NANOINDENTATION OF FERRITIC-MARTENSITIC STEELS – A COMPARATIVE STUDY OF STATIC AND DYNAMIC MEASUREMENTS

Ana Ruiz Moreno, Joint Research Centre. European Commission, Netherlands
Ana.RUIZ-MORENO@ec.europa.eu
Peter Hähner, ibid.

Key Words: nanoindentation, continuous stiffness measurement, ferritic-martensitic steel, indentation size effect

Nano- and micromechanical test techniques offer important advantages for the assessment of neutron irradiation damage (minimized volume of activated material) and ion irradiation damage (limited penetration depth) which is of interest for the emulation of neutron irradiation damage. This paper presents a comparative study of different nanoindentation methods as applied to two ferritic-martensitic steels (T91 and Eurofer97), here investigated in the unirradiated reference state, but envisaged as structural materials for nuclear applications. Depth-controlled single cycle (DSC) measurements at various final indentation depths, force-controlled single cycle (FSC), force-controlled progressive multi-cycle (PMC) measurements, and continuous stiffness measurements (CSM) using a Berkovich tip at room temperature have been combined to determine the indentation hardness and elastic modulus, and assess the robustness of the different methods together with their statistical properties. The Nix-Gao model is applied to analyse the indentation size effects observed with static and dynamic measurement methods. The breakdown of the scaling regime at large inverse indentation depths is sensitive to the dynamic testing parameters. The work has been performed in the framework of nine laboratories engaged in a more comprehensive round robin exercise within the European Energy Research Alliance – Joint Programme on Nuclear Materials (EERA JPNM), the results of which will be presented elsewhere.

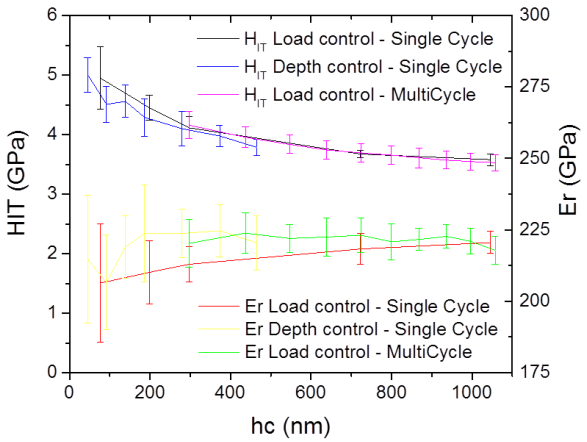

Fig. 1. Hardness and reduced modulus of T91 measured by static nanoindentation

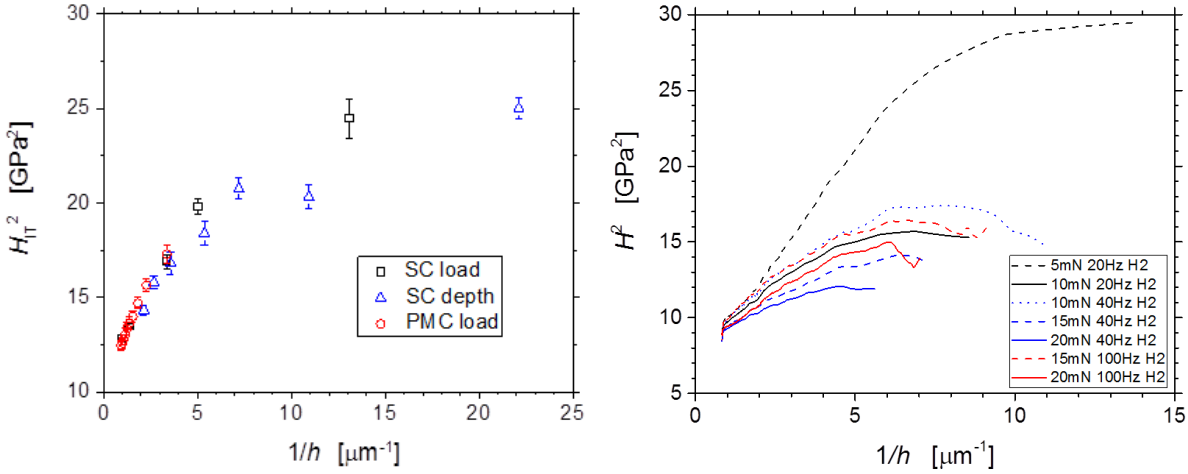

Fig. 2. Nix-Gao model applied to static (left) and dynamic (right) nanoindentation hardness of T91 (averages of 10 measurements for various sinus amplitudes and frequencies)