PVD-grown Antimicrobial Thin Films on PVDF Substrates for Sensors Applications

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Abstract:

Electroactive polymers are the most interesting class of polymers used as smart materials in various applications, such as the development of sensors and actuators for biomedical applications in areas as smart prosthesis, implantable biosensors and biomechanical signal monitoring, among others. For acquiring or applying the electrical signal from/to the piezoelectric material, suitable electrodes can be produced from Ti based coatings with tailored multifunctional properties, as conductivity and antibacterial characteristics, obtained by the inclusion of Ag. This work reports on $Ti_{1-x}Ag_x$ electrodes and Ag-TiN_y electrodes deposited by d. c. and pulsed magnetron sputtering at room temperature on poly(vinylidene fluoride)(PVDF). In the first system ($Ti_{1-x}Ag_x$ electrodes), silver content was varied from 0-100 at. %. For the second system (Ag-TiN_y electrodes), the nitrogen content changed between 0 to 40.3 at. % by increasing the nitrogen gas flow between 0 sccm and 15 sccm and the ratio Ti/Ag changed from 13.4 to 2.2 being clearly the visible decrease on the Ti content in the reactive mode.

The X-Ray Diffraction (XRD) results revealed that the deposition conditions preserve the polymer structure and suggested the presence of crystalline Tiβ phase in pure titanium coating and fcc-Ag phase in pure silver coating for the $Ti_{1-x}Ag_x$ system. For the Ag-TiN_y system it is possible to detect a fcc TiN structure and a fcc Ag phase. Sheet resistivity values show a typical behavior of a binary alloy system, varying between 0.12 and 28.5 Ω/sq for the $Ti_{1-x}Ag_x$ electrodes. For the second system the sheet resistivity decrease with the nitrogen content from 12.0 Ω/sq with 0 at. % to 2.8 Ω/sq for 40.3 at. % of N. The piezoelectricity of the different samples show similar values, showing values from 19.6 to 27.6 pCN^{-1} for the $Ti_{x-1}Ag_x$ system and 13.6 pCN^{-1} as minimum for the Ag-TiN_y system, achieved for the highest N content. In order to assess the mechanical behavior of the as-sputtered films, the film/substrate system was loaded unidirectionally using a tensile machine. The stress-strain curves were analyzed and correlated with the structural data. Moreover, the antibacterial activity of the samples was assessed and it was verified that samples from the second series (Ag-TiN_y) present antibacterial activity, in contrast of the first series ($Ti_{1-x}Ag_x$).