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

HIDEKAZU TANAKA, Institute of Scientific and Industrial Research, Osaka University

Spinel ferrite is a good candidate as a tunable magnetic semiconductor with high $T_C$. Here, we report the gate-induced conductance modulation of $(\text{Fe}_{3-x}\text{Zn}_x)\text{O}_4$ 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$_3/\text{(Fe}_{2.5}\text{Zn}_{0.5})\text{O}_4$ FET, the gate voltage dependence of channel conductance on the (Fe,Zn)$_3$O$_4$ 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$_x$O$_4$ 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.