Transport and magnetic properties of delafossite $CuAl_{1-x}Mn_xO_2$ ceramics

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Wide band gap semiconductors have attracted much attention as a promising class of materials for room temperature ferromagnetism. Recently, both theoretical and experimental works suggest that carrier-mediated ferromagnetism is more favourable with p-type conduction. The delafossite oxide $CuAlO_2$ is a p-type wide-gap materials with a band gap of ~3.5 eV and hole concentration of the order of 10^{17} cm^{-3}. Here we report on the transport and magnetic properties of Mn-doped $CuAlO_2$ ceramics, synthesized by a standard solid state reaction method in an air atmosphere at a sintering temperature of 1150 °C. X-ray diffraction analysis revealed that the equilibrium solubility of Mn ions in $CuAlO_2$ is as low as about 3 mol%. Nondoped samples were semiconducting with hole concentration of ~5.8×10^{16} cm^{-3} and the doping of Mn rapidly increased the resistivity. As a result, $CuAl_{1-x}Mn_xO$ was strongly insulating for x = 0.02 and 0.03. This suggest that, contrary to common expectations, Mn^{2+} substitution for Al^{3+} in the $CuAlO_2$ lattice results in oxygen vacancies to maintain charge neutrality, leading to the compensation of existing acceptors. The temperature dependence of the magnetization for x = 0.02 showed an almost paramagnetic behavior with a negative Curie–Weiss temperature of about −11 K, indicating an intrinsic antiferromagnetic coupling between Mn ions in $CuAlO_2$. The field dependence of the magnetization at 5 K also exhibited no hysteresis shape.

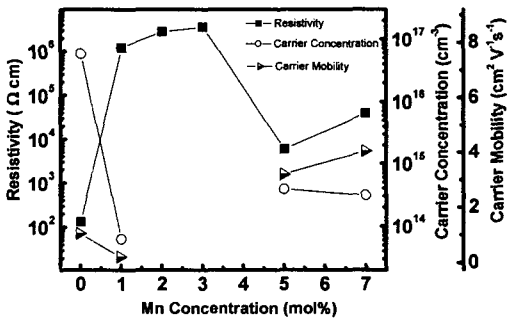

Fig 1. Electrical resistivity, carrier concentration and mobility at room temperature with varying Mn concentration in $CuAl_{1-x}Mn_xO_2$ ceramics ($0 \le x \le 0.07$).