. An important result from these experiments is the verification of an elastic-plastic inclusion analysis. The results of the 1.9 GPa experiment suggest that

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) under certain conditions a dynamic inclusion analysis will be necessary. Another important aspect of the this year's effort was the development of an experimental method to perform low strain-rate tensile experiments on gauge foils. Both mechanican and electrical measurements were obtained while the gauge was subjected to uniaxial tensile stress loading. Almost all gauge calibration is based on shock wave uniaxial strain experiments which are difficult, expensive, and not always accessible to those using these gauges. To avoid this difficulty, it is tentatively proposed that quasi-static experiments of the type developed can be performed to generate the appropriate material constants. In the analysis work, earlier analyses have been modified to permit a better calculation of residual resistance. The theoretical model has been adapted to analyze the quasi-static results.

AFOSR-TR- 83-1286

DETERMINING AND MODELING THE RESPONSE OF PIEZORESISTANCE TRANSDUCERS TO DYNAMIC LOADING

July 1983

Annual Report for Contract AFOSR-82-0132
Covering the Period Ending June 30, 1982

by

Y. M. Gupta

Prepared For:

Air Force Office of Scientific Research
Bolling Air Force Base
Washington, D.C. 20222

Attention: Lt. Col. J. J. Allen

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INTRODUCTION

The objective of this research program is to determine and model the response of piezoresistance gauges subjected to dynamic loading in the stress range 0.1 to 2.0 GPa*. A successful completion of this objective will permit accurate stress measurements under impulsive loading. Because of the stress range of interest, we have chosen to use ytterbium gauges. Although piezoresistance gauges are uniquely suited because of their suitable stress and time range and their adaptability to applications, the interpretation of the gauge data to infer a particular stress component of interest is difficult. This problem has been discussed in detail elsewhere.[1] Recently, a theoretical framework has been developed to quantitatively model the gauge response under shock loading.[1,2] The present research program is intended to extend the earlier work to achieve a first principles understanding of piezoresistance gauge response to enable data interpretation in complex loading situations.

This progress report summarizes the work done in the first year (ending June 30) of the three year program. Details of this work will be published in journal articles. We are currently preparing 3 manuscripts for submission to J. Appl. Phys. and copies of this will be submitted to AFOSR.

PROGRESS

The work in the past year has concentrated on experimental measurements and their analyses. Three main activities were carried out in the past year and these are discussed below. The names in parenthesis are the colloborators on these activities.

* This stress range was deemed of interest to AFOSR programs and applications.

1. Shock Wave Response of Yb Foils (Dr. S. C. Gupta):

The response of Yb foils, oriented parallel and perpendicular to the shock front, was obtained for well defined loading and unloading. The foils were embedded in a PMMA matrix and the longitudinal stress ranged between 0.1 and 2.0 GPa. The data obtained are of high quality and we plan to compile all of the experimental results (resistance change versus time profiles) for distribution to individuals who use ytterbium gauges. These results have provided an empircal calibration for Yb under shock wave uniaxial strain loading. An important result from these experiments is the verification of the elastic-plastic inclusion analysis presented in Ref. 1. Residual resistance measurements upon longitudinal unloading, for both orientations have been obtained. These data show a saturation in the residual resistance beyond a certain stress level in the matrix. Finally, the results of the 1.9 GPa experiment suggest that under certain conditions a dynamic inclusion analysis will be necessary. This result, due to the implications, has to be confirmed by repeating the experiment. We are currently analyzing these data as discussed later.

This activity has been the largest effort of the past year's work.

2. Quasi-static Measurements to Determine the Mechanical and Piezoresistance Coefficients (Dr. D. Y. Chen):

An important aspect of the first year's effort was the development of an experimental method to perform low strain-rate tensile experiments on gauge foils. Both mechanical and electrical measurements were obtained while the gauge was subjected to uniaxial tensile stress loading. Unloading and reloading experiments have also been performed. These measurements along with hydrostatic measurements on foils provide us with sufficient information to obtain the material constants for the phenomenological electro-mechanical model. Apart from the scientific data generated by these experiments, which we are currently analyzing, there is expected to be an important practical benefit. Almost all of the gauge calibration is based on shock wave uniaxial strain experiments. These experiments are difficult, expensive, and not always accessible to those using these gauges Because of material variations between different batches of foils, it is not prudent to use published calibration data. To avoid this difficulty, we tentatively propose that quasi-static experiments of the type we have developed can be performed to generate the appropriate material constants. Confirmation of this suggestion will require that we establish consistency between the quasi-static results and dynamic experiments (discussed above). We are currently working on this problem and will publish a technical report if we are successful in our efforts.

3. Analysis (Dr. S. C. Gupta):

The analytic work has focussed on two main tasks: analysis of the experiments indicated above and determination of the stress field immediately outside the inclusion. In the first task, we have modified our earlier analyses to permit a better calculation of the residual resistance. The theoretical model was adapted to analyze the quasi-static results. The determination of the stress field immediately outside the inclusion is important for determining the conditions under which the inclusion analysis is valid. For example, if tensions develop at the inclusion-matrix boundary, then the welded boundary condition is inapplicable.

PUBLICATIONS AND PRESENTATIONS

We presented three papers at the Third American Physical Society Topical Conference on Shock Waves in Condensed Matter (Santa Fe, NM July 1983).

1. Invited Paper: Y. M. Gupta, "Can Piezoresistance Gauges Be Used To Obtain Time-Resolved Stress Measurements In Shock Wave Experiments?"

2. Contributed Paper: S.C. Gupta and Y. M. Gupta, "Response of Ytterbium Foils Oriented Parallel and Perpendicular to the Shock Front."

3. Contributed Paper: D. Y. Chen, M. H. Miles and Y. M. Gupta, "Determination of Piezoresistive and Mechanical Constants for Piezoresistance Foils Used in Shock Experiments."

Of these, the first and third talks are based in part on the AFOSR work and the second talk is based exclusively on the AFOSR work. In addition, we are currently preparing three manuscripts for publication.

REFERENCES

1. Y. M. Gupta, "Stress Measurements Using Piezoresistance Gauges: Modeling the Gauge As An Elastic-Plastic Inclusion," J. Appl. Phys. (Oct., 1983).

2. Y. M. Gupta, "Analysis of Manganin and Ytterbium Gauge Data Under Shock Loading," J. Appl. Phys. (Oct. 1983).

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