Bioactive Materials 3 (2018) 139–143

Contents lists available at ScienceDirect

Bioactive Materials

journal homepage: http://www.keaipublishing.com/en/journals/bioactive-materials/

Biofunctional Mg coating on PEEK for improving bioactivity

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ARTICLE INFO

Article history:
Received 27 November 2017
Received in revised form
28 December 2017
Accepted 31 January 2018

Keywords:
PEEK
Mg
Coating
Vapor deposition
Antibacterial activity

ABSTRACT

High purity Mg was successfully coated on polyetheretherketone (PEEK) by vapor deposition method in order to improve the bioactivity including antibacterial property of PEEK implant. The morphology and elemental composition of the coating were characterized by scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS), showing that the coating was mainly composed of Mg at deposition temperature of 175 °C, 185 °C, 200 °C and 230 °C. The higher the substrate temperature was, the larger the Mg particle size was. The coating degraded and gradually peeled off from the surface of PEEK after up to 21 days' immersion. It was found that the degradation of Mg coating could strongly kill *Staphylococcus aureus* with antibacterial rate reaching to 99%. Mg can be expected to be coated on those bio-inert biomaterials to offer specific bioactivities.

1. Introduction

Polyetheretherketone (PEEK) with reasonable biocompatibility and suitable Young's modulus to human bone is regarded as one of the most potential candidates for spinal, trauma, oral implantology and orthopedic applications [1–4]. However, PEEK is a kind of bioinert material which induces bad bonding with peripheral tissue, resulting in aseptic loosening even implantation failure [5]. Therefore, some bioactive materials such as HA are usually utilized to form PEEK composites in order to improve their bioactivity [6–9]. Nevertheless, the weak physical bonding between HA and PEEK causes compromised mechanical properties. Meanwhile, various biocompatible materials such as TiO_2 [10], Ti [11], Ta [12] and carbon [13] were also employed by plasma treatment [14,15] to improve the biocompatibility. In addition, as serious postoperative complications, bacterial infection after implantation has become an important problem which needs to be solved.

Magnesium (Mg) as a novel biodegradable metal is breaking the current knowledge of corrosion resistant metallic biomaterials. The current application of biodegradable implants is to support the tissue regeneration and heal the specific trauma during degradation. Nowadays, Mg based metals have become most promising candidates for medical applications owing to their character of biodegradation [16–18], and biofunctions of anti-tumor [19–21], antimicrobial [22–26], osteogenesis inductivity [27–30] and others [31–33]. However, the relative low strength has restricted their application in load-bearing position. Mg based metals in form of bulk have been widely investigated, while the study of Mg coating is relatively rare. Since the degradation behavior of Mg is dramatically affected by galvanic corrosion and high purity magnesium possesses superior corrosion resistance, pure Mg was deposited on Mg alloy to improve the corrosion resistance [34,35]. The biological performance is reflected through surface of materials. Therefore, bioactivity of surface becomes very important for biomaterials. As a kind of bioactive material, pure Mg can be coated on the bioinert materials to improve their surface bioactivity. High purity Mg film was deposited on the oxidized Si wafer by physical vapor deposition technique, and both *in vitro* and *in vivo* tests demonstrated acceptable foreign body reaction [36]. Li et al. [37] reported that Mg was coated on porous Ti6Al4V scaffolds by arc ion plating, which made them showing better osteogenic properties than that the porous Ti6Al4V scaffolds.

In this study, high purity Mg was deposited on PEEK substrate,

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Peer review under responsibility of KeAi Communications Co., Ltd.

https://doi.org/10.1016/j.bioactmat.2018.01.007

and then surface coating was characterized, which would be a new way to improve the bioactivity of PEEK for medical application.

2. Experimental

2.1. Material and coating

A high purity (99.99 wt%) Mg block was employed as evaporation resource. Mg block was placed in a ceramic crucible located inside the furnace at temperature of 175 °C, 185 °C, 200 °C and 230 °C. A commercial PEEK substrate was cut into size of Φ160 mm × 2 mm. The surface was grounded up to 2000 grit sand paper, and then mirror polished with 1 μm diamond grinding paste. The substrates were cleaned ultrasonically in acetone and deionized water, dried by flow N_2 gas, then the substrates were placed in the deposition zone at temperature of 150 °C. The working pressure was controlled at about 1Pa. The generated Mg vapor was spontaneously condensed on the surface of the substrate due to the temperature gradient. Scanning electronic microscopy (SEM) was employed to investigate the surface morphology of the coating.

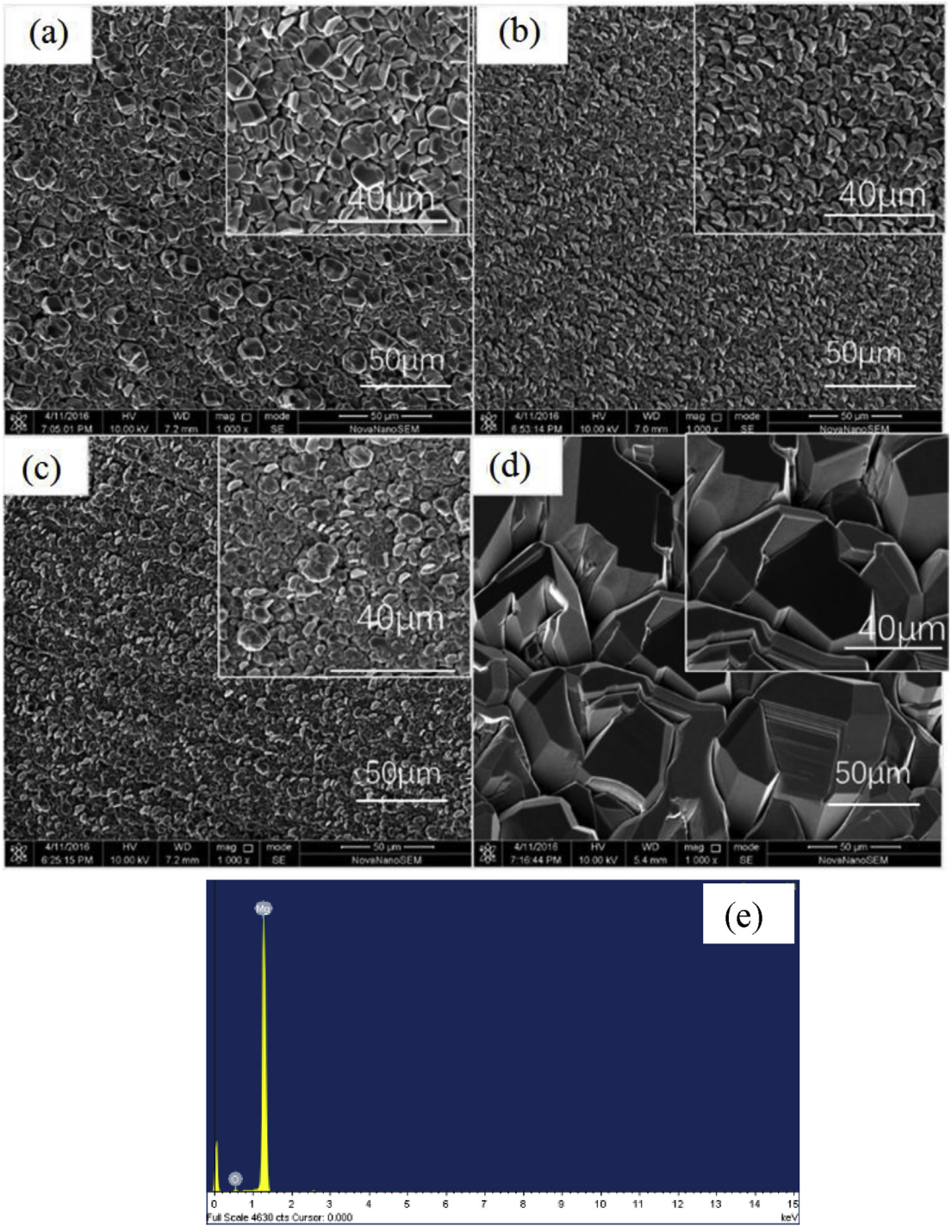

Fig. 1. Surface morphologies of Mg coating fabricated at different temperatures, (a) 175 °C; (b) 185 °C; (c) 200 °C; (d) 230 °C; (e) EDS analysis.