I²CNER Webinar

International Institute for Carbon-Neutral Energy Research (WPI-I²CNER)
Kyushu University

Title

In-situ TEM studies of crack propagation

Speaker Prof. Cynthia Volkert
Institute for Materials Physics, University of Göttingen, Germany

Time& Date 16:00 PM(JST), Wednesday, October 18th, 2023

Abstract

We have developed a method to control and observe the dynamics of crack propagation in thin lamella inside a transmission electron microscope. So far, we have applied the technique to study fracture in wood cell walls, multilayer films, and steel specimens. Combined with the gas pressure capabilities of our microscope, we can also observe environmental effects on crack propagation.

This talk will primarily focus on the effects of a hydrogen ambient on crack propagation in steels. Identifying the atomic scale mechanisms for hydrogen embrittlement in steels remains a much discussed yet elusive goal. On the one hand, microscopy investigations show that hydrogen enhances dislocation motion, while on the other, the quasi-cleavage morphology of the fracture surfaces and early fracture confirm the embrittling role of hydrogen. We attempt to reconcile these apparently contradictory trends using dynamic studies of crack tip propagation in Cr-Mo low alloy steel lamellae. The first stage of crack propagation in the lamellae involves extensive plasticity and thinning ahead of the crack tip, whether hydrogen gas is present or not in the microscope chamber [1]. However, subsequent stages are strongly changed by pressures as low as 2 mbar of H_2. In the absence of hydrogen gas, extensive plasticity continues, leading to crack tip blunting, void nucleation, crack bridging and necking [1]. In contrast, the crack tip in hydrogen gas remains sharp and propagates by the formation and linking up of {100} facetted staircase micro-cracks, without much associated plasticity. We argue that the mechanisms observed in the thin lamella can be extrapolated to the geometry and stress state of bulk materials and account for their fracture behavior. Evidence for contributions from both HEDE and HELP defect mechanisms will be discussed.

[1] L. Tian, C. Borchers, M. Kubota, P. Sofronis, R. Kirchheim, C.A. Volkert, Acta Materialia 223 (2022) 117474.

About the Speaker

Cynthia Volkert is a professor at the Institute of Materials Physics at the University of Göttingen where she specializes in the dynamical behavior of nano-scale materials and in-situ electron microscopy. After a Bachelor degree in physics from McGill University and a PhD from Harvard University, she spent 10 years at Bell Laboratories working on ion-solid interactions, thin metal film deformation, and electromigration. She then moved to Germany, first to the Max Planck Institute for Metals Research in Stuttgart and then to the Karlsruhe Institute of Technology, before moving to Göttingen in 2007. Cynthia was President of the Materials Research Society in 2008 and has served on wide selection of advisory committees and boards, such as for the Humboldt, Max-Planck, Leibniz, and Helmholtz Societies. A few of her current research interests are: understanding the remarkable mechanical behavior of wood, unraveling the mysteries of nucleation, detecting order and avalanche processes in metallic glasses, and studying which material degrees of freedom control the dissipation of energy at sliding contacts.

Registration https://zoom.us/webinar/register/WN_pwc_RlSbR7eIJ6rlWt14JA

Host Prof. Masanobu Kubota

Contact I²CNER・Q-PIT Office of Research Support Services,
Research Support and Public Relations
TEL: +81 92 802-6935
Email: iq-kenkyu@jimu.kyushu-u.ac.jp

Register here!!