Characterization and photoluminescence of Al- and Ga-doped V_2O_5 nanostructures synthesized by thermally activated process

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Abstract

V_2O_5 has an orthorhombic crystal structure, and narrow direct and indirect bandgaps of 2.4 and 2.0 eV. Its optoelectronic properties can be modified by adding various dopants, such as Ga, Al, and Nd, due to the formation of the defect-levels. The applications of V_2O_5 are widely used in gas sensors, catalysts, and electrochromic devices. In this study, Al- and Ga-doped V_2O_5 nanostructures were fabricated by the thermally activated process at 850℃ via the V-S mechanism. The Raman and XRD patterns have showed the typical V_2O_5 orthorhombic crystal structures of Al- and Ga-doped V_2O_5. The variations of c/a and c/b ratios estimated from the XRD patterns confirmed the substitutions of the Al^{3+} and Ga^{3+} into the V^{5+} lattice sites. HRTEM images showed that the growth direction of Al- and Ga-doped V_2O_5 nanostructures were along the [110] direction. The XPS results for the Al-doped V_2O_5, metallic Al was formed inside the nanostructure and the amorphous Al-O and Al-OH phases were generated on the nanostructure surface; for the Ga-doped V_2O_5, Ga-O phase was formed in the V_2O_5 nanostructures. PL spectra showed the increasing intensities in blue (1.94 eV) and green (1.77 eV) emissions of the V_2O_5 nanostructures while the Ga dopant was in 0.5 wt.%, which can be contributed to the formation of $V_{O^{2-}}$ and $Ga^{3+}{}_i$-defects; the Al dopant showed a decreasing intensities in blue (1.94 eV) and green (1.77 eV) emissions of the V_2O_5 while the adding of Al, which can be attributed to the formation of the metallic Al inside the V_2O_5 nanostructures. This study showed that the photoluminescence properties of V_2O_5 nanostructures can be modified by the dopants of Al and Ga. The Al dopants revealed a significantly suppressing effect while starting the addition of Al, and the Ga showed an enhancing effect while the Ga contents were in 0.5 wt.%.

References

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