Michael Grätzel

2009 Balzan Prize for the Science of New Materials
For his many contributions to the Science of New Materials, and in particular for his invention and development of a new type of photovoltaic solar cell, the Dye Sensitized Cell, commonly known as the Grätzel Cell.

Improving the Performance of the Dye Sensitized Solar Cell

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The overall goal of the Balzan research project proposed by Professor Michael Grätzel is to improve the performance of the Dye Sensitized Cell (DSC), commonly known as the Grätzel Cell. An increase in the overall efficiency of this kind of photovoltaic cell from its present 12.3 to nearly 15 percent is predicted, which would strongly contribute to making the DSC a widely used method for producing electricity from sunlight. With the second half of the 2009 Balzan Prize for the Science of New Materials, the Laboratory of Photonics and Interfaces at the Ecole Polytechnique de Lausanne (ETH), directed by Michael Grätzel, will acquire an Atomic Layer Deposition System for the Laboratory and hire Dr. Aswani Yella as a postdoctoral fellow for two years. Aswani Yella is a Ph.D. student who has just finished her thesis with Professor Tausch Tremel in Mainz, Germany. Moreover, part of the sum will support visits of students and researchers from Italian universities within a framework of collaboration on the research project.

In adopting an experimental approach to the design of the Grätzel Cell, the Balzan research project will focus its attention on the interface that separates the materials used in the device for transporting the negative charge carriers (electrons) and positive charge carriers (called holes). The electron transporting material is constituted of a network of very small titanium dioxide (TiO_2) particles whose size is in the nanometer range (a nanometer is one million times smaller than a millimetre) while the hole transporting material is either an electrolyte or a solid p-type semiconductor. These electric charges are generated by dye molecules that are anchored as a monomolecular layer on the surface of the nanocrystalline TiO_2 film. Following excitation by sunlight, the dye molecules inject electrons in the TiO_2 particles and the holes in the electrolyte or solid p-type conductor. For maximum efficiency in converting sunlight to electricity, with the solar cell it is very important to transform these negative and positive photo-generated charge carriers into electric current before they recombine. In order to achieve this goal, the charge-carrier collection has to be significantly faster than their recombination. Contrary to conventional photovoltaic devices, where electrons and holes are generated – and recombined – in the same semiconductor solid, in the Grätzel Cell their recombination takes place across the interface that separates the electron transporting material from the hole transporting material. This provides an opportunity to slow down the charge-carrier recombination by timely engineering of this interface. The Balzan research project will explore several new strategies to slow down the interfacial charge carrier recombination rate. The dye molecule itself is already a molecular insulator and should TiO_2 thus hinder the electron-hole recombination on its own. However, the molecular dye layer formed on the TiO_2 nano-particles by absorption is not usually uniform, leaving part of the surface exposed to interaction with the electrolyte or hole conductor. Consequently, part of the research will be aimed at improving the process of self-assembly of the dye molecules in order to form more compact films on the surface, modifying the chemical composition of the dye molecules to equip them with long alkyl chains, reinforcing reciprocal lateral attraction. This is expected to increase compactness, retarding unwanted interfacial recombination of negative and positive charge carriers. Furthermore, an attempt will be made to use additives in the electrolyte to stimulate the formation of a denser dyed monomolecular layer. Finally the atom layer deposition (ALD) system purchased with the second half of the Balzan Prize will provide a powerful tool to modify the titanium oxide surface by superimposing a very thin layer of a semiconducting oxides in a contiguous and conformal manner. The goal here is to eliminate defects such as oxygen vacancies that are present on the nanocrystalline surface. These defects, called electronic surface states, are known to accelerate interfacial electron-hole recombination. Proper engineering of the interface will slow down interfacial charge carrier recombination, thus increasing open circuit voltage and cell efficiency.

Statement by the Prizewinner: *Im Hinblick auf die zahlreichen denkbaren Anwendungen, die Umweltverträglichkeit ebenso wie die einfache Herstellung und die geringen Kosten sollte die von unserer Forschungsgruppe entwickelte nanokristalline Farbstoffzelle den Weg für eine breitere Nutzung regenerierbarer Energiequellen ebnen helfen und so zur Entwicklung einer lebenswerten Zukunft für die Menschheit beitragen.* Michael Grätzel (Berne, 20.11.2009)