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Multilevel Two-Phase Structuring in the Nitrogen Supersaturated AISI316 Stainless Steel

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Abstract : The austenitic stainless steel type AISI316 has been widely utilized as structural members and mold die substrates. The low temperature plasma nitriding has been utilized to harden these AISI316 members, parts, and dies without loss of intrinsic corrosion resistance to AISI316 stainless steels. Formation of CrN precipitates by normal plasma nitriding processes resulted in severe deterioration of corrosion toughness. Most previous studies on this low temperature nitriding of AISI316 only described the lattice expansion of original AISI316 lattices by the occupation of nitrogen interstitial solutes into octahedral vacancy sites, the significant hardening by nitrogen solid solution, and the enhancement of corrosion toughness. In addition to those engineering items, this low temperature nitriding process was characterized by the nitrogen supersaturation and nitrogen diffusion processes. The nitrogen supersaturated zones expanded by the nitrogen solute occupation to octahedral vacancy sites, and the un-nitrided surroundings to these zones were plastically strained to compensate for the mismatch strains across these nitrided and nitrided zones. The microstructure of nitrided AISI316 was refined by this plastic straining. The nitrogen diffusion process was enhanced to transport nitrogen solute atoms through the refined zone boundaries. This synergetic collaboration among the nitrogen supersaturation, the lattice expansion, the plastic straining, and the grain refinement yielded a thick nitrogen supersaturated layer. This synergetic relation was also characterized by the multilevel two-phase structuring. In XRD (X-Ray Diffraction) analysis, the nitrided AISI316 layer had □- and □-phases with the peak shifts from original lattices. After EBSD (Electron Back Scattering Diffraction) analysis, □-grains and □-grains homogeneously distributed in the nitrided layer. The scanning transmission electron microscopy (STEM) revealed that g-phase zone is N-poor cluster and a-phase zone is N-rich cluster. This proves that nitrogen supersaturated AISI316 stainless steels have multi-level two-phase structure in a very fine granular system.

Keywords : AISI316 stainless steels, chemical affinity to nitrogen solutes, multi-level two-phase structuring, nitrogen supersaturation
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