Quantum phase slips in superconducting Nb nanowire networks deposited on self-assembled Si templates

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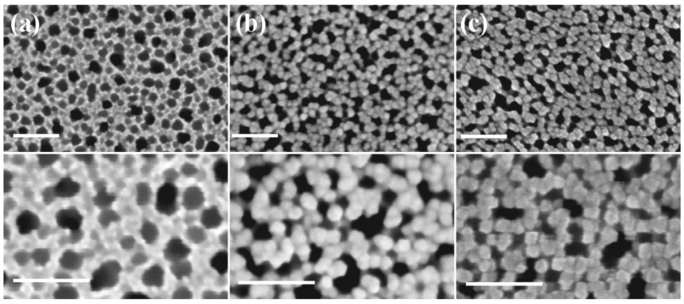
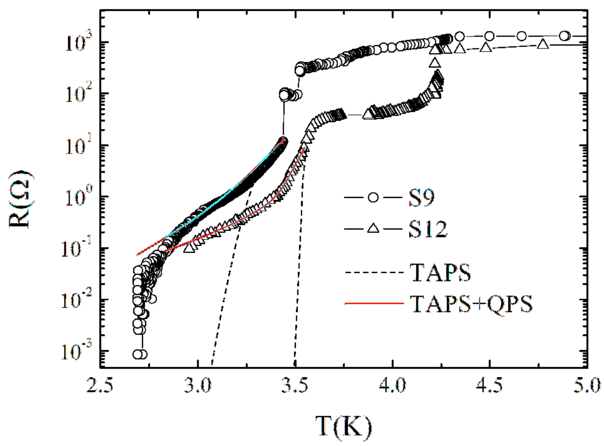
The formation of interconnected networks consisting of Nb ultrathin superconducting nanowires is achieved by using porous silicon (PS) as template substrate. The extremely reduced film thickness (d_{Nb}) favours the deposited material to occupy only the substrate pitch; therefore, the as-sputtered films result as a network of interconnected wires, whose average width, due to the extremely reduced characteristic dimension of the substrates, is comparable to the superconducting coherence length. Scanning electron microscopy (SEM) analysis was performed to investigate the morphology of the samples, which constitute of polycrystalline single wires with grain size of about 10 nm. The samples exhibit nonzero resistance over a broad temperature range below the critical temperature, fingerprint of phase slippage processes. The transport data are satisfactory reproduced by models describing both thermal (TAPS) and quantum (QPS) fluctuations of the superconducting order parameter in thin homogeneous superconducting wires.



Top-view SEM images of (a) a free PS substrate (interpore spacing 50 nm, pore diameter 15 nm) and Nb nanowire networks deposited on PS with nominal thickness of (b) 3.5 nm, (c) 7 nm. In the upper (lower) panels, the images acquired at lower (higher) magnifications are reported. The white scale bar is 100 nm.



Resistive transitions, R(T), of samples with different Nb thicknesses, namely d_{Nb}= 9 (circles) and 12 (triangles) nm. Solid red lines are the results of the fitting procedure including both TAPS and QPS contributions, while the dashed black lines, strongly deviating from the experimental data, are obtained including only the TAPS term.

[1] D.S. Golubev et al., Phys. Rev. B. 78, 144502 (2008).
[2] M.H. Bae et al., Nano Lett. 9, 1889 (2009).