EVALUATION OF IRRADIATION HARDENING OF ION-IRRADIATED REDUCED-ACTIVATION FERRITIC STEELS BY NANO-INDENTATION TECHNIQUES

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The present work investigates the irradiation hardening of reduced-activation ferritic/martensitic (RAFM) steel F82H and Fe-based model alloys after self-ion irradiation experiments to simulate the damage caused by fusion neutron irradiation. The irradiation hardening in the surface damage area was evaluated by means of nano-indentation techniques. The validity of the nano-indentation hardness data obtained from the ion-irradiated alloys was discussed.

The 6.4 MeV Fe^{3+} ion irradiation experiments at 290 °C up to 10 dpa at around 600 nm from the surface were carried out with the 1.7 MV Tandetron accelerator of DuET facility in Kyoto University. The nano-indentation tests were performed with the ENT-1100a (Elionix Co., Ltd.) as well as with the Nano Indentor G200 (Agilent Technologies, Inc.). A conventional loading-unloading methodology was applied to evaluate the hardness at a depth of 200 to 300 nm. Also the constant stiffness measurement [1] was used to obtain the depth-profile of hardness in the ion-irradiated region. The obtained results has been analyzed and discussed based on the Nix-Gao model [2].

As shown in the Fig.1, the depth-sensing nano-indentation techniques with CSM revealed that the hardness gradient of the un-irradiated F82H and Fe-based model alloy can be explained by the indentation size effect (ISE). On the other hand, the hardness depth profile of these materials after ion-irradiation was likely to be composed of two regions; the depth of 100 to 300 nm, and the deeper depth which is affected by the unirradiated (softer) area. It is noted that the hardness gradient at 100 to 300 nm after the ion-irradiation is quite similar with unirradiated one. This result means that the ion-irradiated materials have a similar ISE with the unirradiated ones. The detail of methodology to derive the irradiation hardening of ion-irradiated F82H steel will be proposed from the results of hardness depth profile.

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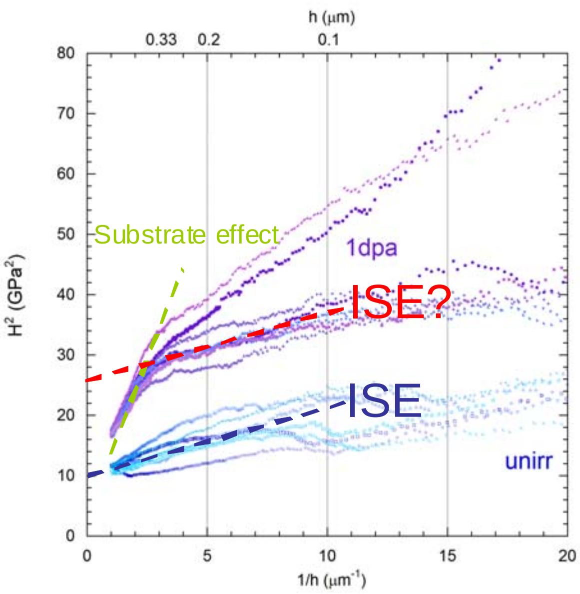

Figure 1: Hardness depth profile analysis based on the Nix-Gao model for the ion-irradiated and unirradiated F82H

[1] W.C. Oliver and G.M. Pharr, J. Mater. Res. 1564 (1992) 1564-1583.
[2] W.D. Nix and H. Gao, J. Mech. Phys. Solids, 46 (1998) 411-425.