MATERIALS SCIENCE AND TECHNOLOGY

CRT/DISAT - Laser processing of polymer-based materials

Funded By	Dipartimento DISAT FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014]
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Context of the research activity	The aim of this PhD project is to investigate in detail the mechanisms underlying the laser-induced transformation of polymer precursors into carbonaceous, graphene-like, and ceramic-like materials, and to optimize processing strategies for their integration into energy devices, particularly fuel cells. La borsa è cofinanziata dai Progetti: Periodo dal 1/03/2026 al 28/02/2027 progetto MEAEM_Codice_MI_ERE_00216_Bando MASE Innovation CUP: F13C25001110001; Periodo dal 01/03/2027 al 28/02/2029 progetto THUNDER GA 101235287 - HORIZON CL5 CUP: E13C25001820006".
Objectives	Laser processing of polymer-based materials has emerged as a powerful and versatile approach for producing carbonaceous, graphene-like, and ceramic-like structures directly from polymer-based precursors. This technique enables localized transformation of polymers through photothermal and photochemical mechanisms, generating conductive, porous, or highly ordered phases that are promising for applications in energy devices. Despite the rapid growth of laser-induced carbonization and laser-induced graphene (LIG) technologies, several scientific challenges remain unresolved. In particular, a deeper understanding is needed regarding the transformation pathways of different polymer families, the role of laser parameters in governing microstructure formation, and the relationships between precursor chemistry, process conditions, and final physicochemical properties. As fuel cells and other energy-conversion systems increasingly rely on engineered interfaces and high-performance catalytic support materials, the ability to design and control laser-derived carbon and ceramic microstructures becomes strategically important for next-generation device fabrication. The aim of this PhD project is to investigate in detail the mechanisms underlying the laser-induced transformation of polymer precursors into

Objectives	carbonaceous, graphene-like, and ceramic-like materials, and to optimize processing strategies for their integration into energy devices, particularly fuel cells. The research will focus on correlating laser parameters (wavelength, fluence, pulse duration, scanning strategy) with the structural, electrical, and chemical features of the resulting materials. A systematic comparison of different polymer precursors will be carried out to identify transformation routes and dominant reaction mechanisms leading to graphitization, heteroatom incorporation, or ceramic phase formation. Moreover, the morphology of the polymeric precursors will be tailored through micro- and nanostructuring approaches (e.g., electrospinning and electrospraying), and the impact of these architectures on the final material properties will be assessed. Advanced characterization techniques (Raman spectroscopy, XPS, electron microscopy, in situ diagnostics) will be employed to build a mechanistic model of the laser-material interaction. Ultimately, the project seeks to engineer optimized laser-written components—such as catalytic supports, porous electrodes, or conductive architectures—demonstrating improved performance in fuel cell environments and contributing to the development of novel, scalable manufacturing approaches for energy technologies.

Skills and competencies for the development of the activity	Candidates should have a solid nanotechnology and materials background and strong motivation to learn through advanced research. Expertise in electrospinning and laser writing technologies, and materials and electrochemical characterization is preferred. Problem solving ability and practical experience for laboratory activity is mandatory.