Structural dynamics in nanoscale laser processing

Anton Plech*

Institute for Photon Science and Synchrotron Radiation, Karlsruhe Institute of Technology, Germany
*E-mail: anton.plech@kit.edu

Laser processing of nanomaterials gains considerable traction, because it may serve the needs for nanoparticle synthesis by purely physical methods without any chemical byproducts and be scalable to large throughput [1]. We specifically seek to understand the structure formation in liquid-based nanosynthesis [2]. Pulsed laser ablation and laser fragmentation in liquids is a method that has been applied to numerous materials systems. Despite its simple realization the fundamental understanding of the processes involved in production of nanoparticles and nanoclusters is hampered by the inherent hierarchical sequence of processes in time and space [3].

One promising access to a detailed identification of fundamental processes is to use pump-probe methods utilizing short x-ray pulses as structural probes. While much of the work has been done so far at synchrotron radiation facilities with 100 ps time resolution the resolution of atomic scale motion may benefit strongly from access to hard XFEL radiation [4].

Within this presentation, I will discuss the processes involved in laser irradiation of liquid-based colloids in view of producing quantum-sized clusters by laser fragmentation or specifically modifying morphology for tuning the photonic response of plasmonic particles.

Laser fragmentation needs to be understood in time length scales, but also in terms of energetics. We have recently observed the fragmentation process [5] and identified different structural responses from reversible heating and melting at low excitation flounce to partial (weak) fragmentation and full spinodal fragmentation with increasing fluence in a colloid in the ensemble average at the European Synchrotron Radiation Facility. Subtle structural reconfiguration of irradiated nanorods [6], on the other hand, is not always caught by the description of the ensemble, but requires single-shot, single-particle approaches, which will be discussed by means of coherent diffraction imaging [7] at the European XFEL.

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