

PhD in Materials Science and Technology

Research Title: Nanostructured materials and nanocrystals for photonics applications (NANOMAX)

Funded by	Politecnico di Torino (Joint Research Projects with Top Universities)
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Context of the research activity	<p>The goal of the NANOMAX project is to develop advanced nanostructured optical materials of interest for photonic applications. Leveraging the collaboration between the partners (Universite Paris Sud and Politecnico di Torino), the research activity will cover the value chain from the synthesis of the glassy materials to their 3D nano-structuring by femtosecond laser irradiation. The fabrication and control of photonic materials properties at the nanoscale such as shape and crystallinity will allow innovative functionalities to be built from the bottom up with huge potential applications in the field of telecommunication, sensing and biomedicine. During the project, different routes for bulk glass material production will be used: e.g. sol gel synthesis and melt quenching. After fabrication of the materials, nano-structuring and crystallization will be pursued in a following step using topical nano-/femto-second laser irradiation to trigger and control localized and oriented crystallization of specific components. The use of laser shaping crystallization will allow 3D direct writing of photonic nanostructured materials both in planar substrates and in optical fibers. Doping these glasses with rare earth ions or inclusion of precursors of nanocrystals will be used in combination with laser irradiation also for the growth of nonlinear optical materials aiming at the next-generation nanocrystals-integrated optical devices.</p>
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Objectives	<p>This Ph.D. program requires a secondment of 18 months to the Universite Paris Sud and the research will be partly carried on at Politecnico and partly at Universite Paris Sud.</p> <p>The Ph.D. project aims at the following objectives, listed here and detailed below:</p>
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	<ul style="list-style-type: none"> - Fabrication of glasses, doped and nanoparticle charged glasses - Laser irradiation for nano-structuring and crystallization - Characterization of the nanocrystals texture and the nanostructure - Applications <p>Fabrication of glasses, doped and nanoparticle charged glasses</p> <p>Bulk glasses to be used as planar substrates or preforms for fiber drawing will be fabricated following two different techniques: sol-gel and melt quenching. The synthesis method will be defined for a specific glass system to obtain homogeneous glasses at the threshold to crystallize under laser irradiation. Glass composition and dopants will be tailored to maximize the photosensitivity. Another approach to be explored in parallel is to incorporate nanostructured materials of dissimilar species into planar substrates for photonic light circuits or glass tubes that will be drawn into optical fibers.</p> <p>Laser irradiation for nano-structuring and crystallization</p> <p>Laser irradiation of the custom-made glasses will be used to induce localized and oriented crystallization. Femtosecond and/or nanosecond laser will be used to leverage their different local thermal stress induced to tweak the material properties.</p> <p>Characterization of the nanocrystals texture and the nanostructure</p> <p>Materials characterization will be a key task for PhD during the project to master and control the fabrication of nanocrystal and nanostructures. Characterization techniques include TEM, EXAFS, XPS, Raman and optical spectroscopy/microscopy.</p> <p>Applications</p> <p>Among the different applications to be explored, one is certainly a new integrated multifunctional material photonic circuits for frequency doubling waveguides, optical switches and passive optical isolators. A final objective is also to demonstrate their advanced applications in various fields such as integrated-optics, nano-optics, optical telecommunication, or bio-photonics.</p>
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<p>Skills and competencies for the development of the activity</p>	<ul style="list-style-type: none"> - Good materials science and/or chemistry background - Basic knowledge of XRD, optical spectroscopy and SEM microscopy - Experience in glass sol-gel fabrication techniques is a plus - Will to spend 18 months in the partner university - Proactive attitude
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