MoSI NANOWIRES: FROM A ONE-DIMENSIONAL QUANTUM FLUID TO SELF-ORGANISED CRITICAL NETWORKS

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Progress in nanotechnology crucially depends on molecular-scale materials with tunable physical or functional properties, yet with well-defined and controllable geometrical structure. $Mo_6S_{9-x}I_x$ (MoSI) nanowires (NWs) self-assemble into functional networks and qualify for applications as diverse as lubricant additives, field emitters, battery electrodes, (bio)chemical sensors, and as conductive or reinforcing component of composites. They disperse in many common solvents including water, where they occur in bundles of diameters ranging from a few 100 nm down to single wires (below 1 nm).

Individual MoSI wires have extremely low coupling to the environment and to each other, which leads to extreme one-dimensional quantum electronic transport behaviour. Flexible bundles of MoSI NWs with different diameters reveal systematic power-law dependence of the conductivity on temperature and voltage. This behaviour can be most convincingly described by tunneling through Tomonaga-Luttinger liquid segments of MoSI wire, which is in some cases modified by environmental Coulomb blockade from deformations or imperfections of the MoSI wires.

Scale-free self-organized critical networks such as the human brain show resistance to failure, fast signal processing, and are of particular interest for nanoelectronics. Hybrid networks of MoSI wires and gold nanoparticles self-assemble in solution. While the length distribution of individual nanowires is log-normal, the lengths of the edges in the network deposited on a substrate show a strong power-law tail indicating scale invariance. This shows that the self-organized critical behaviour is not a property of the nanowire synthesis, but of their self-assembly into networks.