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High-*k* oxide/organic polymer hybrid gate structure for oxide field-effect transistors

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Field-effect doping of transition-metal oxides has been studied extensively in terms of exploration of exotic electronic phases as well as its potential for use in field-effect transistors [1]. A number of studies have focused on the fabrication of gate dielectric structures with strong carrier doping capability. Recent research have also highlighted the critical importance of the gate dielectric/oxide channel interface because the formation of transient layers, defects etc. at the interface often degrades the intrinsic electronic properties. An organic polymer parylene-C was reported to allow successful carrier doping into various transition-metal oxides [2]; the doping level, however, has remained low (10^{12} cm^{-2}) because of its low relative dielectric constant (ε_r~3). Recently, it was proposed by Eyvazov *et al.* that the doping level could be enhanced by overlayer deposition of high-*k* Ta_2O_5 (ε_r~23) on parylene-C [3]. In this work, in order to find a clue to the further enhancement, we have examined the effect of the thicknesses of the two dielectric layers on the enhanced carrier doping.

We have fabricated gate stacks consisting of Au/Ta_2O_5/parylene-C/Pt/Ti on MgO (001) substrates shown in the inset of Fig 1. A parylene-C film was synthesized on Pt/Ti-sputtered MgO by chemical vapor deposition, and a Ta_2O_5 film was subsequently grown by rf sputtering. To investigate the effects of the thicknesses on capacitance characteristics, the thickness of parylene-C ($t_{parylene}$) was varied while that of Ta_2O_5 (t_{Ta2O5}) was fixed at ~120 nm.

The decrease in $t_{parylene}$ was found to substantially enhance carrier doping capability, as shown in Fig. 1. With an optimized condition, $t_{Ta2O5}/(t_{Ta2O5}+t_{parylene})$~0.8, the hybrid gate structure exhibited a more than five-fold increase in sheet carrier density (n_{sheet}) in comparison with parylene, which was comparably large with that obtained by Ta_2O_5 (~10^{13} cm^{-2}). Those results were explained by considering the two dielectric layers as two capacitors connected in series. Attempts to further increase n_{sheet}, e.g. by chemical doping of Ta_2O_5, and to apply the fabricated gate structure to oxide field-effect transistors will also be presented.

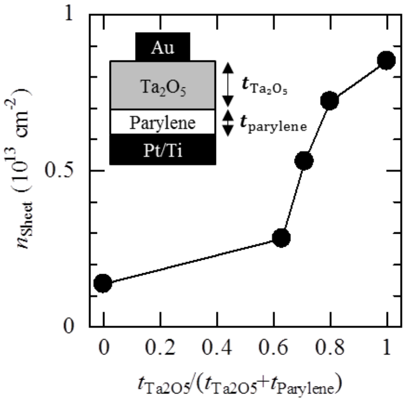

Fig. 1. Variation of sheet carrier density n_{sheet} against the ratio of t_{Ta2O5} to the total thickness $t_{Ta2O5}+t_{parylene}$.

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