MFM imaging of expanded austenite formed in stainless steel and CoCr alloys

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Abstract

Ion beam surface modification methods can be used to create hard and wear resistant surface layers on austenitic stainless steel (SS) and CoCr base alloys using nitrogen ions. This is mainly due to the formation of high N content phase, γN, at relatively low substrate temperatures from about 350 to 450 °C. This surface layer is known as an expanded austenite layer. Different N contents and diffusion rates depending on grain orientations as well as anisotropic lattice expansion and high residual stresses are some peculiar properties associated with the formation of this phase. Another interesting feature of the expanded austenite phase is related to its magnetic character: the expanded phase/layer is found to have ferromagnetic as well as paramagnetic characteristics depending on its N contents (20-30 at.%) and associated lattice expansions (as high as 10%).
The objective of this research is to present new data related to the magnetic nature of the expanded austenite layer/phase formed on austenitic SS (304 SS) and CoCrMo alloys by nitrogen plasma immersion ion implantation (PIII). PIII experiments were performed in the temperature range between 300 and 550 °C for a fixed processing time of 1 hour. Magnetic structures, nitrogen distribution, implanted layer phases, and surface topography were studied by magnetic force microscopy (MFM), secondary ion mass spectroscopy (SIMS), X-ray diffraction (XRD), scanning electron microscopy (SEM), and atomic force microscopy (AFM). The low temperature samples clearly show the formation of expanded austenite phase, γN, while the decomposition of this metastable phase into CrN precipitates occurs at higher temperatures.
MFM imaging reveals distinct magnetic patterns on the stainless steel and CoCrMo alloy surfaces treated at low temperatures where expanded austenite is obtained at the surface. The ferromagnetism of the expanded austenite phase/layer becomes clear through the appearance of the striped magnetic domains. The domain size variations and varying magnetic properties in the different surface grains are observed. This is probably due to non-uniform N contents and anisotropic lattice expansion for differently oriented lattice planes as evidenced by XRD. MFM imaging across the sample cross-sections is currently underway to investigate N composition variation effects as well as depth dependence of the magnetic properties.

Keywords: PIII, CoCrMo alloys, expanded austenite, ferromagnetism, MFM

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