Plasma Based Surface Modification Applied in Material Synthesis

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Climatic changes, global warming and a shortage in raw materials require new, sustainable and environmental friendly energy sources and associated compounds. One possibility is represented by the use of solar cells. Another one is the use of fuel cells. The activity of solar cells is limited to the environmental conditions, the amount of unhampered solar radiation, regardless of the actual demand. Unlike, fuel cells which can produce as much electrical energy as is necessary at the specific moment – as long as hydrogen is available. To facilitate the storage of the solar based energy one can transform the excess solar energy into hydrogen. Hence, the so-generate hydrogen can then re-transformed into electricity when needed.
Nearly half of the solar energy is in the visible region and beyond, but common cells reach a maximal efficiency around 17 %. The sensitisation of wide gap semiconductors is believed to be a promising way to overcome this value. Quantum dots (QDs) have been identified as an auspicious way to develop excitonic solar cells with the advantage that crucial properties such as band gap, electron injection as well as inter-facial charge carrier recombination can be fine-controlled simply by the size of the QDs.
The current manufacturing process is lacking mass production ability (epitaxial growth) or requires harmful precursors (colloid synthesis). Plasma methods, on the contrary, are well-tried in unique layer production.
A new method was developed for the synthesis of lead chalcogenide QDs, embedded in a polythiophene 3-D nano-confinement on a titanium dioxide surface. The method takes place in a H_2S-atmosphere and combines a PECVD-process – thiophen layer creation – and a PVD-process – creation of the PbS QDs. The goal was, first, to control the size of the QDs and prevent nano-particle agglomeration and, second, to achieve a stable anchoring of the them on the TiO_2 surface with improved dynamics of the bond with regard to electron transport and charge carrier recombination.
The surface organised particle were analysed by using different techniques and, furthermore, the final probability of generating electrons by the incident light was analysed by means of photo-electrochemical analytics.
Fuel cells are a well known efficient alternative that allows an electrical current to be generated, keeping to a minimum the environmental hazard. There are numerous ways to design the cell regarding to the hydrogen donor and the oxygen donor. For cars and off-grid facilities so called Proton exchange membrane fuel cells (PEMFC) are widely used. They operate at low temperatures and with the oxygen from the ambient air. One crucial point for the mass market introduction is the price which is mainly determined by the catalyst used – platinum – an expensive while rare ore. A substitution with an abundant and low-cost alternative is hence desirable.
A new approach was conducted in the hopes of developing a new technique that uses plasma based powder treatments. The powder was a mixture of iron or cobalt acetate and carbon which showed in the past promising results when treated with nitrogen. Here we used an ICPE plasma and a variation of different Ar-N-atmosphere to generate

and maximize the catalytic activity of the final powder.
It was analysed by means of surface properties and also through electrochemical analysis for an insight into the generated current and available voltage.