Modification of single-atom Ag contacts by CO adsorption

Atasi Chatterjee[1], Jan Philipp Stöckmann [1] ,Christoph Tegenkamp[1,2], Herbert Pfnür [1]

[1]*Institut für Festkörperphysik, Leibniz Universität Hannover, 30167, Hannover, Germany*
[2]*Institut für Physik, Technische Universität Chemnitz, 09126, Chemnitz, Germany*
chatterjee@fkp.uni-hannover.de

Electro-migration (EM) was reported several times in literature for creating sub-nm spaced electrodes for molecular measurements, which, however, was considered as an unreliable method. Here we demonstrate a reliable way to reproducibly form atomic point contacts by EM. For this purpose, we used an ultra-high vacuum (UHV) 4-tip SEM/STM to contact the structures locally and observe them in real time. It turned out to be most important to reduce the initial width of the structures below the average grain size of the Ag films (30 nm) in order to ensure a single grain boundary at their narrowest constriction. At surface temperatures of 100K we were thus able to avoid the formation of multiple contacts and suppress competing thermal migration [1]. Ag electrodes (< 20 nm at the narrowest constriction) were fabricated using a combination of e-beam lithography (EBL) and focused ion beam (FIB) milling on a Si (100) substrate. Conductance histograms exhibit the quantized conductance maxima in multiples of the conductance quantum G_0.

Conductance, σ, of these atomic point contacts ($0.9\ G_0 < \sigma < 1.3\ G_0$) was strongly altered when the CO molecule was adsorbed in situ on the contacts at 100 K. Conductance suddenly dropped by a factor of about 15 to a new stable conductance plateau, suggesting that CO adsorption alters the contact configuration formed with Ag electrodes [2]. Current versus voltage curves turned out to be asymmetric and showed a slightly rectifying behavior for negative voltages, indicating presence of a single asymmetric CO molecule between the contacts. Furthermore, at 100 K, bi-stable conductance switching between 0.08 and 0.14 G_0 was observed with lifetimes of the higher conducting state of 0.1-1 milliseconds. The origin of these observations are discussed within the framework of existing models.

References:

[1] A Chatterjee, T Bai, F Edler, C Tegenkamp, K Weide-Zaage, H Pfnür, J. Phys. Condensed Matter,30, 084002 (2018).
[2] Zoltán Balogh, Dávid Visontai , Péter Makk , Katalin Gillemot, László Oroszlány , László Pósa , Colin Lambert and András Halbritter, Nanoscale,6,14784,(2014).