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Research paper

Neutron diffraction residual strain measurements in nanostructured hydroxyapatite coatings for orthopaedic implants

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ABSTRACT

The failure of an orthopaedic implant can be initiated by residual strain inherent to the hydroxyapatite coating (HAC). Knowledge of the through-thickness residual strain profile in the thermally sprayed hydroxyapatite coating/substrate system is therefore important in the development of a new generation of orthopaedic implants. As the coating microstructure is complex, non-destructive characterization of residual strain, e.g. using neutron diffraction, provides a useful measure of through thickness strain profile without altering the stress field. This first detailed study using a neutron diffraction technique, non-destructively evaluates the through thickness strain measurement in nanostructured hydroxyapatite plasma sprayed coatings on a titanium alloy substrate (as-sprayed, heat treated, and heat treated then soaked in simulated body fluid (SBF)). The influence of crystallographic plane orientation on the residual strain measurement is shown to indicate texturing in the coating. This texturing is expected to influence both the biological and fracture response of HA coatings. Results are discussed in terms of the influence of heat-treatment and SBF on the residual stress profile for these biomedical coatings. The results show that the through thickness residual strain in all three coatings was different for different crystallographic planes but was on average tensile. It is also concluded that the heat-treatment and simulated body fluid exposure had a significant effect on the residual strain profile in the top layers of HAC.

1. Introduction

The structure–property relationships of biomaterials such as hydroxyapatite {HA, $Ca_{10}(PO_4)_6(OH)_2$} play an important role in the response of artificial implants (Leeuwenburgh et al., 2008). HA has an almost identical chemical composition to that of the mineral component of bone, and can be successfully thermally sprayed on metallic orthopaedic implants

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