Improved contacts for individual SWCNT based CNFETs

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This talk will focus on a novel fabrication flow for field-effect transistors with individual SWCNT channels (CNFETs) having electrical contacts with long lifetime and narrow distribution of device on-resistances. The approach is based on combination of a sacrificial layer protecting as-grown SWCNTs during CNFETs fabrication process, plasma oxidation to remove photo or e-beam resist residuals from contact areas, and deposition of optimized thickness of the Cr adhesion layer prior to noble metal deposition for electrical contacts. As grown SWCNTs are covered by Al2O3 sacrificial layer deposited by atomic layer deposition (ALD) to prohibit their direct contact to resist [1] and to protect them from oxygen plasma impact during further processing. Al2O3 layers thicker than 18 nm protect SWCNT sufficiently from the impact of one minute applied 100 W oxygen plasma as we proved by CNFET electrical measurements and SWCNT Raman spectroscopy. The sacrificial alumina layer is then removed by hot H3PO4 prior to formation of electrical contacts. We have shown [1,2] that utilization of this protective/sacrificial layer greatly improves the cleanliness of nanotube surfaces in respect to resist residuals without detectable change of their original properties. The median on-resistance for alumina passivated, Pd/Au-contacted CNFETs reached 190 kOhm which is nearly 3x lower value than the one of CNFETs prepared without using sacrificial layer and oxygen plasma [2]. Imortantly, the inter-quartile dispersions of the CNFETs on-resistance were narrowed from 2050 to 247 kOhm. We observed long lifetime of devices prepared by this fabrication approach (longer as 90 days) even for non-passivated CNFETs using Cr layer thinner than 2 nm in Cr/Au contacts [3].

[1] W. Liu, et al.„ *Sensors and Actuators B* **198**, 479 (2014).
[2] W. Liu, et al.„ *Phys. Status Solidi B* **1-7**, xxx (2016).
[3] W. Liu, et al.„ *Nanotechnology* **27**, 015201 (2016).