Ming Fang

EMD Performance Materials

Atomic Layer Deposition of Yttrium Oxide Using a Liquid Yttrium Precursor, Y-08

Ming Fang, Jean-Sebastien Lehn, Joby Eldo, Jacob Woodruff, Ravindra Kanjolia (EMD Performance Materials)

Yttrium Oxide (Y_2O_3) films deposited by ALD have been extensively studied as a promising high-k material for future device manufacturing such as in MOSFETs and memory applications due to its wide band gap (~5.5 eV), high permittivity (>10), and high thermal stability. Pure or doped Y_2O_3 containing films have also been used in other applications such as in solid oxide fuel cells, protective coatings, photonics, and quantum information processing.

Herein, we report the studies of atomic layer deposition (ALD) of Y_2O_3 thin films using a newly developed volatile, scalable, liquid yttrium precursor, Y-08, with ozone and/or water as co-reactants.

A comparison of oxygen sources shows that "ozone followed by water" leads to a higher growth per cycle {0.81 Å/cycle} compared to either ozone-alone {0.51 Å/cycle}, or water-alone {0.16 Å/cycle}. The ALD window starts at 310 °C on the system tested, and the growth/cycle is 1.09 Å/cycle when saturation is achieved with both the Y-08 and oxygen sources doses. The refractive index ranges from 1.90 to 1.95. XPS analysis confirms that the bulk of film consists of exclusively oxygen and yttrium; but there was some carbon contamination on the film surface.

An yttrium oxide film deposited on a via with 20:1 aspect ratio (1800-nm deep, and 90-nm wide) shows excellent conformality when characterized by SEM (Figure 1), with film thickness ranging between 22.5 and 26 nm outside the via (Figure 2a), and 23 and 26 nm at the via bottom (Figure 2b).

We demonstrate that the liquid nature and high volatility of our new yttrium precursor promotes easier precursor delivery and more controllable ALD processes for manufacturing good quality Y_2O_3 thin films for future semiconductor applications.