Soft conductors from nanoscale carbon

Matteo Pasquali
Departments of Chemical & Biomolecular Engineering, Chemistry, and Materials Science & NanoEngineering; The Smalley Institute for Nanoscale Science & Technology, Rice University, Houston, TX, USA
Contact e-mail: *mp@rice.edu*

Certain materials properties are viewed as contradictory. For example, high electrical and thermal conductivity are associated to hard, crystalline materials like metals. Conversely, softness is associated with biological materials, polymers, and disordered structures, which are thermally and electrically insulating. We have accepted that certain ostensible contradictions cannot be resolved. For example, we have no material that is electrically conductive and can be sutured or sewn, despite obvious needs in medical devices and wearable electronics.

Nanoscale carbon—including CNTs and graphene—has remarkable electrical, thermal, and mechanical properties. I will discuss how CNTs and graphene can be assembled into soft conductors.

CNTs and graphene can be solution-processed in acids, their sole solvents [1, 2]. Low concentration solutions can be used for making flexible films [3] and porous, three-dimensional structures that combine conductivity and softness [4]. At high concentration, CNTs and graphene form liquid crystals that can be spun into high-performance multi-functional fibers [5, 6]. These fibers combine high conductivity, strength, and the emergent property of softness; they are finding applications in aerospace electronics, Hi-Fi cables, and field emission. As soft conductors, CNT fibers provide a natural interface to the electrical function of the body as restorative sutures for electrically damaged heart tissue and electrodes for stimulating and sensing brain activity [7].

[1] V. A. Davis et al. *Nature Nanotech.* **4**, 830 (2009).
[2] N. Behabtu et al. *Nature Nanotech.* **5**, 406 (2010)
[3] F. Mirri et al. *ACS Nano*, **6**, 9737 (2012).
[4] T. T. Hsu et al. *Under review* (2015).
[5] N. Behabtu et al. *Science*, **339**, 182 (2013).
[6] C. Xiang et al. *ACS Nano*, **7**, 1628 (2013).
[7] F. Vitale et al. *ACS Nano*, ASAP online, DOI: 10.1021/acsnano.5b01060 (2015).