Next generation photoelectrochemical reactors and solar-to-hydrogen metrology

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Hydrogen production from renewable energy sources without CO_2 emission is a major part of emerging hydrogen-based economies. The worldwide interest in hydrogen technologies lies in their great potential for energy storage as well as chemical and materials industry. In contrast to well established electrolysis technologies, direct conversion of solar power to hydrogen can be technologically realized through photo electrochemical (PEC) water splitting. In this contribution, a scalable PEC reactor technology will be presented based on conventional high-efficiency Si solar cells and thin film solar cell technology with up to 10% solar-to-hydrogen efficiency. Test reactors allow an assessment of solar-to-hydrogen (STH) performance and stability of integrated PEC modules as well as anode and cathode subsystems. A novel PEC measurement setup has been implemented based on LED sun simulators that allows a high precision measurement of STH efficiency with discontinuous sampling. Specifically, it addresses the parameters irradiation quality, reaction temperature, and gas measurement. Applications will be shown in measuring Faraday and STH efficiencies of a copper indium gallium selenide photocathode and the influence of reaction temperature on the photocurrent of a WO_3 photoanode. Finally, perspectives in upscaling, techno-economical assessment, and implementation of PEC hydrogen production in renewable energy systems and green chemistry will be discussed.