Reconstructing the Evolution of Bulk Plastic Deformation From Limited Surface Displacement Measurements

Junjie Yang[1], Daniel Magagnosc[2], Tamer Zaki[1], Jaafar A. El-Awady[1]

[1]*Department of Mechanical Engineering, Johns Hopkins University, USA*
[2]*Army Research Laboratory, USA*

ABSTRACT

Interpreting acoustic emission (AE) is a non-destructive evaluation (NDE) technique based on the elastic stress waves caused by irreversible deformations in materials. The core challenge is decoding AE signals and quantitatively determining the source, or deformation mechanisms. We adopt variational and machine-learning approaches to decode the complex interconnections between plastic deformation mechanisms in metals and the AE they emit. Surrogate measurements of AE associated with different dislocation mechanism were first obtained from full 3D elastodynamic-field solution incorporated into 3D Discrete Dislocation Dynamic simulations. Data assimilation procedures use the AE signals at individual sensors only, and reconstruct the plastic deformations. We show that the dislocation activities history in 3D can be accurately reconstructed using a single AE sensor. This approach enables the decoding of hard-to-interpret surface AE measurements and reconstruct plastic slip intrinsically in the material during deformation.