Effect of Nitrogen Content on the Corrosion Resistance of Zr-Ni-Al-Si Thin Film Metallic Glass

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Nitrogen-free and nitrogen-doped Zr-Ni-Al-Si thin film metallic glasses (TFMGs) were prepared through a plasma emission monitoring (PEM) control process in a co-sputtering system. The corrosion behaviors of these TFMGs coated onto AISI 420 stainless steel substrates in 3.5 wt. % aqueous sodium chloride were studied using electrochemical impedance spectroscopy and equivalent circuit simulation. Nitrogen contents of 11.1 and 15.4 at. % were obtained for TFMGs fabricated under 30 and 70% Zr target poisoning rates, respectively. The amorphous and nitrogen-free TFMG provided the highest corrosion impedance after one hour of immersion in 3.5 wt.% aqueous sodium chloride due to its featureless and dense microstructure. However, the corrosion impedance values of this nitrogen-free TFMG decreased rapidly after immersion for 12 and 24 hours, which could be attributed to its poor adhesion to the AISI 420 stainless steel substrate. Meanwhile, the 15.4 at. % N-doped TFMG showed a stable and good corrosion resistance after immersion for 1 to 24 hours due to its dense nanocomposite microstructure consisting of ZrN nanograins embedded in an amorphous matrix. The lowest corrosion impedance values were found for the TFMG containing 11.1 at. % nitrogen, and this finding can be attributed to the columnar microstructure of this TFMG, which provides a shortcut for the corrosive electrolyte to penetrate through the boundaries to the AISI 420 stainless steel substrate.

Keywords: Zr-Ni-Al-Si thin film metallic glass, plasma emission monitoring, target poisoning, corrosion test, electrochemical impedance spectroscopy

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