Using Spectroscopy to Design New Types of Solar Cells

F. J. Himpsel

Physics Department, University of Wisconsin Madison

Solar cells are the ideal solution to the energy problem, converting abundant solar energy directly into electricity, which can then be converted into all other types of energy with nearly 100% efficiency. An area of 100×100 square miles is sufficient to satisfy the electricity needs of the US with currently available solar cells. But that would cost about a trillion dollars.

This overview illustrates how spectroscopy with soft X-rays can assist the development of new materials and new designs for solar cells with better price/performance ratio. The starting point is the most general layout of a solar cell, which consists of a light absorber sandwiched between an electron donor and an electron acceptor. There are four relevant energy levels, which can be measured by a combination of X-ray absorption spectroscopy and photoelectron spectroscopy [1]. This allows much more variation than a standard semiconductor solar cell, where only the band gap is variable. Examples for the design process will be given, such as organic dyes as absorbers, p-doped diamond films as inert donors, and the combination of all three components in one molecule (D-π-A complexes [2]). In order to speed up the development of new solar cells, a feedback loop is currently being established between spectroscopy, theory, synthesis, and device fabrication.

[1] http://uw.physics.wisc.edu/~himpsel/solar.html
[2] A. Yella, H.-W. Lee, H. N. Tsao, C. Yi, A. K. Chandiran, Md. K. Nazeeruddin, E. W.-G. Diau, C.-Y. Yeh, S. M. Zakeeruddin, M. Grätzel, Science **334**, 629 (2011).