MAR15-2014-020272

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Dual field effects in spinel ferrite field effect devices: electrostatic carrier doping and redox reactions

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Spinel ferrite is a good candidate as a tunable magnetic semiconductor with high T_C. Here, we report the gate-induced conductance modulation of $(Fe_{3-x}Zn_x)O_4$ solid solution to demonstrate the dual contributions of volatile and non-volatile field effects arising from electronic carrier doping and redox reactions using field effect device structure with a ferroelectric $Pb(Zr,Ti)O_3$ and an ionic liquid DEME-TFSI. In the $Pb(Zr,Ti)O_3/(Fe_{2.5}Zn_{0.5})O_4$ FET, the gate voltage dependence of channel conductance on the $(Fe,Zn)_3O_4$ layer shows the typical hysteresis behavior reflecting the ferroelectric polarization, indicating the static carrier modulation [1] . In contrast, in the DEME-TFSI/$(Fe_{2.5}Zn_{0.5})O_4$ FET, a large hysteresis observed in the drain current vs gate voltage characteristics is not accounted for solely by electrostatic doping, strongly suggesting the presence of chemical reactions[2]. In more details, the characteristic hysteresis virtually disappears for the heavily Zn substituted system,$(Fe_{2.2}Zn_{0.8})O_4$ with less carrier concentration [3]. These observations revealed the coexistence of two types of field effects in the $Fe_{3-x}Zn_xO_4$ devices, and the tuning of field-effect characteristics via composition engineering should be extremely useful for fabricating high-performance oxide field-effect devices. References; [1] Appl. Phys. Lett. 98 (2011) 102506, [2] Adv. Mater. Interfaces 1 (2014) 1300108, [3] Sci. Rep. 4 (2014) 5818.