Title : Laser-Assisted Processing of Deep Eutectic Solvent-Based Precursors for Functional Micro- and Nanostructures

Dr. Ilya Tumkin (ORCID: 0000-0003-4841-7529)
Ruhr University Bochum, Germany
ilia.tumkin@ruhr-uni-bochum.de

Keywords

Laser processing; Deep eutectic solvents; Microfabrication; Flexible electronics; Material science.

Recent developments in laser-assisted microfabrication show growing interest in combining ultrafast laser processing with chemically functional precursor for localized synthesis and modification of conductive materials. In this context, deep eutectic solvents (DESs) attract increasing attention as tunable and environmentally friendly precursor platforms due to their high metal-ion solubility, ionic conductivity, and flexible chemical composition. Such systems provide new opportunities for laser-induced synthesis under highly localized nonequilibrium conditions, where photothermal, thermochemical, and nonlinear optical processes occur on micro- and nanoscales. These studies are closely related to the fundamentals of laser–material interactions, laser micro/nano machining, and lasers in nanoscience.

One important direction concerns direct laser metallization using copper-containing DES and nanoparticles (NPs) precursors. Local laser irradiation enables thermochemical reduction and growth of conductive copper microstructures directly on polymers, flexible substrates, and other thermally sensitive materials without vacuum processing or multistep lithography. Particular attention is devoted to energy transfer, precursor decomposition, nucleation, conductive phase formation, and beam-based surface modification during ultrafast laser exposure. Such approaches enable fabrication of conductive microelectrodes and patterned structures for flexible electronics and electrochemical sensory platforms.

Another rapidly developing direction involves polymerizable DESs as a new type of photoresist for two-photon polymerization (2PP). Unlike conventional photoresists, these systems combine structural fabrication with ionic conductivity, mechanical flexibility, and tunable chemical functionality. Nonlinear laser excitation enables high-resolution fabrication of functional three-dimensional micro- and nanostructures while simultaneously controlling local physicochemical properties of the material.

The combination of laser processing with chemically engineered precursor systems opens broad opportunities for fabrication of electrochemical sensors, flexible and wearable platforms for real-time monitoring, conductive microelectrodes, and multifunctional microscale structures with integrated electrical, optical, and chemical functionalities. Such approaches are highly promising for next-generation flexible electronics, biointegrated devices, and functional micro/nanosystems.