**HIGH-TEMPERATURE FRACTURE TEST USING CHEVRON-NOTCHED TUNGSTEN MICROCANTILEVERS**

Bo-Shiuan Li, Department of Materials, University of Oxford, Parks Rd., Oxford OX1 3PH, UK
bo-shiuan.li@materials.ox.ac.uk
David Armstrong, Department of Materials, University of Oxford, Parks Rd., Oxford OX1 3PH, UK
James Marrow, Department of Materials, University of Oxford, Parks Rd., Oxford OX1 3PH, UK
Steve Roberts, Department of Materials, University of Oxford, Parks Rd., Oxford OX1 3PH, UK

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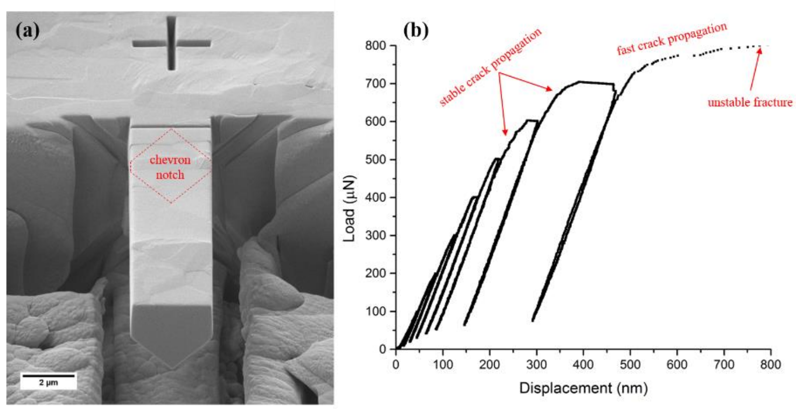
The combination of focused-ion beam (FIB) based sample preparation and nanoindentation allows fracture tests to be conducted at the micro-scale. Micro-fracture tests are of great interest to the nuclear materials community, as it allows direct measurements of fracture toughness within thin ion-irradiated layers and significantly reduces the volume of radioactive samples required as compared to working with neutron irradiated samples.

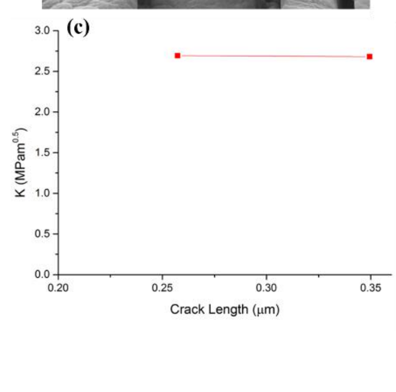
The main drawback of existing micro-fracture tests is its limitation to brittle materials, as only linear-elastic fracture mechanics (LEFM) solutions have been developed so far. Tungsten-tantalum (W-Ta) alloy, is the primary candidate material for the plasma facing components of a future fusion reactor divertor, however is a semi-brittle material. LEFM solutions neglect any local plastic deformation that contribute to the blunting of the crack tip, therefore underestimate the true fracture toughness. Elastic-plastic fracture mechanics (EPFM) is necessarily to quantitatively analyse the complete fracture process, this greatly complicates both sample manufacture and experimental analysis. This research introduces a novel chevron-notch design to the W-Ta micro-cantilevers to promote stable crack growth which is a requisite for the EPFM approach.

Cantilevers, manufactured using FIB machining, were loaded via a cyclic method, using a G200 Nanoindenter to monitor the stiffness in each cycle. By monitoring the decrease in stiffness of the cantilever through the cycles, crack length can be measured. Given detailed information of the crack length and the cantilever geometry, the complete fracture process of the semi-brittle W-Ta alloy can be quantitatively analysed.

Initial results showed the fracture toughness of W-1%Ta alloy at room temperature is 2.7 MPa·$m^{0.5}$, showing no significant R-curve behaviour before the onset of unstable fracture. This revealed no crack tip blunting occurred when tested at room temperature. This result is consistent with previous macro-scale fracture tests of W-1%Ta alloy at room temperature.

The future goal is to extend this technique at elevated temperatures using our hot nanoindenter (up to 750 °C). This will provide quantitative analysis of the fracture process of W-Ta alloys at real reactor operating environment. By comparing micro- with macro-fracture toughness, this will also shed light on the feasibility of using micro-fracture tests to probe bulk fracture toughness.




(a) FIB-milled micro-cantilever of W-1%Ta alloy with chevron notch near the fixed end

(b) Cyclic load-displacement data of the tested cantilever, showing stable/fast/unstable crack behaviours with increasing load

(c) Fracture toughness vs. crack length, indicating no crack-resistance behaviour of the W-1%Ta cantilever at room temperature