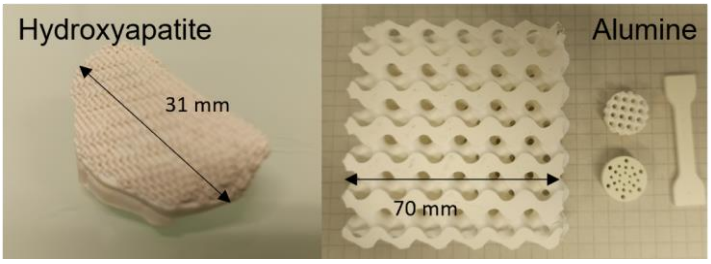
LABO - Axe et Equipe : ICCF - MPS

Thesis supervisor: Jean-Marie NEDELEC (Professeur), jean-marie.nedelec@sigma-clermont.fr

Co-supervisor : Stéphane DESCAMPS (Professeur), s_descamps@chu-clermontferrand.fr

Title of PhD subject : Formulation and implementation by additive manufacturing of bioceramics and composite bioinks based on polysaccharide hydrogels mechanically reinforced by bioceramics.

Summary :
Despite advances in orthopedic surgery and materials for bone reconstruction, the regeneration of large bone defects still remains a challenge. To fill the bone defect while reproducing the structure of the bone, we can turn to ceramic or composite additive manufacturing techniques, which make it possible to finely modulate the architecture of the final material. The topographical, mechanical, chemical and biological properties of the parts obtained will be optimized in order to provide the physical and chemical signals necessary for the cells responsible for bone regeneration.
In a biomimetic approach to imitate the structure of bone and its biomechanical properties, this project will be dedicated to the development of bioceramics obtained by 3D printing and to the 3D bioprinting of hydrogels reinforced by these same bioceramics.
The laboratory has acquired significant expertise in 3D printing of bioceramics. The thesis will extend the range of materials available for so-called SLA or DLP techniques. (see figure)
3D bioprinting of hydrogels has seen significant growth in recent years because it allows cells to be encapsulated in a 3D environment similar to the extracellular matrix in vivo. This is an interesting approach for tissue regeneration or in vitro tissue modeling. However, the formulation of the bioink is very important, because it must be extrudable, have rapid gelation kinetics, and be biocompatible so that the encapsulated cells can survive and proliferate. Furthermore, in the context of bone tissue regeneration, the mechanical properties of the finished part must be close to those of bone. This is difficult to achieve with only hydrogels. This is why we are interested here in developing hybrid materials loaded with bioceramic particles. This part of the project will be carried out in collaboration with the 4BIO GePEB team from the Pascal Institute in Clermont-Ferrand.
Bioinks based on polysaccharide hydrogels will therefore be formulated with bioceramics. The rheological properties of the bioinks thus formulated will be studied, in order to verify the extrudability and gelation kinetics of the hydrogels. Different concentrations of polymers and bioceramics in inks will be studied. The bioinks will then be shaped by extrusion to obtain 3D parts of different porosity and topography. As for all-ceramic parts, the physical and chemical signals that the materials can provide are the elastic modulus, compressive strength, porosity, topography, and bioactive ions present in bioceramics.



Examples of 3D ceramic structures printed in the laboratory

Profile: The candidate will have a strong taste for working at the interfaces of different engineering science disciplines. With good knowledge in materials science, the candidate must either be familiar with or be interested in additive manufacturing techniques and for the design of digital models.