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Department of
Mechanical Engineering
The University of Hong Kong

DEPARTMENT OF
MECHANICAL ENGINEERING
THE UNIVERSITY OF HONG KONG

"Distinguished Research Seminars by two Fellows of the Royal Academy of Engineering"

Slip, dislocations and stored energy density in polycrystal crack nucleation and growth

Date: 20 March, 2024 (Wednesday)
Time: 3:00 p.m. – 4:00 p.m.
Venue: LE6, Library Extension Building
HKU

Speaker: Professor Fionn Dunne
RAEng/Rolls-Royce Research Chair
Rolls-Royce Nuclear UTC Director

Abstract:
Short, microstructurally-sensitive crack growth in engineering alloys may contribute a significant fraction of fatigue life but is not yet fully mechanistically understood. Nucleation site, crack path tortuosity and rates of initiation and growth remain key questions to address and solutions at the microstructural length scale could offer the potential of substantive improvement in safety-critical component design.

In this presentation, studies based on integrated small-scale experiment, high-resolution characterisation and discrete dislocation and crystal plasticity modelling will be presented to address hypothesised aspects of the mechanistic bases of the above phenomena. Quantification of slip, lattice curvature and dislocation density, and stored energy density have provided insights in to strain localisation, crack nucleation site [1] and crack paths, and propagation rates in a range of engineering alloys [2]. As a particular example, the crystallographic nature of short crack growth in HCP zirconium alloy is addressed, and its relationship to slip activation and crack tip stored energy density considered by comparison of experimental measurements of crystallographic growth rates and crack paths with crystal plasticity modelling.

[1] Nikoletta Prastiti et al. Discrete dislocation, crystal plasticity and experimental studies of fatigue crack nucleation in single-crystal nickel. Intl. Jnl. Plasticity, 126, 2020. https://doi.org/10.1016/j.ijplas.2019.10.003.
[2] Yilun Xu et al. Microstructural fracture mechanics: stored energy density at fatigue cracks. Jnl. Mech. Phys. Solids. 146, 104209, 2021. https://doi.org/10.1016/j.jmps.2020.104209.

Biography:
Professor Fionn Dunne researches in micromechanics of microstructure-level deformation and the mechanistic drivers of fatigue crack nucleation and growth, including Titanium cold dwell fatigue. A particular focus is bringing together quantitative characterisation (DIC and EBSD) with computational discrete dislocation and crystal plasticity. He was RAEng/Rolls-Royce Research Chair, Rolls-Royce Nuclear UTC Director, served on MOD's Research Programmes Group, and currently on MPI's Intl. Sci. Advisory Board. He led the HexMat EPSRC programme grant (£5m), and is partner on the USAF MAI Dwell Programme. He was elected Fellow of the UK's Royal Academy of Engineering in 2010, and awarded the IoM3's Harvey Flower Prize 2016.

[Replacement] Continuum Dislocation Dynamics (CDD) based on "All-Dislocation" Density (ADD): A New Formalism of Dislocation-based Crystal Plasticity

Date: 20 March, 2024 (Wednesday)
Time: 4:00 p.m. – 5:00 p.m.
Venue: LE6, Library Extension Building
HKU

Speaker: Professor Alfonso H.W. Ngan
Department of Mechanical Engineering
The University of Hong Kong
Hong Kong

Abstract:
One of the holy grails of computational material science is to satisfactorily predict metal plasticity from fundamental dislocation physics. Currently, discrete dislocation dynamics (DDD) is still limited to small quantities of dislocations irrelevant to most engineering applications, and slip-system based crystal plasticity (CP) lacks details of dislocation physics. Continuum dislocation dynamics (CDD) has received considerable interests for bridging the gap at the meso-scale. Recently, an exact evolution equation for an "all-dislocation" density (ADD) that represents continuum dislocation quantities over both space and dislocation-character domains has been developed by the present author. For coarse-grained simulations, ADD is superior to the Nye tensor or other representations of geometrically necessary dislocations (GND), since the statistically stored dislocation (SSD) contents which are important for dislocation dynamics will be preserved. In this talk, this new approach of CDD based on ADD will be presented.

Biography:
Professor Alfonso Ngan is Kingboard Professor in Materials Engineering and Chair Professor of Materials Science and Engineering at the University of Hong Kong. His interests include novel stimuli-responsive materials, material defects and their modelling, and nanomechanics, including applications to biological systems. His main contributions include a method for correcting viscoelastic effects in nanoindentation measurements of soft materials which has been converted into a Chinese national standard, understanding of stochastic deformation behaviour in small crystals, an exact formalism of continuous dislocation kinematics, and the discovery of a novel class of metal hydroxides/oxides as stimuli-responsive actuating materials. His research-related honours include the Rosenhain Medal from the Institute of Materials, Minerals and Mining, UK (2007), Changjiang Professorship from the Chinese Ministry of Education (2019), and Guanghua Engineering Science and Technology Prize of the Chinese Academy of Engineering (2020). He is currently an associate editor of the International Journal of Plasticity, and an International Fellow of the Royal Academy of Engineering in the UK.

ALL INTERESTED ARE WELCOME

For further information, please contact Professor A.H.W. Ngan at 3917 7900.