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Generation of Integrated Solid-State Microelectrochemical Optoelectronic Devices by Coupling Dye-Sensitized Solar Cell and Redox Supercapacitor

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Photovoltaic cells based on dyes adsorbed on nanostructured semiconductor oxide electrodes, typically titanium dioxide, are under intensive investigation as alternatives to traditional silicon based solar cells. Dye-sensitized solar cells (DSSC) have shown efficiencies of 11% using a dye-covered nanocrystalline anatase TiO_2 film in combination with a liquid electrolyte, typically I^-/I_3^- redox system in organic medium. There has been growing interest in replacing liquids by solid state materials, so-called hole conductors such as electronically conducting polymers, copper thiocyanates/iodides or (2,20,7,70-tetrakis (N,N-dimethoxyphenylamine)-9,90-spirobifluorene) (spiro-OMeTAD). The solid-state version of DSSC is easier to assemble, and it is likely to exhibit higher stabilities. Another important advantage is lack of toxic and dangerous solvents which may leak when the solar cell is damaged. Although the energy conversion efficiency of solid state DSC is still lower than that of iodine/iodide based cells, it can be improved to over 6%. Such systems are of interest to the development of solid-state microelectrochemical optoelectronic devices.

An important issue in solar cell technology is the storage of generated electrical energy for later use. In this respect, semi-solid layer-type electrochemical supercapacitors, as compared to typical batteries and electrolysis cells, offer the advantage of long-term stability upon repeated cycling and relatively low energy loss in the charge-discharge cycle. In this study, hydrous ruthenium oxide has been selected as a potential charge storage material for the integrated optoelectronic supercapacitor. To make the device practically solid, a proton-conductive polymer membrane has been used as an electrolyte. Organic D35 dye was used to sensitize TiO_2 photoanode and such a conducting polymer as P3HT (Poly-(3-hexylthiophene-2,5-diyl) served as hole conductor. The combination of the composite material with dye-sensitized solar cell allowed to obtain a photo-rechargeable supercapacitor (Photo-Supercapacitor) characterized by high charging voltage of 0.8 V. The specific capacitance, power density and coulombic efficiency and energy conversion efficiency of the hybrid cell was analyzed in details and will be discussed during presentation.