From Multifunctional Carbon Nanotube Yarns and Transparent Sheets to Fuel-Powered Muscles and Devices for Energy Harvesting, Storage, and Conversion

R.H. Baughman, NanoTech Institute and Department of Chemistry, University of Texas at Dallas

Various new nanotechnologies will be described: (a) solid state fabrication methods for the manufacture of strong nanotube yarns and transparent nanotube sheets at industrially useable rates; (b) solution processing methods producing super-tough nanotube yarns; (c) artificial muscles with giant strokes and giant force generation capabilities that are powered by high energy density fuels; (d) novel generic methods for tuning the electrical, magnetic, and optical properties of conductors by giant charge injection; and (e) devices for thermal and solar harvesting, energy storage, energy conversion, electron field-emission, sensing, and light emission. These solid-state processed nanotube yarns are much tougher than graphite yarns, almost as tough as the Kevlar® used for anti-ballistic vests, and (unlike such organic polymers) are highly resistant to creep and to properties degradation due to chemical, thermal, or radiation exposure, abrasion, or knotting. These highly conducting nanotube sheets are both transparent and have higher gravimetric strength than the strongest steel plate and the Kapton® and Mylar® used for ultra-low-weight air vehicles and under evaluation for solar sails. Powered by fuels providing over 30 times the energy storage density of batteries presently used for autonomous robots and prosthetic limbs, the most easily deployable artificial muscles can simultaneously provide a hundred times the force generation of natural muscle, a hundred times the work per cycle, and larger strokes than natural muscle. Finally, a surprisingly generic method for charge-injection-based tuning of the bulk properties of electrolyte-free nanostructured materials avoids dopant intercalation and associated problematic structural changes. Implications are described for diverse devices that function without electrolyte contact for electrochemically switched elements, from electron field-emission sources to chem-FET sensors and magnets.