Photoelectrochemical water splitting by GaAs nanowire arrays on Si

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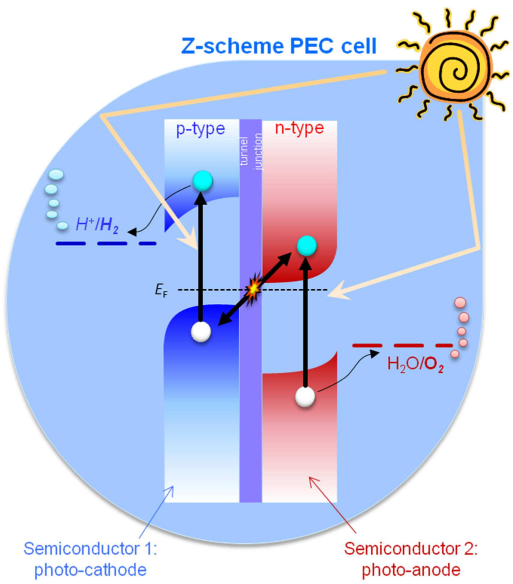

The conversion and storage of renewable energies is a demanding and indispensable research topic to ensure mankind's future energy supply in a sustainable manner. The Sun is one of the largest sources of clean energy capable of satisfying the Planet's current power demand. While harvesting solar energy can be achieved by using conventional photovoltaics, the photo-generated electricity cannot be stored as such, and must be connected to the grid for immediate usage or to a battery for storage. By comparison, artificial photosynthesis, which converts solar energy directly into fuel through the formation of energy-rich compounds such as hydrogen, hydrocarbons or alcohols, solves in one go both issues: harvesting and storage.[1] The current challenge in the field of solar fuels is to develop a sufficiently efficient and stable solar-to-chemical conversion system that can compete with fossil fuels. In this project, we address the conversion from sunlight to fuel by using a tandem z-scheme device with nanostructured (Al)GaAs and Si semiconductors which are responsible for harvesting sunlight and efficiently drive the appropriate carriers towards the surface. Two main goals are aimed in this project: 1) the optimisation and design of a stable tandem nanowire based solar energy conversion system, 2) the incorporation of novel electro-catalysts that are physically and electrically attached to the semiconductor nanowires. In the first part, (Al)GaAs nanowires with the appropriate band structure are fabricated on Si substrate.[2] Due to the instability of the as-grown material in water, the influence on charge transfer of thin interfacial layers such as TiO_2 or Al_2O_3, which are used for protection of the semiconductor surface, will be investigated. Second, the semiconductors surface is modified with new electrocatalysts, [3] in order to ensure and optimize the interfacial charge transfer between the semiconductors and the reactant (H_2O and CO_2), either in the liquid or gas phase. The role of the electro-catalyst is to lower the over-potentials and accelerate the transfer kinetics efficiently and selectivity to drive the desired redox reaction. Traditionally, noble metal nanoparticles have been used as catalysts, but we will explore the use of chalcogenides, organic and bio-mimetic electrocatalysts. Investigations on material physical and electrical properties, device stabilities and corrosion processes are carried out with a combination of processing and characterization techniques available in the two groups; from physical and chemical synthesis techniques, to solid state, electro-chemical and product quantification characterization.

(1) Bard, A.; Fox, M. Artificial Photosynthesis: Solar Splitting of Water to Hydrogen and Oxygen. *Acc. Chem. Res.* **1995**, 141–145.

(2) Russo-Averchi, E.; Heiss, M.; Michelet, L.; Krogstrup, P.; Nygard, J.; Magen, C.; Morante, J. R.; Uccelli, E.; Arbiol, J.; Fontcuberta i Morral, a. Suppression of Three Dimensional Twinning for a 100% Yield of Vertical GaAs Nanowires on Silicon. *Nanoscale* **2012**, *4*, 1486–1490.

(3) Schwinghammer, K.; Mesch, M. B.; Duppel, V.; Ziegler, C.; Senker, J.; Lotsch, B. V. Crystalline Carbon Nitride Nanosheets for Improved Visible-Light Hydrogen Evolution. *J. Am. Chem. Soc.* **2014**, *136*, 1730–1733.