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Analysis of silicon-based integrated photovoltaic-electrochemical hydrogen generation system under varying temperature and illumination

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Abstract

Last decade witnessed tremendous research and development in the area of photo-electrolytic hydrogen generation using chemically stable nanostructured photo-cathode/anode materials. Due to intimately coupled charge separation and photo-catalytic processes, it is very difficult to optimize individual components of such system leading to a very low demonstrated solar-to-fuel efficiency (SFE) of less than 1%. Recently there has been growing interest in an integrated photovoltaic-electrochemical (PV-EC) system based on GaAs solar cells with the demonstrated SFE of 24.5% under concentrated illumination condition. But a high cost of GaAs based solar cells and recent price drop of poly-crystalline silicon (pc-Si) solar cells motivated researchers to explore silicon based integrated PV-EC system. In this article a theoretical framework is introduced to model silicon-based integrated PV-EC device. The theoretical framework is used to analyze the coupling and kinetic losses of a silicon solar cell based integrated PV-EC water splitting system under varying temperature and illumination. The kinetic loss occurs in the range of 19.1%–27.9% and coupling loss takes place in the range of 5.45%–6.74% with respect to varying illumination in the range of 20–100 mW/cm². Similarly, the effect of varying temperature has severe impact on the performance of the system, wherein the coupling loss occurs in the range of 0.84%–21.51% for the temperature variation from 25 to 50 °C.

Key words: Polycrystalline silicon; Electrochemical cell; Electrochemical impedance spectroscopy; Integrated PV-EC system

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