# Linear magnetoresistance in 3-dimensional carbon nanostructure with periodic spherical voids.

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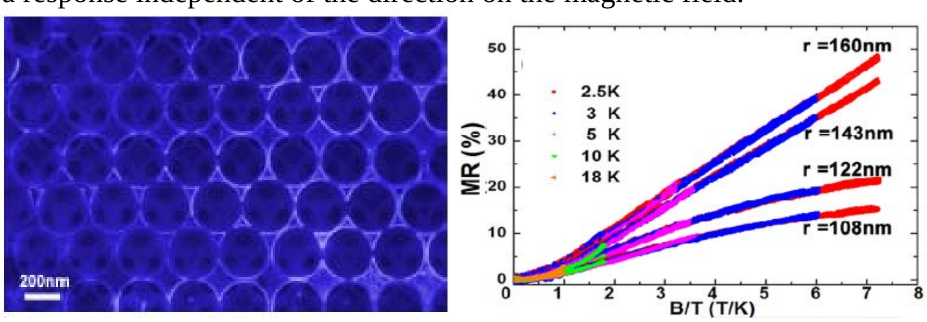
Introduction of minute amounts of chemical impurities (doping) has been tremendously effective in controlling the technological properties of semiconductors. However, alternative strategies for property control without the introduction of foreign elements into the system are of interest. Manipulation of geometric parameters can be a route to control the physical behavior in designing materials. For example, by the introduction of imperfections, non-saturating linear magnetoresistance (MR) has been achieved in silver chalcogenides, $Cd_3As_2$, MnAs-GaAs, and in the topological insulator $Bi_2Te_3$ films. Such linear MR arises from the distortions in current density induced by a large spatial fluctuation in the conductivity and mobility, which can be explained by the random-resistor network[1] model of Parish and Littlewood.
Here we present a study[2] on carbon nanostructures with the spherical voids exhibit interesting temperature and magnetic field dependent transport properties. By increasing the void size, the structures are tuned from metallic to insulating; in addition, the magnetoresistance (MR) is enhanced. Our investigation in the magnetic fields (B) up to 18 T at temperatures (T) from 250 mK to 20K shows that at high temperatures (T>2 K), the MR crosses over from quadratic to a non-saturating linear dependence with increasing magnetic field. Furthermore, all MR data in this temperature regime collapse onto a single curve as a universal function of B/T, following Kohler's rule. Remarkably, the MR also exhibits orientation insensitivity, i.e., it displays a response independent of the direction on the magnetic field.




SEM image of carbon nanostructure with spherical voids (left). A universal behavior of the MR as a function of B/T for all four samples, following Kohler's rule (right).

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[1] M. M. Parish and P. B. Littlewood, Nature 426, 162 (2003).
[2] L. Wang et al. , *Appl. Phys. Lett.* **109**, 123104 (2016).