Characterization of the tribological behaviour of magnetron-sputtered Ti-based thin films: A small-scale *in situ* analysis

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Thin films play an important role on biomaterial applications. Recently, PVD Ti-Ag films were characterized regarding their conductivity and flexibility for biosensors. However, their rubbing against skin or fabrics was not considered. Therefore, the wear behaviour of these binary films has been investigated with a laboratory-made mini-tribometer. It is implemented into an environmental Scanning Electron Microscope (e-SEM). It was seen that the tribological response of Ti-Ag films is greatly influenced by their chemical composition. In particular, the Ag-richest film shows a remarkable tribological behaviour, with Ag clusters, acting as a lubricating phase.

Keywords: Small-scale tribology, environmental-SEM, PVD thin films, *in situ*

1. Introduction

The nature of interface in contact with living species is the prime interest in the field of biomaterials (prostheses, biosensors, implants…) This interface can be modified with physical vapour deposition in terms of chemistry, structure, microstructure… Previously, for the biosensors, intense research activities were dedicated to Ti-Ag thin films regarding the biocompatibility of titanium, and anti-bacterial character of silver. Even though there are some studies focused on conductivity and flexibility[1] of these films, their damaging by rubbing was not investigated. However, wear is a key-issue which needs to be better understood considering the friction of bio-sensors against body, skin, and clothes. Objective of this study is to determine and explain the effect of films composition and the environment on tribological behaviour of Ti-Ag films. For a mechanistic reason, we propose a dynamic original analysis carried out *in situ* and at a small scale

2. Methods

Ti-Ag films were deposited via magnetron sputtering of a duplex target, controlling their chemistry. Four different Ag/Ti (at.) were selected: pure Ti, low-, moderate-, and high-Ag contents. In order to deeper characterize the tribological behaviour of films, the proposed novel approach is using a laboratory-made reciprocating ball-on-disc micro-tribometer. The device can be introduced into e-SEM. In the e-SEM, tribological tests can be conducted under various pressures, from 10^{-4} Pa (High vacuum) to 10^{3} Pa, or in various atmospheres (humid or inert gas…). The tribological analysis is discussed considering microstructural results (XRD, TEM and RBS…).

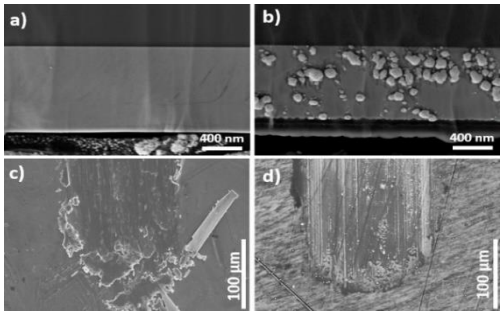

Figure 1: Cross sections and wear tracks of a,c) Ti-rich, b,d) Ag-rich Ti-Ag films;

3. Results

The first aspect was to analyse the effect of film composition on wear behaviour. During the tribo-tests, weak film adhesion was revealed and film spallation was observed for all film except the Ag-richest one (Ag/Ti (at.)=3.14). This film showed better wear character without any deformation and with one order of magnitude smaller friction coefficient than the others. This enhancement on the tribological response would be due to the presence of Ag-based clusters (for the test under high vacuum) (figure 1), which may play the role as a lubricating phase. In order to investigate the effect of environment, tribo-tests were performed inside SEM Under water vapor gaseous environment with various relative humidity values. From a qualitative (track morphology) and quantitative (friction coefficient) viewpoint, slight modifications between films were recorded, suggesting that the tribological evolution of Ti-Ag films is rather governed by its composition.

4. References

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