EUROPEAN SYNCHROTRON RADIATION FACILITY
INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Spatially resolved texture and strain investigation of hydroxyapatite in bone close to coated and uncoated implant	**Experiment number**: **SC-1337**
Beamline:	**Date of experiment**: from: 17 September 2003 to: 23 September 2003	**Date of report**: 14/02/05
Shifts:	**Local contact(s)**: Dr Guillaume GEANDIER	*Received at ESRF:*

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Report:

Bone is a composite material whose components are primarily collagen and hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$ (HAp). The c-axes of the apatite crystallites and the collagen fibres are preferentially oriented, e.g., in the long bones in the directions of the stresses that the bones need to withstand. Bone occurs in two principal structural forms: cortical, or compact bone, which forms a dense matrix, and spongy bone. We used in this work cortical bone [1,2].

At the interface with an implant, Ti-6Al-4V, a bone tends to change its properties, affecting the acceptance of the implant. Ti-6Al-4V presents good mechanical proprieties and is biocompatible. HAp has low mechanical strength, but very good osteointegration and biocompatibility. The combination of these two materials gives mechanical strength and good osteointegration proprieties at the interface [3].

We used in this study bone material from one sheep with two implants, Ti-6Al-4V, (20 mm x 10 mm x 1.4mm) inserted in its left and right tibia bones, the implant having one face coated, the other not. In order to

improve these coatings, it is necessary to investigate the texture transformations of the bone's properties, as a function of the distance from the implant-interface [4,5].

The texture of bone has been investigated by synchrotron radiation on ID15B at ESRF. We probed the samples with a spatial resolution of 300 μm in order to investigate the preferred orientation of HAp crystallites in bovine tibia and calculate the pole figures from the orientation distribution function. The WIMV method has been used for describing the texture, implemented into the MAUD program (Material Analysis Using Diffraction) of L. Lutterotti [6]. We refined first the crystal structure from the sum of all data and afterwards the texture of the 360 whole neutron powder diffraction patterns.

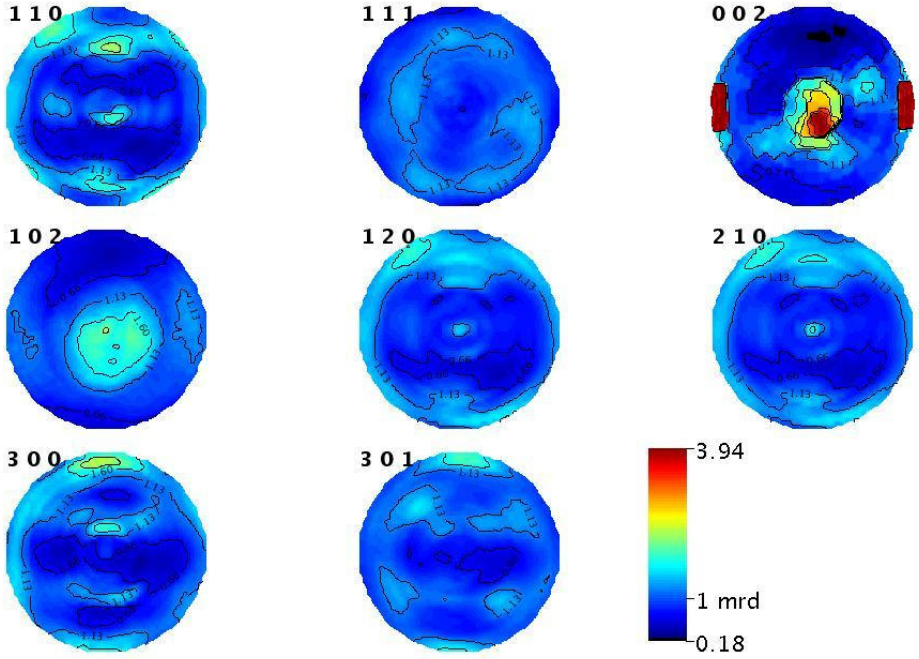

FIG. 1- Pole figures measured at 0 mm from the interface with implant no-coated to HAp

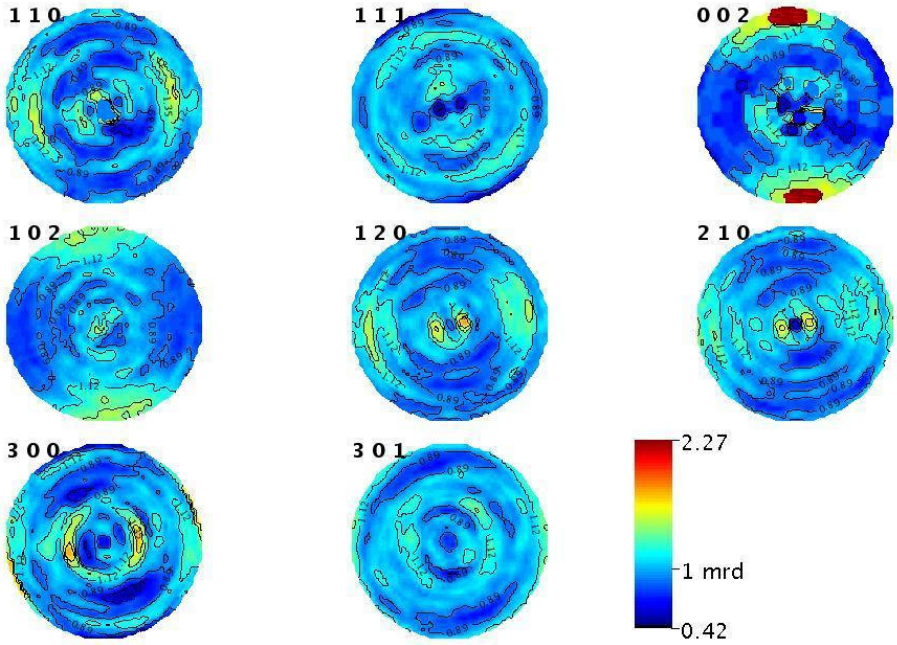

FIG. 2- Pole figures measured at 0 mm from the interface with implant coated to HAp

The figures 1 and 2 show the pole figures of the HAp crystallites at the interface with implant. The HAp crystallites have two various orientations at the interface with the implant. The implant coated to HAp make possible to preserve the preferred orientation of the bone, but with the implant non-coated the HAp crystallites change completely the preferred orientation in an area of 2 mm, after this area we can show the usually preferred orientation of bone. The mechanical properties of bone will also depend on this arrangement of HAp crystallites. This change of the preferred orientation creates certainly a perturbation at the interface and generates more probably cracks. The new bone material close to the interface may become unstable. In consequence, this instability increases the rejection rate of prosthesis.

Surface coating can reduce significantly the rejection rate of implants; therefore the HAp coating on titanium alloy should possess a very good combination of biocompability and mechanical properties.

This texture study with synchrotron radiation of sheep tibia at the interface with implant revealed that it is necessary to cover implants with HAp.

This work was been presented in Users' Meeting 2005, Parallel Sessions: Materials Science.

References:

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