Plasma-based nitriding and oxidizing of CoCrMo: investigation of structural and corrosion characteristics for biomedical applications

Fotini Noli*†[1], Jean-Paul Rivière[2], Luc Pichon[2], Orhan Ozturk[3], and Michel Drouet[2]

[1]Aristotle University – Department of Chemistry, Aristotle University, GR-54124 Thessaloniki, Greece
[2]Institut Pprime (PPRIME) – CNRS : UPR3346, Université de Poitiers, ENSMA – Département de Physique et Mécanique des Matériaux, SP2MI, Teleport 2, Boulevard Pierre et Marie Curie BP 30179, 86962 Futuroscope Chasseneuil Cedex, France
[3]Izmir Institute of Technology – Department of Physics, Izmir Institute of Technology, Gulbahce-Urla, 35430 Izmir, Turkey

Abstract

In order to improve its surface mechanical properties and corrosion resistance, plasma-based nitriding and/or oxidizing treatments were applied to biomedical grade CoCrMo alloy. Three kinds of treatments were performed: some CoCrMo samples have been subjected to nitridation at moderate temperature (395∘C) in 60 mTorr of N2–H2 with R.F. plasma excitation of 700W for 150 min. Other CoCrMo samples were oxidized at 395∘C in pure O2 (60 mTorr) with R.F. plasma excitation of 700W for 120 min. Duplex treated samples were initially nitrided and then oxidized with the same experimental conditions. Various surface analysis techniques were used to investigate the composition and the structure of the layer formed on the CoCrMo alloy as XRD and XPS whereas the N-and O-depth profiles were determined by GDOES and NRA. The nitriding leads to a nitrided layer over few microns, consisting of a supersaturated nitrogen solution in the FCC austenitic-like g matrix (nitrogen concentration is _˜25 at.%). The XRD data showed the formation of an expanded FCC γN phase as well as the formation of CrN phase. The oxidation leads to the formation of a thin ($<$ 70 nm) oxide layer whereas the oxygen penetration is deeper (up to 0.3 μm) after the duplex (nitriding+oxidizing) treatment. Low load (25 g) surface microhardness is significantly improved thanks to the nitriding step whereas the oxidizing treatment did not bring any significant modification neither on the virgin sample, neither on the previously nitrided one.

Investigation of the corrosion behaviour of the samples was performed using electrochemical techniques (potentiodynamic polarization and cyclic voltammetry). The samples were electrochemically treated in simulated body fluid 0.9% NaCl (37oC) in order to study their pitting corrosion resistance. The morphology and microstructure of the surface of plasma nitrided and oxidized CoCrMo samples before and after the corrosion tests was examined by SEM-EDS.

The duplex samples, subjected to plasma nitridation and oxidation, exhibited the lowest deterioration and the better resistance to corrosion compared to the nitrided and the untreated material.

*Speaker
†Corresponding author: noli@chem.auth.gr

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