ELEMENT-SPECIFIC MEASUREMENT OF HOLE TRANSPORT IN A Ni-TiO_2-Si PHOTOLECTRODE USING TRANSIENT EXTREME ULTRAVIOLET SPECTROSCOPY

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A passivating oxide layer is critical for the stability and the performance of solar-fuel photoelectrodes. While the semiconductor surface can be passivated by a few nanometer oxide film, the best performance often correlates with a thicker and defect-rich amorphous TiO_2 layer. The defect states are suggested to facilitate hole transport between the semiconductor and metal catalyst. In this presentation, transient extreme ultraviolet (XUV) absorption spectroscopy quantifies the electron and hole transport between each element of a photoexcited Ni-TiO_2-Si photoelectrode. A ballistic hole tunneling from the p-type Si to the Ni metal is measured in 100 fs after photoexcitation of the Si. The measured hole injection efficiency is 26%. The transient hole population is then measured to back-diffuse through the TiO_2 on a picoseconds timescale, followed by an increased electron-hole recombination at the Si-TiO_2 interface. By temporally resolving the population of electrons and holes in each layer of the junction, the hole transport velocity in the TiO_2, the hole mobility in the Si, the diffusion constant of holes in the TiO_2, and the surface recombination velocity at the Si/TiO_2 interface are quantized.