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Resistive Switching Memory Devices Based on Layer-by-Layer Assembled-Superparamagnetic Nanocomposite Multilayers via Nucleophilic Substitution Reaction in Nonpolar Solvent

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We demonstrate a facile and robust layer-by-layer (LbL) assembly method for the fabrication of nonvolatile resistive switching memory (NRSM) devices based on superparamagnetic nanocomposite multilayers, which allows the highly enhanced magnetic and resistive switching memory properties as well as the dense and homogeneous adsorption of nanoparticles, via nucleophilic substitution reaction (NSR) in nonpolar solvent. Superparamagnetic iron oxide nanoparticles (MP) of about size 12 nm (or 7 nm) synthesized with oleic acid (OA) in nonpolar solvent could be converted into 2-bromo-2-methylpropionic acid (BMPA)-stabilized iron oxide nanoparticles (BMPA-MP) by stabilizer exchange without change of solvent polarity. In addition, bromo groups of BMPA-MP could be connected with highly branched amine groups of poly (amidoamine) dendrimer (PAMA) in ethanol by NSR of between bromo and amine groups. Based on these results, nanocomposite multilayers using LbL assembly could be fabricated in nonpolar solvent by NSR of between BMPA-MP and PAMA without any additional phase transfer of MP for conventional LbL assembly. These resulting superparamagnetic multilayers displayed highly improved magnetic and resistive switching memory properties in comparison with those of multilayers based on water-dispersible MP. Furthermore, NRSM devices, which were fabricated by LbL assembly method under atmospheric conditions, exhibited the outstanding performances such as long-term stability, fast switching speed and high ON/OFF ratio comparable to that of conventional inorganic NRSM devices produced by vacuum deposition.

Keywords: Layer-by-layer assembly, Nonvolatile memory devices, Magnetic nanoparticles, Nucleophilic substitution reaction

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The Structural Investigation for the Enhancement of Electrical Conductivity in Ga-doped ZnO Targets

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ZnO materials with a wide band gap of approximately 3.3 eV has been used in transparent conducting oxides (TCO) due to exhibiting a high optical transmission, but its low conductivity acts as a role of a limitation for conducting applications. Recently, Ga or Al-doped ZnO (GZO, AZO) becomes transparent conducting materials because of high optical transmission and excellent conductivity. However, the fundamental mechanism underlying the improvement of electrical conductivity of the GZO is still the subject of debate. In this study, we have fully investigated the reasons of high conductivity through the characterization of plane defects, crystal orientation, doping contents, crystal structure in Zn_{1-x}Ga_xO (x=0, 3, 5.1, 5.6, 6.6 wt%). We manufactured Zn_{1-x}Ga_xO by sintering ZnO and Ga₂O₃ powders, having a theoretical density of 99.9% and homogeneous Ga-dopant distribution in ZnO grains. The GZO containing 5.6 wt% Ga represents the highest electrical conductivity of 7.5×10⁻⁴ Ω⁻¹·m. In particular, many twins and superlattices were induced by doping Ga in ZnO, revealed by X-ray diffraction measurements and TEM (transmission electron microscopy) observations. Twins developed in conventional ZnO crystal are generally formed at (110) and (112) planes, but we have observed the twins at (113) plane only, which is the first report in ZnO material. Interestingly, the superlattice structure was not observed at the grains in which twins are developed and the opposite case was true. This structural change in the GZO resulted in the difference of electrical conductivity. Enhancement of the conductivity was closely related to the extent of Ga ordering in the GZO lattice. Maximum conductivity was obtained at the GZO with a superlattice structure formed ideal ordering of Ga atoms.

Keywords: Ga-doped ZnO, Twin, Superlattice, Electrical conductivity