APATITIC CRYSTAL GROWTH ON HYDROXYAPATITE AND SOME OXIDE MATERIALS COATED ON FERROELECTRIC CERAMICS

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ABSTRACT

Electric poling was found to enhance crystal growth on hydroxyapatite by the effect of BaTiO₃. The enhancement was observed on the negatively polarized surface, while the crystal growth was restricted on the positively poled surface. Based on these results, the effect was attributed to the condensation of Ca²⁺ ions due to the electrostatic attraction of aligned dipole moments of BaTiO₃.

INTRODUCTION

Not only the unparalleled bioactivity but also the electric properties of hydroxyapatite (HAp) are partly attributed to its lattice OH⁻ ions, which are surrounded with Ca²⁺ in the HAp structure and are reportedly stable up to ca. 1000K in air. The dielectric measurements were carried out at first for the understanding of the bioactive characteristics of HAp. As a result, HAp ceramics were proved to exhibit dielectric characteristics below ca. 800K. The later studies by the thermally stimulated current method showed that HAp ceramics were polarizable above the monoclinic-hexagonal phase transition temperature (~500K) due to the reorientation of the lattice OH⁻ ions along the c-axis. Taking the polarizability into account, we conducted the study on the poling effect on the crystal growth on HAp ceramics. Very recently, we observed the remarkable effect of electric poling on crystal growth. (1, 2) BaTiO₃ is well-known as a material with a high dielectric constant. BaTiO₃ has spontaneous polarization, which can be oriented by an external electric field. This report shows how poled BaTiO₃ has an influence on apatitic crystal growth.

METHODS AND MATERIALS

Laminated films of BaTiO₃ and HAp were prepared by electrophoretic deposition (EPD) (Fig.1). BaTiO₃ powders (Kanto chemicals) and HAp powders (Taihei chemicals) were used. After electrophoretic deposition, the specimens were sintered at 1473K. The crashed powders of sintered specimens were analyzed by X-ray diffraction (XRD). The as-sintered ceramic specimens, which were sandwiched between Pt plates, were poled using a dc field of 1200V/cm at 473K for 5 min. The poled specimens were quenched to room temperature, then immersed in a simulated body fluid (SBF) for 1h~48h. The washed and dried specimens were subjected to scanning electron microscopy (SEM).

RESULTS AND DISCUSSION

Figure 1 shows the X-ray diffraction pattern of the sintered specimen, indicating that HAp and BaTiO₃ remained after sintering at 1473K.

Figure 2 shows the HAp surface before immersion. It shows the HAp-coated surface.

Fig.1 X-ray diffraction pattern of the HAp-coated BaTiO₃ specimen sintered at 1473K.

Fig.2 HAp-coated surface before immersion.

Figure 3 shows the SEM photographs of the negatively polarized HAp surfaces of the poled specimens after immersion in SBF. It was observed that crystal growth took place even in 1h, and the crystal grew with time. Therefore it was shown that negative charges accelerate crystal growth on HAp (Fig.4). On the other hand, Fig.5 shows the SEM photographs of the positively polarized HAp surfaces of the specimens after immersion in SBF, and no crystals were grown on the positively charged surface even in 48 h. The crystal growth was observed after 2 week-immersion. Therefore the poling effect of preventing crystal growth was found to be maintained for a considerable period.

Previous study has shown that the crystal growth occurs on the negatively polarized surfaces of the poled HAp in SBF within a few hours. Furthermore, this study shows that the crystal growth occurs within only 1 h. by the effect of poled BaTiO₃.

(A) 1 h.

(B) 3 h.

(C) 12 h.

Fig.3 Change of negatively polarized HAp surfaces of the poled specimens after immersion in SBF.

Fig.4 Apatitic crystal growth model on HAp

(A) 48 h.

(B) 2 weeks

Fig.5 Positively polarized HAp surfaces of the poled specimens after immersion in SBF.

SUMMARY

Crystal growth on HAp was enhanced or restricted by changing the poling direction of BaTiO₃.

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