Stress Analysis of Hydroxyapatite Coatings for Orthopaedic Implants

Residual stress | Surface treatment

Implants are commonly made of titanium coated in hydroxyapatite, which is the main constituent of human bone. It is believed that one of the main reasons for failure is the development of residual stress at the metal-hydroxyapatite interface. The hydroxyapatite coating (HAC) is typically 220 micrometres thick, and the residual stress at the titanium-HAC interface is mainly due to differences in the thermal and mechanical properties of the two materials. The orthopaedic implant industry can use stress profile models to monitor the quality of the HAC, but this is often difficult to validate using standard analytical methods.

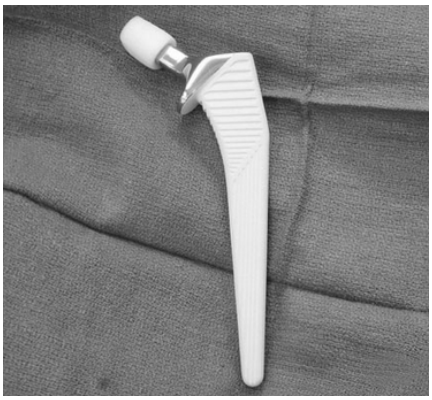

Figure 1. A femoral implant with hydroxyapatite coating.
Picture from Cho et al, Clin. Orthop. Surg., 2010

This study used neutron diffraction analysis, a non-destructive technique for through-thickness strain measurements.

The experiments were configured to determine the through-thickness residual strain profile of the coating-substrate system. Typical results of residual micro-strain are shown in Figure 2.

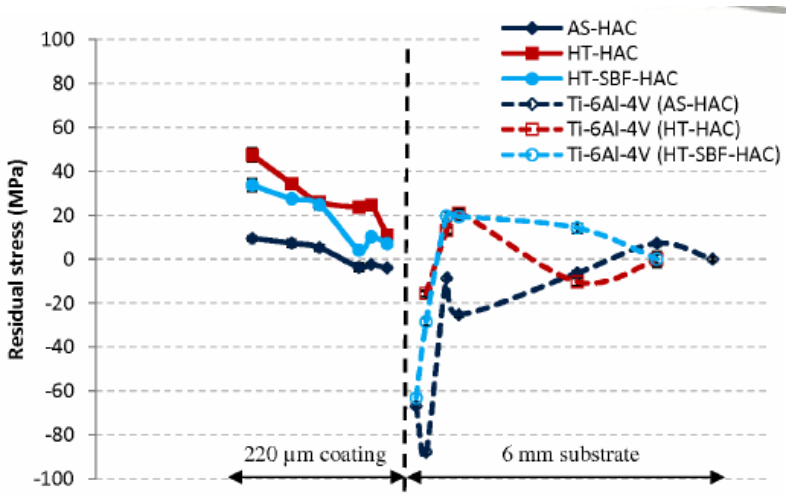

Figure 2. Residual stress profile of HAC coatings with a Ti-6Al-4V substrate. The samples used were nanostructured hydroxyapatite plasma sprayed coatings on a titanium alloy substrate: as-sprayed (AS); heat treated (HT); heat treated then soaked in simulated body fluid (HT-SBF)).

- It was concluded that the combination of heat treatment and exposure to simulated body fluid had a significant effect on the residual strain profiles in the upper layers of the hydroxyapatite coating.

[Ref: R. Ahmed et al., J. Mechanical Behaviour of Biomedical Materials (2011) and STFC documentation]

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