Zero-Dimensional Side Contacts to hBN Encapsulated Carbon Nanotubes

G. Abulizi[a], A. Baumgartner[a], K. Watanabe[b], T. Taniguchi[b], and C. Schönenberger[a]

[a]Institute of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland
[b]National Institute for Material Science, 1-1 Namiki, Tsukuba 305-0044, Japan

Combining one-dimensional (1D) carbon nanotubes (CNTs) with 2D hexagonal boron nitride (hBN), e.g. using hBN as clean substrates for quantum dots (QDs) [1], or atomically thin hBN as tunnel barriers to CNTs [2], bears great potential for a large variety of substrate supported clean CNT nanostructures. In this work we focus on hBN encapsulated CNTs coupled to normal metals and superconductors by "0D" side contacts. A surprising technical advantage of these side contacts in controled "mixed-dimensional" heterostructures is the very large yield and reproducibility of the contact characteristics. For devices with normal metal side contacts we report the formation of very clean single QDs in single-wall CNTs and clear double QD characteristics in multi-wall CNTs, demonstrating ideal electrical contacts also to the inner tube of a multi-wall CNT. For devices with superconducting MoSi side contacts we report large supercurrents in magnetic fields of up to 2.5 T, multiple Andreev reflections, multiple but individually resolved Andreev bound states, and hysteretic sub-gap structures observed in current-biased multi-wall CNTs. We expect that this new type of clean CNT devices will result in the observation of new effects in hybrid superconducting interacting 1D systems.

[1] A. Baumgartner *et al.*, Appl. Phys. Lett. 105, 023111 (2014)
[2] G. Abulizi *et al.*, Phys. Status Solidi B 253, 2428 (2016)