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Correlation between Oxidation State and Electron Blocking Performance of Tungsten Oxide Interlayer in Organic Solar Cell

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Solution-processed tungsten oxide thin film with thickness of about 30 nm is prepared from ammonium tungstate. This layer is introduced into the interface between the poly(3-hexylthiophene):[6,6]-phenyl-C61-butyric acid methyl ester (P3HT:PCBM) layer and the ITO electrode to be used as an electron blocking layer. The annealed tungsten oxide thin films at 150°C and 300°C show amorphous phase, while the 400°C -annealed tungsten oxide film shows crystalline phase. At 150°C annealing temperature, the conversion efficiency is significantly improved from 0.71% to 1.42% as the condition is changed from vacuum to air atmosphere, which is related to oxidation state of tungsten in amorphous phase. For the air annealing condition, the conversion efficiency is further increased from 1.42% to 2.01% as the temperature is increased from 150°C to 300°C, which is mainly due to the removal of the chemisorbed water. However, a slight deterioration in photovoltaic performance is observed when the temperature is increased to 400°C, which is ascribed to poor electron blocking ability due to the formation of crystalline phase. It is concluded that W^{6+} oxidation state and amorphous nature in tungsten oxide interlayer is essential for blocking electron effectively from the active layer to the ITO electrode.

Keywords: Bulk hetero junction, Organic solar cell, Interlayer, Tungsten oxide, Oxidation state, Crystallinity