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# Synthesis of tin oxide thin films by using a sol-gel process with non-toxic solvents and its application to memristors

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When using a sol-gel process to synthesize semiconductor thin films, toxic solvents and high-temperature sintering processes were usually required. Although toxic solvents are generally chemical active and solutes normally have higher solubilities to these solvents, they are harmful to human bodies and environmentally unfriendly. Besides, high-temperature sintering processes will arise high manufacturing cost, much time consumption and low process compatibility. This study synthesized tin oxide ($SnO_x$) semiconductor thin films by using a sol-gel process. The precursor solution was obtained by using a non-toxic solvent of $C_2H_5OH$. After $Cl_2Sn_2$, $H_2O$ was dissolved in the $C_2H_5OH$, this mixed solution was continuously stirred at $80^0$ for 24 hours and it was aged at room temperature for 1-2 days. The solution was opaque initially and turned into transparent after stirring and the aging process. A $SnO_x$ thin film was deposited on the ITO substrate by using a spin coating process. Then, the deposited $SnO_x$ film was cured on a hotplate at $70^0$ for 60s to remove the solvent. We also investigated concentration effects on $SnO_x$ characteristics. Current-voltage curves of the optimal SnOx thin film exhibit significant bipolar resistive switching behavior and highly stable endurance characteristic. The carrier transport mechanism was also studied. An X-ray photoelectron spectroscopy (XPS) was used to examine chemical structures of the deposited $SnO_x$ films. The oxidation number of Sn and concentrations of lattice oxygen and non-lattice oxygen were explored. The crystallinity of the $SnO_x$ film was examined by using X-ray diffraction (XRD) analysis. Fourier transform infrared (FTIR) was utilized to obtain chemical bonds. A UV-visible spectroscopy was employed to study the transparency and the optical band gap. This approach has advantages of simplicity, low-cost and high throughput, and it can be applied to future flexible electronics.

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