CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
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S0218

Project Title
Predicting Material Failure: Correlation between Deformation Luminescence and Hysteresis

Abstract

Objectives/Goals
Material failure prediction would revolutionize modern engineering. Currently, scientists and commercial systems are unable to measure the impact of stress and, most importantly, to predict structural failure. The ultimate objective of this study is to develop a reliable material failure prediction model by analyzing the characteristics of deformation luminescence (DL) of materials under stress.

Methods/Materials
Mechanoluminescent irradiated Lithium Fluoride (LiF) crystals were utilized in experiments to observe DL as the material undergoes hysteresis. An Instron testing system was used to compress LiF with various stress, strain, load speed, cycling, and time duration variables. Photomultipliers were used to capture photon emission data. Data was collected both manually and with an oscilloscope computer data acquisition system from which mathematical models were derived.

Results
As LiF was stressed to its elastic limit, DL was found to increase drastically, signaling hysteresis. Under prolonged conditions, DL was found to decay in various mathematical relations against stress, strain and time duration. Also, DL increased logarithmically with load speed. Photon emissions were also found to be effective in identifying the presence of internal cracks and denoting the phenomena of fracture. The accumulative total of photons emitted up to fracture remained relatively constant even under different stress regimens.

Conclusions/Discussion
Conclusively, DL was demonstrated to be a superior indicator of hysteresis, the precursor to failure. The accumulative total of photons emitted up to fracture was found to be an potential predictor for material failure. The discoveries made in this study will help develop a reliable material failure prediction system. These findings will ultimately improve the safety and efficiency of vehicles, machines, and structures we use today.

Summary Statement
The purpose of this study is to develop a novel material failure prediction system by analyzing deformation luminescence of materials under stress.

Help Received
Used lab equipment at UCLA under the supervision of Dr. Putterman and Dr. Chakravarty