Abstract:

The "isotropic, homogeneous" assumptions commonly considered in the macroscopic modeling of materials break down across multiple length scales for a wide range of realistic scenarios. Atomistic flaws like Schottky defects (missing atoms) or Stone-Wales defects (rotated bonds) in ordered crystalline materials like Graphene affect the far field Cauchy stress evolution and the local energy release rate. Multi-scale predictions of the mechanical strength and energy release using molecular dynamics (MD) are observed to deviate from the linear elastic fracture mechanics (LEFM) below a certain length scale. The deviations will be highlighted in the presentation for Graphene nanoplatelets subjected to isotropic, uniaxial straining at room temperature. Similarly, polycrystals are composed of grains appearing in different sizes, shapes, and orientations. The assumption of macroscopic homogeneity is associated with considering an effective elastic stiffness for the bulk medium. On the other hand, the macroscopic isotropy corresponds to a random grain orientation distribution in the respective microstructure. However, this spatial variation in the grain orientations results in microscopic heterogeneities that scatter the propagating elastic waves, resulting in attenuation in energy and a change in wavespeed (phase velocity). The existing analytical models consider first-order correlations between grain boundaries. These models can provide reasonably accurate estimates of attenuation and wave speed for elastic wave propagation in metals with a low degree of heterogeneity, for example, aluminum. However, these estimates break down with an increase in the crystallite anisotropy. This presentation will highlight the frequency-dependent effects on the attenuation and wavespeed estimates for elastic wave propagation in common metals through the development of an analytical model, including the higher-order statistical correlations between grain boundaries. Lastly, the microscopic heterogeneities also influence the macroscopic crack speed divergence (Paris law) in metals subjected to fatigue fracture. The presentation will include finite element cohesive zone models (FE-CZM) toward validation through the acoustic emission experiments and the analytical crack speed divergence at criticality.

Biography:

Anubhav Roy is a postdoctoral researcher at CNRS (France), where the CNES-funded project aims at acoustic characterization and residual lifetime prediction for fatigue fracture in alloys. Anubhav received a PhD in Engineering Science and Mechanics from The Pennsylvania State University. At Penn State, he worked with Dr. Christopher Kube toward understanding elastic wave propagation in polycrystals.
Anubhav received the Sabih and G¨uler Hayek graduate fellowship in Engineering Science and Mechanics in 2019 and 2020. Proposing a bottom-up scheme to facilitate an in situ, real-time monitoring of the processing–structure–property relationships for additively manufactured metals, Anubhav received the Best Poster Presentation award at the International Congress in Ultrasonics (Belgium) in 2019. In 2020, in collaboration with Sandia National Laboratory, he developed a computational tool propSym that efficiently reduces any general order (and rank) material property tensors corresponding to all crystal point groups. He was a part of Dr. Kube's research on developing the large-on-large acoustoelastic theory for anisotropic materials. Anubhav is among the five recipients of the 2022 ASNT (American Society for Nondestructive Testing) Fellowship Award. In the past, he earned a Master of Science in Aerospace Engineering and Mechanics from the University of Alabama in 2018, where he received the Outstanding Graduate Research Assistant award. Anubhav worked as an undergrad intern in some of the most prestigious groups at IIT Kharagpur (2014), IIT Bombay (2015), and IISC Bangalore (2015).

He holds a bachelor's in Construction Engineering from Jadavpur University (Kolkata, India), where he worked on developing nondestructive evaluation (NDE) strategies for metals and laminated composites.

Anubhav's current research is focused on developing acoustic precursors to crack speed divergence (criticality) in the fatigue fracture of metallic alloys subjected to small-scale yielding, following a thorough characterization of the same to validate the finite element cohesive zone model (FE-CZM). During his PhD at Penn State University, his dissertation investigated the effects of including higher-order statistical correlations between the grain boundaries on the homogenized estimates of wavespeed and attenuation for elastic wave propagation in polycrystals. During this time, he also developed the 'propSym' software to reduce a general order material property tensor of any rank based on symmetries from crystallographic point groups and respective generalized constitutive models.