Investigations of the Regeneration of Hydroxyapatite Crystallites in Bone after Implantation Using Synchrotron Radiation

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The use of the implants has become current since 1930. With the improvement of technology, metals have been used in the medical field. As a long-term establishment is a meter of the therapeutic success, it is necessary to use biocompatible implants in order to have good mechanical, corrosion and fracture resistance.

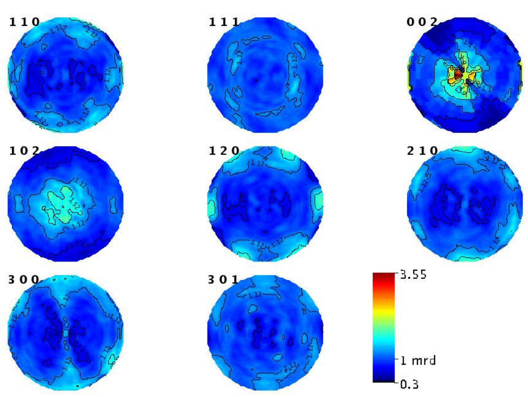
Medicine experiences an accelerated development of new technology, aiming preventive, diagnostic and therapeutic progress. Decision makers of health and the experts have to make choices and to establish strategies according to criterions of safety, of effectiveness and of utility. The world market of biomaterials is very important and in full growth. The European commission estimate this market at 25 G€ with an annual growth rate of 5 to 7%. Europe represents a third of this market. The orthopaedic biomaterials present 8 G€ of this market, with an annual growth rate of 7%. Hip and knee prosthetics alone represent 40% of this market segment, with respectively 750 000 and 500 000 medical interventions per year [1].

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 [2,3].

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 [4].

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 [5,6]

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 [7]. We refined first the crystal structure from the sum of all data and afterwards the texture of the 360 whole neutron powder diffraction patterns.



Reconstructed pole figures from Rietveld analysis using MAUD program and all the diffraction Patterns measured on ID15B

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