CALIFORNIA STATE SCIENCE FAIR
2006 PROJECT SUMMARY

Name(s)
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Project Number
S0216

Project Title
Detection of Metal Fatigue and Defects by Electron Work Function Topography and Gradient

Abstract

Objectives/Goals
I explore the electron work function (EWF) and its relationship with metal fatigue and defects. All materials fatigue, deteriorate and eventually fail, disrupting everyday use of vehicles, machines, and structures. Since no method currently exists to actively monitor deformation, my objectives are (1) to develop an original real-time monitoring method for fatigue, (2) to detect surface and internal defects, and (3) to propose a parallel dislocation mechanism for both exo-electron emission of metals and deformation luminescence of ionic crystals, which was studied previously.

Methods/Materials
Compressive and three-point bending tests on hardened aluminum were conducted to determine the effects of plastic deformation and flaws on exo-electronic emission. Because low-energy exo-electrons dissipate quickly in the atmosphere, the Kelvin method, measuring the EWF gradient, was utilized to measure the increased surface electric potential resulting from exo-electron emission. Mathematical modeling and analysis were done from stress-strain data taken by a material testing system and EWF data from a Kelvin probe

Results
The results show that the EWF gradient is (1) a clear real-time indicator for metal fatigue, (2) useful for determining cumulative deformation in the lifetime of a metal through derived mathematical modeling. EWF topographies, taken from Kelvin probe mounted on a three-dimensional stage, were found to be effective in (1) identifying and pinpointing the locations of both surface and internal flaws, and (2) visualizing the stress distributions of a metal under load.

Conclusions/Discussion
I observed novel phenomena with implications for an original non-destructive, non-contact, on-site, real-time monitoring method. The EWF is an intrinsic attribute of the lattice structure of a metal, and therefore provides accurate characterization of overall metal health. These findings may lead to safer use of vehicles, machines, and structures.

Summary Statement
My study presents an original real-time metal monitoring method, which is effective in indicating fatigue, pinpointing flaws, visualizing stress distributions, and determining cumulative deformation.

Help Received
Used lab equipment at UCLA under supervision of graduate student, Mr. Juan Escobar.