MATERIALS SCIENCE AND TECHNOLOGY

AMMIN - Innovative scaffolds for tissue engineering: joining DLP technology with multi-functional ceramic particles

Funded By	Politecnico di TORINO [P.iva/CF:00518460019]
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Context of the research activity	Design and development of biomedical scaffolds for tissue engineering based on ceramics and/or polymer-ceramic composites. Digital Light Processing will be used to obtain scaffolds with hierarchical and tuned porosity to maximize the vascularization and tissue integration. Ceramic or ceramic/polymer particles, even in the form of multi-phase core-shell particles, will be added to provide the scaffolds specific functionalities.
Objectives	The spreading of Additive Manufacturing (AM) technologies in the fabrication of ceramic biomaterials has started a new era of personalized medicine, especially in the tissue engineering field. Some key advantages - compared to traditional processes - deserve mentioning, and precisely the customization of the implants, enabling patient-specific designs based on individual anatomical data; the possibility of tailoring the inner architecture, allowing the fabrication of intricate porous structures that replicate the natural bone and enhance integration; the material efficiency, as the additive methods reduces material waste compared to subtractive methods and avoid mold fabrication. Although several AM techniques can be used to process bioceramics, vat-photopolymerization technologies (including Digital Light Processing, DLP) stand out due to their highest resolution and accuracy in the printed parts. In this three-year research program, the key advantages of using DLP to process ceramics and ceramic-polymer composite scaffolds will be joined with additional skills and facilities to fabricate core-shell particles, where the distinct particle layers will be designed to provide specific functionalities (such as antibacterial, anti-tumoral, osteoinductive/conductive properties, etc.) to the scaffold. Thus, core-shell multi-functional particles will be developed and used as a feedstock in photopolymerizable resins suitable for the DLP process. The following 3D printing process will allow the fabrication of biomedical scaffolds, whose structure – even in the form of a hierarchically complex or even graded structures – will be engineered to target specific anatomical tissues and related diseases. The presence of the mentioned core-shell particles will provide additional functionalities to the scaffolds in specific relation to the targeted tissue and disease.

	Specific research topics and objectives are detailed in the following: ¿ To provide a bibliographic survey to highlight the state-of-the art of the research topic, specifically finalized at defining the technologies, the key requirements and the challenges of innovative scaffolds for tissue engineering. ¿ To elaborate multi-functional powders, especially in the form of core-shell particles, where the distinct layers will be designed to provide specific properties to the final scaffolds. ¿ To prepare slurries for DLP, made by mixing such multi-layer particles with proper photopolymerizable resins, and to characterize them mainly in terms of rheological behavior and printability. ¿ To fabricate the biomedical devices by DLP, even in the form of complex/graded scaffolds and compositions, by setting and optimizing printing parameters and post-processing steps. ¿ To provide full characterization of the developed scaffolds, in terms of microstructural, compositional, structural, functional and biological properties, thus to validate the achievement of the defined key requirements.

Skills and competencies for the development of the activity	Ability to perform laboratory experiments in autonomy (after proper training), including materials elaboration (such as development of core-shell particles, dispersion of particles into polymer medium), forming especially by DLP technology, eventual sintering, materials characterization (physical, microstructural and mechanical characterizations); ability to adapt laboratory facilities for materials synthesis, processing and characterization to the ongoing tasks; basic knowledge of 3D design software; critical data analysis and processing; reports and articles writing.