SMALL-SCALE MECHANICAL TESTING OF NUCLEAR STRUCTURAL MATERIALS

Vineet Bhakhri, Canadian Nuclear Laboratories, Chalk River (ON), Canada
vineet.bhakhri@cnl.ca
Colin Judge, Jaganathan Ulaganathan, Chris Dixon, Clinton Mayhew, Daniel Arnold, Heidi Nordin, Sterling St Lawrence, Canadian Nuclear Laboratories, Chalk River (ON), Canada
Cameron Howard, Peter Hosemann, Department of Nuclear Engineering, University of California, Berkeley (CA), USA

Keywords: Nuclear Materials, Nano-indentation, Micro-Tensile Testing, Micro-compression Testing.

Material property changes due to harsh reactor environment conditions, such as neutron irradiation and high temperature, may limit the performance and the safe operating envelopes of all reactor types. Quantitative information on the material properties changes is needed to support ongoing life extension/ life management efforts of the existing global reactor fleet, as well as for design and development of future advanced reactor concepts. Testing of larger radioactive test specimens is challenging and expensive, as it requires their handling and testing in shielded facilities. Testing smaller sized specimens has an advantage in terms of their reduced activity that allows for safer handling and cost effective testing processes.

In this poster, examples of various small-scale ex-situ and in-situ SEM mechanical testing techniques, currently being developed at CNL, and in collaboration with UC Berkeley, will be included. The applications of nano/micro-indentation, micro-compression and micro-tensile testing to acquire local and bulk properties measurements in structural nuclear materials are being explored, with an aim to extend their use to characterize radioactive specimens extracted from reactor components. In particular, nano/micro-indentation testing, in combination with EBSD measurements, is being used to perform spatial mapping of mechanical properties of metallic alloys of interest to the nuclear industry (Fig. a). The use of this technique to investigate the localized kinetics of plastic deformation to determine the strength of the rate controlling obstacles is also being explored. Whereas, in-situ micro-compression testing is employed to determine the bulk material flow properties from small specimens extracted from reactor components (Fig. b). Micro-structural features, such as grain-boundaries and twins, play an important role in determining bulk material behavior, and hence the structural integrity of materials used in a reactor environment. Finally, micro-tensile test examples, showcasing test specimens containing these isolated interfaces in non-irradiated and irradiated Ni-based super alloys, to investigate the role of neutron irradiation on their strength will be presented (Fig. c).

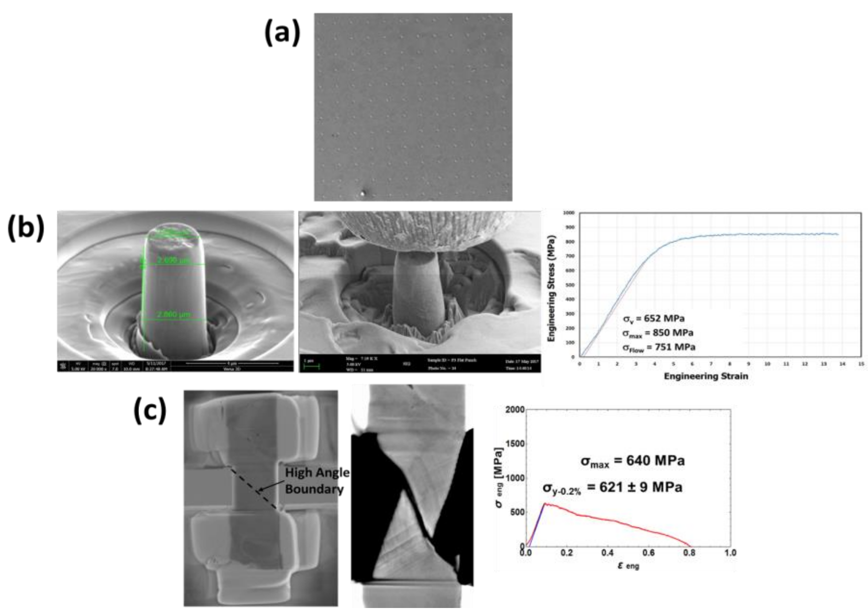

Figure: Small-scale mechanical testing at CNL: (a) Nanoindentation testing for spatial mapping, (b) Micro-compression tests for bulk material property evaluation, (c) Micro-tensile testing of specimens with isolated micro-structural features