

Chapter 24

Calcium Phosphate Coating on Titanium by RF Magnetron Sputtering

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ABSTRACT

In this chapter, the authors discuss the fabrication and properties of calcium phosphate coatings on titanium (Ti) by radio-frequency (RF) magnetron sputtering. First, they address the necessity of surface modification of metallic biomaterials and the effectiveness of calcium phosphate coating. Next, they briefly review the processes used in the application of calcium phosphate coatings and present the effect of sputtering parameters on the phase and deposition rates of these coatings. Finally, the chapter discusses the performance of amorphous and crystalline (oxyapatite) calcium phosphate coatings on Ti based on in vitro and in vivo evaluations.

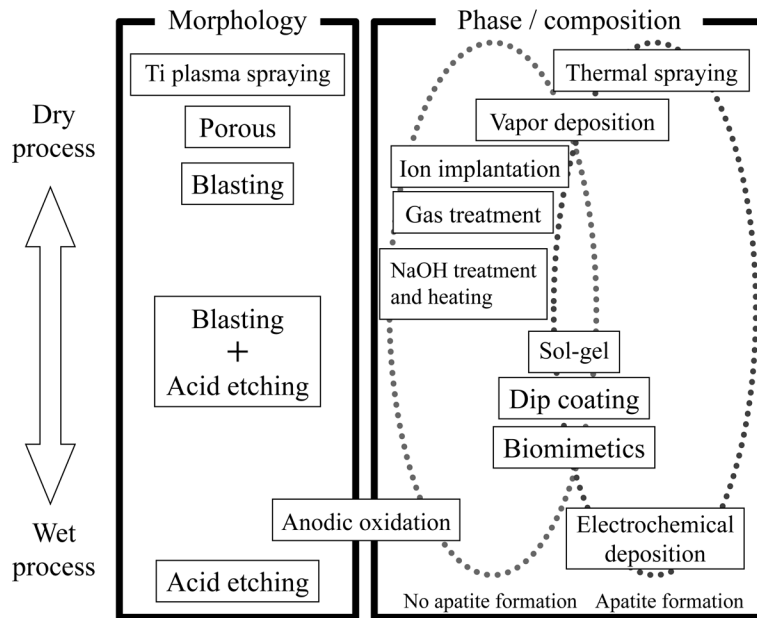
INTRODUCTION

Metallic biomaterials can be used to replace damaged hard tissue because of their mechanical strength, ductility, and durability (Niinomi et al., 2005). More than 70% of medical implants are made of metallic biomaterials. Among metallic biomaterials, titanium (Ti) and its alloys have been widely used in dental and medical implants because they can be directly connected to living

bone at an optical microscopic level, i.e., osseointegration (Brånemark et al., 1977). The fixation between implants and bones, however, can be influenced by the state of the bones and the implant/bone interfacial area. Because the microstructure and phase of metallic materials are generally well-controlled by thermomechanical treatment to produce the mechanical properties required for biomedical applications, the bone compatibility of these materials needs to be improved while still maintaining their microstructural and mechanical properties. Surface modification using calcium

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Figure 1. Surface modification processes for improving the bone compatibility of metallic biomaterials



phosphate coating is a promising way to improve the bone compatibility of biomaterials. Calcium phosphate is the main inorganic component of hard tissues, although its mechanical strength is limited in load-bearing situations (LeGeros, 1988).

In this chapter, we discuss the fabrication of calcium phosphate coatings on Ti by radio-frequency (RF) magnetron sputtering and also discuss their properties with a focus on the improvement of bone compatibility. We first review how surface modification is performed using calcium phosphate coatings for metallic biomaterials and then describe the fabrication processes and performance of calcium phosphate coatings.

SURFACE MODIFICATION USING CALCIUM PHOSPHATE COATING

Figure 1 shows the surface modification processes used for improving the bone compatibility of metallic biomaterials (Goto et al., 2011). The morphology and phase/composition of their surface layers are modified using a dry process,

a wet process, or both processes. The aim of modifying the surface morphology is to increase the adhesion strength between bones and implants by means of an anchorage effect (Hanawa, 2003). The purpose of phase/composition modification is to form an apatite (calcium phosphate) coating or a non-apatite coating that enhances the formation of apatite.

Calcium phosphate coating on metallic biomaterials has been developed since the 1970s, and plasma spraying (de Groot et al., 1987) has been applied to calcium phosphate coatings on Ti-6Al-4V alloy implants for clinical use since the mid-1980s (Yankee et al., 1991). Plasma spraying offers the advantages of high deposition rates at a relatively low cost. However, the adherence to a metal substrate and the uniformity of plasma-sprayed calcium phosphate coatings are insufficient in some ways. For this reason, many coating processes for calcium phosphate coating on Ti and its alloys have been investigated including physical vapor deposition (PVD), such as sputtering (Wolke et al., 1994; Narushima et al., 2005), pulsed laser deposition (PLD) (Wang et

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