O_2 Plasma Treatment on the CoCrMo Alloy.

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Introduction:

ASTM F-75 CoCrMo alloy is widely used in the medical device industry. One of the methodologies that can be used as a modification and/or cleaning tool is RF plasma treatment. Gas plasmas contain activated species that can affect chemical and/or physical surface reactions. In the present study, X-ray Photoelectron Spectroscopy (XPS) was used to investigate and characterize the surface effects on the CoCrMo alloy modified with an O_2 plasma treatment process. The experiments conducted in this study examine the surface changes that occurred with the exposure of CoCrMo materials to O_2 plasma as a function of both power and time.

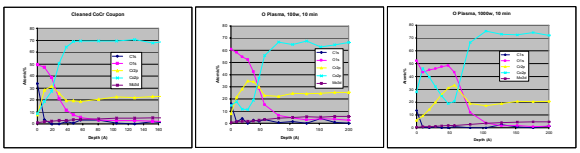
Methods:

The samples for this study consisted of one-inch diameter polished (Ra = 0.1µm) CoCrMo disks. After polishing, the CoCrMo disks were ultra-sonically cleaned in detergent, RO water and EtOH.

Plasma surface treatments were conducted in a PVA TePla 7200 Plasma Processing System (PVA TePla America, Inc. CA). The plasma modifications were conducted by placing clean CoCrMo samples on the middle tray (grounded) of the chamber. Plasma parameters included an O_2 pressure of 300 mTorr with a flow rate of 250 sccm. Process variables investigated in this study included plasma power and treatment time. Treatments were conducted at five (5) different power settings (100, 300, 500 800 and 1000 watts). The treatment time intervals were 5, 10 and 30 minutes.

The surface chemistry of the treated samples was characterized using X-ray Photoelectron Spectroscopy (XPS). XPS data was obtained using a PHI Quantera SXM system (PHI, MN). The XPS data collected included a survey scan, a high resolution multiplex scan (for C, O, Co, Cr, Mo) and sputter depth profile for each sample.

Results/Discussion:



a b c

Figure 1. XPS depth profile of CoCrMo surface before and after O_2 plasma treatment, a) before plasma treatment, 3). after 10 min 100w O_2 plasma treatment, c) after 10 min 1000w O_2 plasma treatment.

Figure 1 presents comparative XPS depth profile data obtained before and after the O_2 plasma treatment. It shows 1. After O_2 plasma treatment, the C content on the surface decreases to 15% from over 30%, 2. O_2 plasma treatment changes the near-surface chemical composition by increasing the thickness of the oxide layer and forming a Co enriched zone in the outer region of the oxide layer. 3. Increasing the plasma power from 100w to 1000w exhibits further changes in the composition of the CoCrMo surface. While the increased wattage does not result in any further reduction of the surface C concentration, but the higher treatment power does result in the formation of a thicker Co enriched oxide layer relative to the 100w treatment.

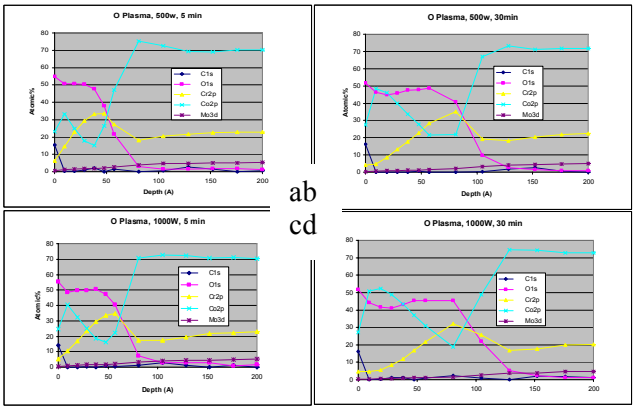


Figure 2. XPS depth profile shows time effect of O_2 plasma treatment on CoCrMo: a) 500w, 5 minutes, b) 500w, 30 min, c) 1000w, 5 min and d) 1000w, 30min.

The effects due to plasma treatment time were similar to those observed when power varied: After 5 minutes of O_2 plasma treatment, the surface C concentration dropped to 15%. In addition, the 5-minute O_2 plasma treatment also resulted in the formation of Co enriched oxide layer approximately 3nm thick. Increasing the plasma treatment time led to further enhancements in the oxide layer thickness as well as the development of the Co enrichment zone.

Conclusions:

1. O_2 plasma treatment can effectively reduce and/or remove residual C contamination.
2. A 5-minute O_2 plasma treatment results an increased surface oxide thickness and formation of Co enriched region.
3. The magnitude of these surface chemistry changes are dependent on the plasma treatment parameters, such as time and power.