Effects of laser treatment for surface structuring on AZ31 Mg alloy degradation

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INTRODUCTION

Mg-based alloys are highly appealing for degradable biomedical implants and have the potential to substitute some of the current metals employed in orthopaedic and cardiovascular applications [1]. They show a high corrosion rate in physiological fluids [2]: Modulating their degradation pattern and corrosion rate still represents the main challenge to justify their use *in vivo*. A possible way to modulating the corrosion rate is through the modification of the surface morphology and chemistry. This work is aimed at exploring the potential of using laser surface structuring on AZ31 Mg alloy for controlling degradation behaviour. The corrosion rates of different surface structure conditions are assessed.

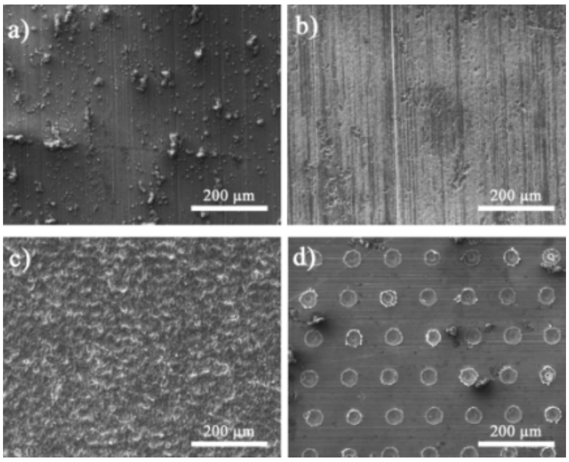

Fig. 1: Tested surface structures a) plain; b) low roughness, c) high roughness, d) dimpled.

METHODS

AZ31 plates (0.4-mm-thick) were cut in 10×20 mm² specimens. Laser surface structuring was performed and 3 structures were patterned: 1- high roughness – HR (R_a= 1.069 µm), 2- low roughness – LR (R_a= 0.218), and 3- dimpled – DP (R_a= 0.862 µm) (Fig. 1). In order to assess the degradation behaviour, static immersion tests was carried out in PBS solution for 14 days. The average corrosion rate (CR_a) was determined based on the weight loss method. Cross sections of the specimens allowed observing the degradation layer. Atomic absorption spectrometry was employed to measure the release of Mg^{2+} ions in the degradation solution. X-ray photoelectron spectroscopy (XPS) analysis was carried out to assess the surface chemistry of all samples before and after the degradation test.

RESULTS

Preliminary results confirmed that surface structure influences the average corrosion rate of the AZ31 Mg alloy (Table 1). The lowest average corrosion rate (1.9 ± 0.03 mm/y) was observed for the DP surface. The thinner degradation layer (40 µm) was observed on the DP samples, whereas for the others specimens it was about 80 µm. Despite these differences, the surfaces showed similar ion release behaviour in the degradation solution. Surface analyses showed that the concentration of carbon atoms on the surface was lower on the surface structured specimens compared to the plain surface before immersion, thus highlighting the cleaning effect of surface treatment. Moreover, LR and HR treatments decreased surface Zn concentration, compared to the amount of the bulk alloy, while DP treatment increased it.

Table 1: Average corrosion rates (CR_a) of the plain and laser structured samples.

Type	Plain	LR	HR	DP
CR_a (mm/y)	2.4±0.03	2.6±0.05	2.3±0.04	1.9±0.03

CONCLUSIONS

The hindered corrosion rate for DP type is suspected to be mainly due to changes in surface chemistry. The formation of degradation layer also followed the dimple geometry, depicting the geometrical influence. The laser treatment can be further optimized for graded corrosion behaviour of Mg-based alloys.

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