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Correlative microscopy approach to mix different scales in the porous dentin material

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It is proposed in this talk to consider multiple resolution observations of dentine materials synthesized at multiple scales with a general inverse problem approach by combining confocal e.g. with SEM observations at different scales. Thus correlative microscopy aims to access a large range of scales for a given region by combining what is impossible by using one instrument alone.

Dentin is the bulk material of the tooth and presents a complex hierarchical structure. At the macroscopic scale, it can be seen as a first approximation as a homogeneous material located in between enamel and pulp cavity. But at the tissue level, it presents a microstructure made of tubules, peritubular dentin and intertubular dentin (entity dimension : a few microns). At a lower scale, the intertubular dentin is a composite made up of collagen fibers and hydroxyapatite crystals (entity dimension : 100nm).

Knowing the influence of the topology at each scale is of utmost importance for dental restoration. It is thus strongly needed to provide a robust and durable link between the restorative material and the sane biomaterial. Local defaults will create stress concentration which will be the source of crack initiation either immediately or later due to cyclic loading and fatigue phenomena. On the other hand low resolution is often required to survey large regions, for example to locate and image sparse features such as critical features, but for which structural information is required at much higher resolution.

The proposed mathematical approach is viewed as an inverse problem: it starts a material structure at a given resolution with a given larger scale apparatus. dispersed topography at diverse point sampled in the structure, find the fine fitted topography at the fine scale everywhere in the sample. To reach this goal we use concepts such as variational image restoration and texture synthesis together with PDE/FEM image analysis.

In this talk, dentin 3D imaging using Focused Ion Beam-Scanning Electron Microscopy (FIB-SEM) and Confocal Laser Scanning Microscopy (CLSM) is performed and used in order to get some physical properties such as permeability and elasticity modulus at different scales.

References

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