Ionic Liquid Gating of Metal Quantum Point Contacts: Effect of the Size of Ions

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Electric-double-layer (EDL) gating with ionic liquids has been attracting considerable interests owing to its tremendous gating power.[1] Since the EDL formed at liquid/solid interfaces functions as a huge capacitance and can induce large charge accumulation, it is used for gating not only organic materials, oxides, and semiconductors, but also metal systems,[2] even though they have a short charge screening length.

In this work, we have used a liquid-gated EDL transistor geometry for gold nanojunctions to control the conductance of metal quantum point contacts (QPCs). The sample structure used in this work is shown in Fig. 1. The ionic liquid we used was DEME-TFSI. Figure 2(a) shows the V_G-dependence of the conductance of a gold junction when $G \sim 100G_0$, where G_0 stands for the quantized conductance $G_0 = 2e^2/h$. The conductance of the gold junction increases with increasing V_G. However, the conductance increase saturates when $V_G \sim 1$ V. For the case of an atomic scale QPC with $G \sim 4\ G_0$, the conductance changes only by 1 G_0 (Fig. 2(b)). We have studied similar atomic scale QPCs and found that the conductance changes typically only by 1-2 G_0. These may be attributed to a geometrical reason; since the size of the cations is finite (diameter ~ 1.18 nm) and 4 times larger than the size of gold atoms, when the surface is covered by 1 monolayer of cations, further gating becomes much less efficient (Fig. 2(c)). For atomic scale QPCs, this geometrical effect may be more significant. This result gives a new insight when EDL gating is used for atomic scale systems.

References: [1] H. Shimotani, et al., Appl. Phys. Lett., **92,** 242107 (2008). [2] H. Nakayama et al., Appl. Phys. Exp. **5,** 023002 (2012).

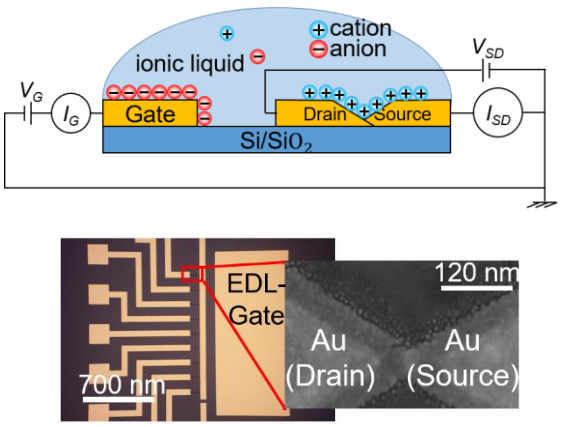

Fig. 1: Schematic illustration (upper) and the microscope/SEM image (lower) of gold-EDL transistors.

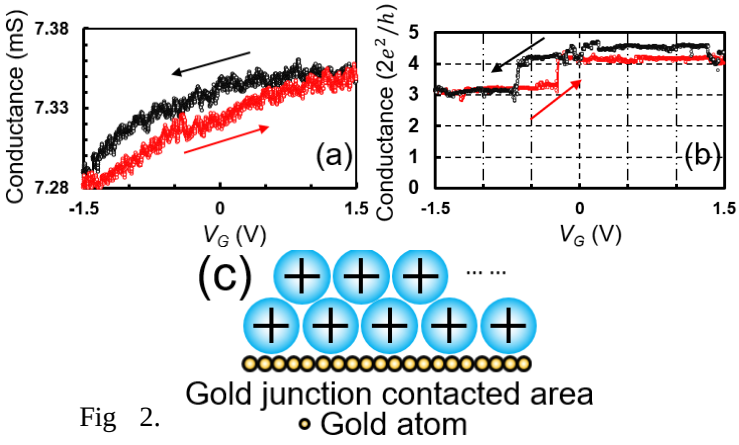

Fig 2. V_G-G plot of gold junctions measured at 220K. (c) shows a schematic illustration when the gold surface is completely covered by cations.