MAGNETOTRANSPORT IN QUASI-ONE DIMENSIONAL POLYMER NANOFIBERS

H.J. Lee, S.H. Jhang, H.S. Kim, Y.W. Park (Seoul National U., Physics); A.N. Aleshin (A.F. Ioffe Physical Technical Institute)

Introduction

Nanosized conducting objects provide model systems for the investigation of transport phenomena on mesoscopic scale, where quantum confinement and Coulomb charging play an important role. In this connection polyacetylene (PA) nanofibers are of interest as a model system for nanotransport studies because of simple chemical structure, well-defined polycrystallinity, and good ability for doping.

Experimental

Single R-helical PA fibers with a cross section, typically 40 - 60 nm (high), 100 - 300 nm (wide), and a length up to ~10 μm, were deposited on top of 2 μm spacing platinum electrodes as reported in previous work[1]. The fibers were doped with iodine from vapor phase up to saturation level right before transport measurement. The magnetoconductance (MC) up to H = 18 T was measured in a longitudinal configuration (H J) using a superconducting magnet (SCM2) at the NHMFL.

Results and Discussion

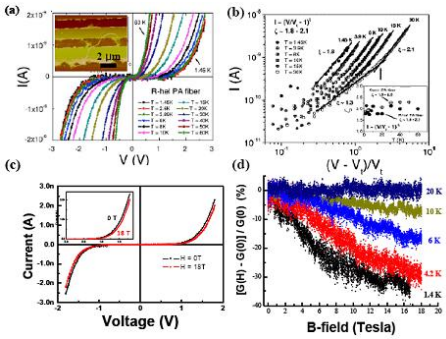

Fig. 1. (a) Typical I-Vs at low temperatures. Inset: AFM image of R-helical PA fiber used in our study. (b) I vs. $(V-V_t)/V_t$. (c) I-V characteristics at T = 1.4 K at H = 0 T and18 T. (d) MC at low temperatures.

Figure 1(a) presents the I-V characteristics for such R-helical PA nanofibers at low temperatures, T = 1.45 – 60 K. The I-Vs at T < 60 K are symmetric and strongly nonlinear with a narrow Ohmic region. The current starts to flow only above some voltage threshold (V_t) as temperature goes below 30 – 40 K. The scaling exponents, ζ, obtained form I vs. $(V-V_t)/V_t$ log-log plots at high biases are found to be $\zeta \sim 1.8 - 2.1$ and weakly temperature dependent [Fig. 1(b) and inset]. The existence of V_t, its temperature dependence, and scaling exponents are characteristic of the Coulomb-blockade transport similar to that in quasi-1D arrays of metallic nanoparticles, separated by tunneling nanobarriers[2,3]. As can be seen from fig.1(c) the low temperature I-Vs are nonlinear in both cases: with and without magnetic field and the negative MC is observed clearly. Also, the rate of the negative MC in the wide range of magnetic field is temperature dependent and reduced with increasing temperature, smearing out for T > 20 K as shown in fig.1 (d).

Conclusions

We report MC and I-V characteristics of helical PA nanofibers doped with iodine. The MC up to 18 Tesla is negative in the temperature range of 1.4 to 20 K. From highly non-Ohmic I-V characteristics, we demonstrate that at low temperatures such a polymer fiber can be considered as an array of small conducting regions separated by nanoscale barriers.

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References

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