SS1-004

Solution-processed Dielectric and Quantum Dot Thin Films for Electronic and Photonic Applications

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Silicate-silsesquioxane or siloxane-silsesquioxane hybrid thin films are strong candidates as matrix materials for ultra low dielectric constant (low-k) thin films. We synthesized the silicate-silsesquioxane hybrid resins from tetraethoxyorthosilicate (TEOS) and methyltrimethoxysilane (MTMS) through hydrolysis and condensation polymerization by changing their molar ratios ([TEOS]:[MTMS] = 7:3, 5:5, and 3:7), spin-coating on Si(100) wafers. In the case of [TEOS]:[MTMS] 7:3, the dielectric permittivity value of the resultant thin film was measured at 4.30, exceeding that of the thermal oxide (3.9). This high value was thought to be due to Si-OH groups inside the film and more extensive studies were performed in terms of electronic, ionic, and orientational polarizations using Debye equation. The relationship between the mechanical properties and the synthetic conditions of the silicate-silsesquioxane precursors was also investigated. The synthetic conditions of the low-k films have to be chosen to meet both the low orientational polarization and high mechanical properties requirements. In addition, we have investigated a new solution-based approach to the synthesis of semiconducting chalcogenide films for use in thin-film transistor (TFT) devices, in an attempt to develop a simple and robust solution process for the synthesis of inorganic semiconductors. Our material design strategy is to use a sol-gel reaction to carry out the deposition of a spin-coated CdS film, which can then be converted to a xerogel material. These devices were found to exhibit n-channel TFT characteristics with an excellent field-effect mobility (a saturation mobility of ~ 48 $cm^2V^{-1}s^{-1}$) and low voltage operation (< 5 V). These results show that these semiconducting thin film materials can be used in low-cost and high-performance printable electronics.