Daria V. Andreeva
Centre for Advanced 2D Materials, National University of Singapore, Singapore
Daria.baeumler@gmail.com

Acoustic Implosions for Synthesis of Carbon Materials and Oscillations between Diamond and Graphite phases

Nonlinear modulation of microstructures concerns questions also relevant for understanding of the origin of life, material science, geo- and bio- science. Recent examples are the formation of chiral and hierarchically structured porous metal composites, epitaxial strain induced transitions in layered oxides, switchable infrared nanophotonic elements based on phase change materials, design of autonomous motors, etc.
However, the main question is, how to establish a dynamic control of useful characteristics, for example dynamic control of crystal / grain size and composition modulation in solids. A possible answer is to develop a new generation of dynamic impactors that can trigger oscillations of structures and functions.
In my talk I focus on ultrasonically triggered cavitation, that can be defined as growth and collapse of microbubbles, as a unique approach to generating a strong shock impact and, thus, a rapid increase of temperature and pressure at a localized area (<0.02 μm). At 20 kHz bubbles oscillate with a period of 50 μs. Adiabatic collapse of a bubble leads to electron temperature up to tens of eV. Thus, shock impact of oscillating bubbles creates highly non-equilibrium conditions for a dynamic modification of liquids and solids at microseconds time scale.
I will talk about the linearity of cavitation driven microstructural changes in metals, namely changes in Ni grain sizes and transformations of Ni phases in Ni based alloys vs. time of ultrasonic treatment.
Our work shows that the Interaction of microbubbles with surfaces drive several forces that lead to both grain growth and grain size reduction. The main questions are: Which forces drive grain growth and which forces trigger grain size reduction? What is the coupling mechanism that allows periodic switching between forces in the cavitating medium and leads to nonlinear effects in solids?
Furthermore, the efficiency of the ultrasonically modified Ni compounds in synthesis of carbon phases can be established as a tool for monitoring of the effects of cavitation on solids. I will demonstrate cavitation driven sp2 and sp3 carbon transformations on Ni surface.