Charged defects mitigation in metal single-electron transistors with tunnel barriers prepared by atomic layer deposition

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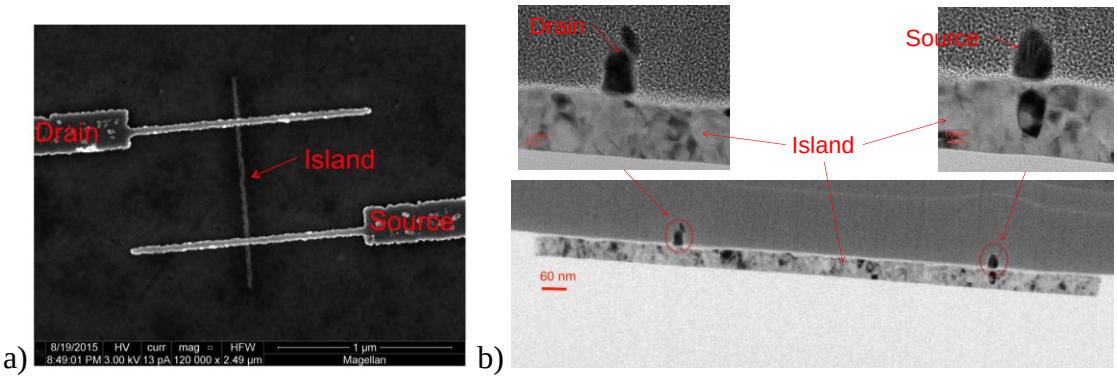
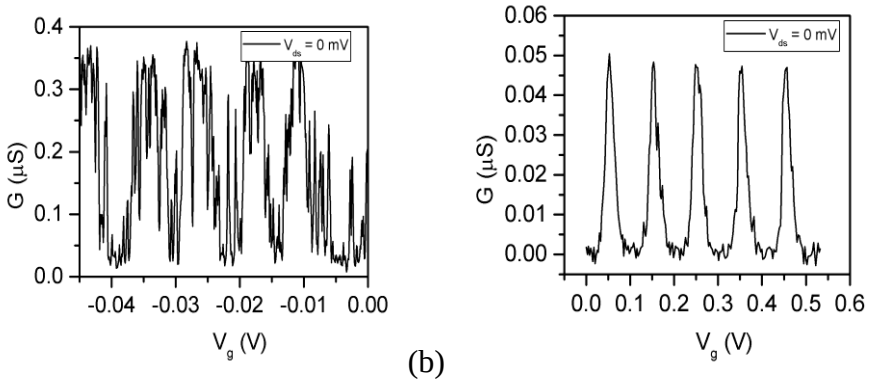
The performance of single electron transistors featuring Ni-insulator-Ni tunnel junctions [1] prepared by plasma-enhanced atomic layer deposition (PEALD) of dielectrics (SiO_2, Al_2O_3, and stacked layers), Fig. 1 is investigated for various in- and post- fabrication treatments. We demonstrate that while the reduction of parasitic metal oxide forming during dielectric deposition can be achieved by using either hydrogen anneal or hydrogen plasma treatments, the performance of fabricated devices changes radically depending on which type of treatment is chosen. In particular, several orders of magnitude difference in the random charge noise was observed in devices that differ by only a single post-deposition treatment step, Fig. 2. We present a comprehensive comparative study of several different treatments and discuss potential physical models that explain these observations.

[1] G. Karbasian, M. S. McConnell, A. O. Orlov, S. Rouvimov and G. L. Snider, Journal of Vacuum Science & Technology A 34 (1), 01A122 (2016).



a) b)

Figure 1. SEM (a)_and TEM (b) micrographs of the fabricated device



(a) (b)

Figure 2. Coulomb blockade oscillations in the MIMIM devices (M= Metal, I=Insulator) in two SETs featuring ALD SiO_2 insulator but with different post-fabrication treatments: a)anneal at 375 C in H_2/Ar; b)remote H_2 plasma; measurements performed at T=400 mK