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Aluminum Oxide Passivated Chemically Assembled Single-Electron Transistors

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We have succeeded in the elaboration of single-electron transistors (SETs) with the use of bottom-up processes of electroless plating and chemisorption of Au nanoparticles [1]. The passivation of the SET devices is expected to show improvements in the stability of the device and the gate capacitance. We have reported the silicon nitride passivated SET by using catalytic chemical vapor deposition (CAT-CVD) [2]. The silicon nitrides passivated SET made possible the elaboration of topgate structures that showed a much higher gate capacitance than the side gates. However the silicon nitride passivated SET sometimes show instability of the electrical properties at near room temperature.

Here, we introduce amorphous AlOx as the passivation layer of the SET. We elaborated our chemically assembled SETs with the combination of top-down and bottom-up methods. 25 nm initial gap patterns were designed by electron beam lithography (EBL) and a titanium/gold layer was evaporated in high vacuum. Electroless plating in iodine solution allowed us to reduce the size of the nanogaps to less than 5 nm. Au nanoparticle was added and chemisorbed with the use of alkanedithiol self-assembled monolayer. A 50 nm AlOx layer was finally deposited by pulse laser deposition at room temperature. The AlOx passivated SETs showed clear and stable Coulomb oscillation (Fig. 1) and Coulomb diamonds (Fig. 2) behavior at the temperature of 9 K with modulation of the side gate electrode. These results show the capacity of the alkanethiol-protected Au nanoparticle SETs to work under a passivation layer of aluminum oxide made by the pulse laser deposition.

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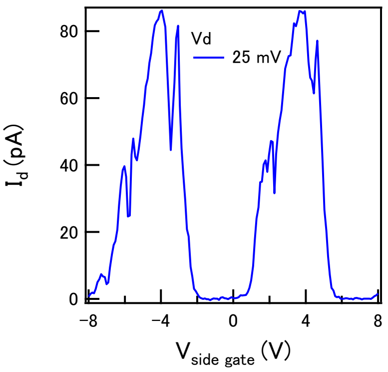

Fig. 1 Coulomb oscillation of Al_2O_3 passivated SET

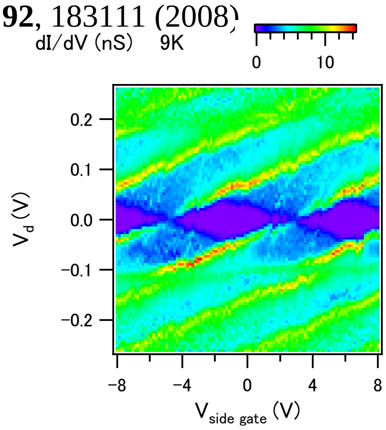

Fig. 2 Stability diagram of Al_2O_3 passivated SET