The Effect of Ni Ion Implantation on the Nanoindentation Response of a Ni 50.5at%-Ti 49.5at% Shape Memory Alloy

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Ion implantation is explored as a novel method to control the superelastic response of a solution-treated Ni50.5-Ti49.5 shape memory alloy, through the creation of irradiation-defects that could serve as nucleation and/or pinning sites for the B2-B19' phase transformation. Ni ion implantation levels (< 0.1 DPA) are used that are typically less than those reported in the literature for amorphization. TEM characterization reveals nanometer-scale defects and diffraction patterns are consistent with partial amorphitization. Instrumented nanoindentation arrays into the polished cross section reveal hardness increases of up to 70% at ~3 microns below the implanted surface, yet the recoverable displacement upon unloading is comparable to that for unirradiated material. Upon reindentation into existing indents, the irradiated material exhibits a highly linearized loading/unloading response with reduced hysteresis compared to unirradiated material. These results demonstrate that relatively low (<0.1 DPA) levels of Ni ion implantation can dramatically alter the critical stress and hysteresis of NiTi shape memory alloys. The mechanistic origins for these observations are explored and hypotheses are postulated based on finite element simulations of nanoindentation and phase field simulations of shape memory alloys with defects.

Keywords: Shape memory alloys, irradiation, nanoindentation.

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