Mechanical Properties of Thermally Aged and Ion Irradiated FeCr Alloys

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Fe-Cr alloys consisting of tempered ferritic martensitic microstructure are envisaged as one of the leading candidate structural materials for both fission and fusion reactors. The thermal aging and/or irradiation of Fe-Cr based alloys at temperatures below ~450°C leads to the formation of the Cr-rich α' phase which degrades mechanical performance. Under this context, the indentation mechanical properties of 14 to 25 % high purity Fe-Cr alloys are examined as function of ageing times to 900 h at 350, 450 and 550 °C. The special features of this work include measuring the nanoscale and microscale mechanical properties using three different indenter tips, namely Berkovich, Vickers and spherical. The Vickers and Berkovich pyramidal indenters provide traditional nanoindentation hardness results that can be compared with prior hardness studies. The spherical indenter with radii of 1, 5 and 10 μm are used to provide quantitative information on work hardening capacity of the different tested materials and thereby provides valuable information on both the yield and ultimate compressive strength. Fe18%Cr samples fabricated in the solid solution state and heat treated to induce pre-existing Cr-rich precipitates of various sizes and number densities were irradiated with 8 MeV Fe ions to a midrange (~1μm) dose of 0.35 displacement per atom (dpa) at 300, 350 and 450 °C with dose rates of 10^{-3}, 10^{-4} or 10^{-5} dpa/s. Fe-14%Cr samples in an initial solid solution state were also examined following ion irradiation at these same conditions. The nanoscale indentation hardness of these irradiated samples was examined using Berkovich and spherical indenters and will be compared with the behavior of the thermally aged specimens.