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Effect of carrier concentration of ITO films on Quantum Efficiency Window in Heterojunction Silicon Solar Cells

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In this paper, the effects of carrier concentration on dielectric constant of ITO films were investigated by spectroscopic ellipsometry. From SE results, we find the pronounced shift of the ε 1 peaks toward high energy with concentration; while contrarily, the ε 2 values at low energy region increases with decreasing concentration. These shifts are attributed to the Burstein-Moss and free-carrier absorption effects within ITO films. With increases carrier concentration, the values of extinction coefficients show quite different behaviors in range of wavelength from 200 to 1200 nm. The reduction in k at $\lambda \leq 500$ nm, while increasing at $\lambda \geq 500$ nm was observed. The QE of HJ solar cells behaviors can be roughly classified into two regions: short-wavelengths ($\leq$ 650 nm) and long-wavelengths region ($\geq$ 650 nm). With increasing carrier concentration as well as energy band gap, QE shows improvement at short-wavelength, while at long-wavelength QE shows opposite trend. Widening band gap energy due to Burstein-Moss shift is the key to improve QE in short-wavelength; simultaneously FCA effect due to optical scattering is attributed to the reduction in QE at long-wavelength. In spite of band gap extension, Jsc calculated from QE decreases from 34.7 mA/cm2 to 33.2 mA/cm2 with increasing carrier concentration. It demonstrated that FCA effect may more govern Jsc in the HJ solar cells.

Keywords: solar cell, ITO, Heterojunction silicon