Intrinsic conduction mechanism in polymer nanofibers

K. H. Kim[1,2], S. Lara-Avila[2], S.Kubatkin[2], and Yung Woo Park[1]

1. Seoul National University, Korea
2. Chalmers University, Sweden
ywpark@snu.ac.kr

Conductive polymers are an attractive route to cost effective and versatile nanoelectronics. Chemical synthesis of these materials offers possibility to chemically bottom-up engineer the electronic function of polymers at will, and yet produce them in large scale. As of now, several proof of concept devices based on conductive polymers have been shown that span a great range of applications including flexible field-effect transistors, actuators, sensors, and nano-optoelectronic devices. Insight in fundamental electron transport properties in these materials is of utmost importance for further practical development. Recent studies of I-V characteristics on pristine polymer nanofibers and carbonized polymer nanofibers show the similar power law scaling behavior despite the structural differences: the former quasi one-dimensional and the latter quasi-amorphous carbon networks of two- or three- dimensional. Both types of materials give apparent power law dependence of current with voltage and temperature and scaling of all measurements into a single universal curve. We have interpreted the power law scaling in carbonized polymer nanofibers as the manifestation of the Efros-Shklovskii variable range hopping (ES-VRH) in wide range of T and V parameters, which we suggest as the main transport mechanism of pristine polymer nanofibers[1]. The magneto resistance (MR), however, shows distinct behavior between the two materials. The pristine polyacetylene nanofibers show zero magneto resistance (ZMR) in high electric field, $E = 3 \times 10^4$ *V/cm*[2]. But the MR of carbonized polyacetylene nanofibers remains positive which is typical for the VRH conduction. The applied electric power for the MR measurement of the pristine polyacetylene nanofibers in high electric field is $P=1.2\mathrm{x}10^{-9}$ *Watt*, which is small enough to eliminate the heating effect. The ZMR observed in polyacetylene nanofibers in high electric field is explained with the de-confined conduction of spinless charged soliton which is a 1-D topological insulator[3]. A possibility to investigate the Majorana state in the polyacetylene nanofibers will be discussed.

[1] K. H. Kim, S. Lara-Avila, H. Kang, H. He, J. Eklof, S. J. Hong, M. Park, K. Moth-Poulsen, S. Matsushita, K. Akagi, S. Kubatkin and Y. W. Park, “Apparent power law scaling of variable range hopping conduction in carbonized polymer nanofibers”, *Sci. Rep.* **6**, 37783 (2016)
[2] Y. W. Park, “Magneto resistance of polyacetylene nanofibers”, *Chem. Soc. Rev.* **39**, 2428 (2010)
[3] A. Choi, K. H. Kim, S. J. Hong, M. Goh, K. Akagi, R. B. Kaner, N. N. Kirova, S. A. Brazovskii, A. T. Johnson, D. A. Bonnell, E. J. Mele, and Y. W. Park, “Probing spin-charge relation by magnetoconductance in one-dimensional polymer nanofibers”, Phys. Rev. B **86**, 155423 (2012).

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