MATERIALS SCIENCE AND TECHNOLOGY

Ateneo - Design and development of advanced ceramics by Digital Light Processing for sensing and environmental applications

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Context of the research activity	Additive manufacturing (AM) has brought about a real revolution in the manufacture of advanced ceramics used for both structural and functional applications. Among AM technologies, vat-photopolymerization processes such as Stereolithography (SL) and Digital Light Processing (DLP) definitely stand out for high-quality surface finishing and resolution, as well as relatively quick building times and reproducibility. In addition, within SL and DLP it is nowadays possible to design and develop unprecedented geometries and complex shapes, whose inner architecture are customized on the ground of specific applications. Advanced ceramics, shaped as highly porous structures find a number of applications such as membranes, filtration systems, sensing and piezoelectric devices, catalytic and gas capture substrates. In fact, for all these applications, high surface-to volume ratios and interconnected porosities favor the contact with external gas and fluids, with potential enormous increase of the performance in the above applications. In this frame, innovative 3D structures like the so-called Triply Periodic Minimal Surface (TPMS) cells are gaining more and more success due to the exceptionally high specific surface area and other peculiar properties. Therefore, this research focuses on the design and development of advanced oxide ceramics by DLP. The research will include all processing steps: design of the structure, elaboration of the slurry, printing of the object, post-processing and sintering, final characterization.
Objectives	The objective of this Ph.D. thesis is to produce and characterize dense and macroporous oxide ceramics suitable for environmental (such as carbon capture) and for sensing applications (structural and/or environmental sensing). The research will include the elaboration of suitable ceramic slurries, with high solid content and low viscosity to prevent the formation of cracks, pores, samples warping, and other defects in fired ceramics. Therefore, slurries will be characterized in terms of rheology and printability. The slurries will be printed to provide both single shape objects (like bars and pellets, suitable for

Objectives	a preliminary mechanical characterization) as well as complex shapes, customized in agreement to the forecast applications. Special attention will be paid to innovative 3D structures, like Triply periodic minimal surface (TPMS) cells characterized by high surface-to-volume ratio. The post-printing processes, including debinding and sintering, will be optimized, in ordert to fabricate defect-free final pieces. Finally, the sintered materials will be fully characterized from a microstructural, functional, and mechanical point of view in function of the targeted application.

Skills and competencies for the development of the activity	During the 3 years PhD program, the researcher will develop the following skills: - Capability to perform literature survey and to use it for comparative and critical analysis of research results; - Autonomy in laboratory activity, in performing research, using equipment and interpreting results; - Capability and autonomy in the use of stereolithography machine - Ability to prepare research reports and to communicate the obtained results - Curiosity and interest in the research, skills to propose solutions, to identify original aspects of the research, to propose new characterization techniques and their potentialities.