Project 4.4 Ultrafast melting and crystallization of metals (experimental)

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Unit: SL1.1
www: http://www.ifpan.edu.pl/SL-1/html/l-sl11.html

Background:

Melting and solidification are transitions between structurally ordered and disordered states of matter. Both processes have been extensively studied by physicists and are widespread in daily life: melting of ice and crystallization of water are both a part of our everyday experience. They are also of fundamental importance for materials science and engineering since they underlie important technological processes like casting or welding. The common knowledge is that melting and freezing occur at the same temperature. In more general case however, the actual melting and freezing temperatures are not equal. The phenomenon of existence of a liquid below its nominal freezing point is known as supercooling and is a common feature of virtually all liquids. The reverse event – superheating of a solid is much more rare. To be achieved, superheating requires heating the material extremely rapidly, fast enough to outrun melting. This peculiar asymmetry between melting and solidification originates from different microscopic mechanisms of the solid-liquid and liquid-solid transition. Those mechanisms are fairly well understood when temperature does not change rapidly and melting or solidification proceeds slowly. Yet, when high heating and cooling rates are involved and transformation proceeds in a superheated or a supercooled regime, the theoretical predictions cannot be easily verified. This is because of the characteristic timescale of the transformation which is extremely short and for which the relevant time unit is a picosecond. For such short times, the conventional experimental techniques which typically require seconds or even hours to perform a single measurement, remain completely useless. In this project we aim to bypass this timescale limitation by employing state-of-the art experimental techniques involving the so-called “pump-probe” approach.

Aim:

The aim of the proposed project is to understand the process of melting followed by glass formation and/or crystallization in metals. Pure elements and alloys in form of nanostructures (mostly thin layers) will be studied. The planned research involves the use of ultrafast annealing methods with lasers. It will be combined with structural characterization by a variety of experimental techniques involving optical, X-ray and electron scattering (including time-resolved measurements on ultrashort time scales of ps-ns), both with use of laboratory equipment available at IP PAS (optical and electron microscopy, SEM, TEM) and large scale facilities (x-ray diffraction on synchrotron sources and free electron lasers). The work will provide experimental data and analysis significant for understanding of the fundamental mechanisms responsible for melting and glass formation. The project will be carried out on in the international environment, in particular in collaboration with European XFEL and Universitaet Duisburg-Essen, Germany.

Requirements:

- highly motivated student, preferably with Physics educational background and interest are desired,
- He/She should hold a M.Sc. degree in Physics or Materials Sciences or in a related research field (or an equivalent that qualifies one for PhD studies in physics in the country of issue),
- She/He should have strong interest in experimental science, but also to some extent in theoretical work,

- any experience with fs laser and/or electron/X-ray-based techniques, in particular electron/X-ray diffraction will be an asset,
- good programming skills in Matlab or Python will be an asset,
- good communication skills in written and spoken English are necessary for efficient completion of the doctoral thesis.

Funding:

Scholarship: grant funding of 5000 PLN per month, before subtracting obligatory employer and employee social security contributions (~15%), for 39 months (with a possibility of extension up to 48 months, under condition of grant prolongation)

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