Master Thesis

Flexo-Photovoltaic effect in oxide ceramics

Conventional solar cell efficiency cannot exceed the theoretical Schottky-Queisser limit. The bulk photoelectric effect induced by strain gradients in a material does not obey this limit but is not fully understood. In this thesis, the strain gradient will be engineered with dislocations and the effect shall be analyzed in a stay abroad in Warwick, UK.

In addition to a PhD Position, we are searching for a M.Sc. student from condensed matter physics or materials science for developing a new research field. This will be part of collaborative work between Prof. Rödel (Materials Science at Darmstadt, recent recipient of a large research grant for dislocation-tuned functionality in oxides) and Prof. Marin Alexe (University of Warwick, UK).
The student is suggested to spend about 40 % of his time at Darmstadt for creating controlled dislocation structures and spend the remainder at the University of Warwick for measurements of photoelectric effects at high strain gradients around dislocations. The necessary financial travel support will be provided.
Background: The photovoltage in usual semiconductors is limited by the respective band-gap energy while the so-called Schottky-Queisser limit is the upper bound value for efficiency. Lately, it could be shown that a high photovoltage exceeding the band-gap energy can be induced in ferroelectric materials. This depends on the non-centrosymmetric crystal structure of the materials, which causes an asymmetry in photo-excited charge carriers. In this case, large band-gap material has been shown to obtain the highest photovoltage but with very low efficiencies. An asymmetry in charge carriers can also be facilitated in centrosymmetric materials by inducing a strain gradient. In a very recent landmark study, a similar effect as the flexoelectric effect was shown to cause a photovoltage in regular centrosymmetric materials[1]. This could open the door for inducing a high photovoltage in band-gap optimized semiconductors exhibiting a high efficiency.

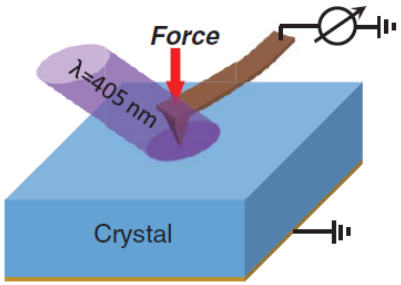

Fig. 1: Schematic of setup for local measurement of flexo-photovoltaic effect[1].

The student will gain in-depth knowledge about the physics behind the photovoltaic effect and the mechanics for the introduction of stress gradients in ceramics. The international working environment in the groups also offers an excellent opportunity to gain intercultural experience and be part of new high impact research.

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Reference:

1. Yang, M.-M., D.J. Kim, and M. Alexe, *Flexo-photovoltaic effect.* Science, 2018. **360**(6391): p. 904.