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Magnetron Sputtered Amorphous Carbon Nitride Coatings as Corrosion Protection

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Abstract –The thin film amorphous carbon (a-C) can be considered as a class of materials with properties similar to those of diamond films. In this study, the corrosion resistance of 316L stainless steel on which thin films of amorphous carbon nitride (a-$CN_{0.18}$) have been synthesized were investigated by electrochemical impedance spectroscopy (EIS) in H_2SO_4 (0.1M, 0.5M, 1M). The films were deposited by RF magnetron sputtering from a graphite target. The results show that the carbon layer strongly decreases the anodic dissolution of steel and his protective power remains high even after 8 months of immersion.

From the point of view of their organisation, the solids consisting of the element carbon can be divided into two groups: crystalline and amorphous carbon. There are two main crystalline forms, diamond, which all are hybridized carbon sp^3, and graphite, which all are hybridized carbon sp^2. The amorphous carbon corresponds to a random distribution of carbon atoms. Such a structure can be achieved by a random distribution of sp^3 and sp^2 hybridized carbon. Interest diamond lies in the variety of its unique properties, among which the mechanical, optical and electronic. However, we can not use the bulk material because its high cost. Coating materials used for technological applications with thin layers, is the most interesting way to transfer sought properties to the materials less noble. The thin film amorphous carbon (a-C) can be considered as a class of materials with properties similar to those of diamond films. Obtained by steaming or by sputtering of a graphite target, a-C is composed primarily of carbon atoms in sp^2 hybridization. To dope these materials and modify its electronic properties, we use other elements such as nitrogen and boron. Among many other possible technological applications a-C is an interesting material to be used as a protective coating to improve the lifetime or the performance of metallic substrates when exposed to aggressive environments [1,2].

In this study, the corrosion resistance of 316L stainless steel on which thin films of amorphous carbon nitride (a-$CN_{0.18}$) have been synthesized were investigated by electrochemical impedance spectroscopy (EIS) in H_2SO_4 (0.1M, 0.5M, 1M). The films were deposited by RF magnetron sputtering from a graphite target. The substrates (plates of 5.5 x 6.0 cm) were mechanically polished, degreased, ultrasonically cleaned, dried and finally mounted on a substrate holder and loaded into the magnetron sputtering chamber for the coating deposition. High purity argon (99.99%) was used as sputter gas and the nitrogen percentage was imposed in these films by controlling the argon/nitrogen plasma composition. The electrochemical cell consists of three electrodes: (i) the working electrode diameter 36 mm, (ii) a counter electrode consists of a grid of platinum, and (iii) a reference electrode in saturated solution of K_2SO_4. The experiments were performed with 10 mV sinusoidal perturbation at different potential (-0.4V, -0.2V, 0V, +0.2V, +0.4V) and the frequency range varied from 60 kHz to 1mHz.

The diagrams of electrochemical impedance show that stainless steels have a high resistance to corrosion, due to a very thin film passive, which is formed naturally on the surface of the material but the size of the loop capacitive is always lower for stainless steel without a-$CN_{0.18}$ coating. The carbon layer strongly decreases the anodic dissolution of steel. His protective power remains high even after 8 months of immersion. Polarization resistance of coated steel is larger than that of non-coated steel. This shows that the corrosion rate is ten times lower when steel is coated with amorphous carbon. The thin layer of amorphous carbon nitride gives a better anticorrosive performance to 316L stainless steel for all investigated potential in H_2SO_4.

References

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