Bulk- and Flexo-Photovoltaic effects

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Two years after the invention of modern prototype solar cells, it was found that a ferroelectric material, BaTiO$_3$, exhibits a photovoltaic effect distinct from that of p-n junctions, later called the bulk photovoltaic (BPV) effect. Under uniform illumination, a homogeneous ferroelectric material gives rise to a current under zero bias, i.e. short-circuit current (ISC), that depends on the polarization state of the incident light, and produces an anomalously large photovoltage well exceeding the bandgap energy. The microscopic origins of this effect are still under debate. It is supposed to originate from the asymmetric distribution of photoexcited non-equilibrium carriers in k-space, caused by absence of centrosymmetry in the material. In the recent past, the entire field of photo-ferroelectrics has been revitalized by the reports of photovoltaic effect in BiFeO$_3$ (BFO), which is a ferroelectric/multiferroic material with one of the lowest band gap and significant semiconducting properties.

The talk will firstly present a short history and the basics of the bulk photovoltaic effect, tip enhancement, as well as the electronic origin of the anomalous BPV in some materials such as BiFeO$_3$. I will show how the tip-enhanced effect, i.e. enhancement of the short-circuit photocurrent density at an AFM tip contact area, may be at the basis of harvesting devices with efficiency exceeding the Shockley–Queisser limit. Finally, I will discuss a new photovoltaic effect which turns the BPV effect into a universal effect allowed in all semiconductors by mediation of the flexoelectric effect.

Professor Marin Alexe has been recently appointed as Chair of Functional Materials at the University of Warwick after spending about 18 years at the Max Planck Institute of Microstructure Physics-Halle (1996-2013). He has received the PhD degree from the Institute of Atomic Physics Bucharest in 1995. His research interest is physics and engineering of complex oxide thin films for information technology and integration of functional materials for oxide electronics. He has published more than 280 papers and 2 books and has an h-index of 53. In the last five years he has given more than 30 invited talks and lectures at international meeting and conferences. He was recently awarded Wolfson Research Merit and Theo Murphy “Blue Sky” Awards of the Royal Society.