Cylindrically anisotropic carbon structures based on graphenes: nanofibres, multi-walled nanotubes, multi-layered nanoscrolls and composite structures

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Carbon nanofibers, multi-walled carbon nanotubes and multi-layered carbon nanoscrolls possess many extraordinary mechanical, thermal and electronic properties stemming essentially from their unique geometric and chemical structures.The properties are based on those of a graphene sheet and are similar to those of graphite. But unlike graphite crystals and graphenes revealing rectilinear anisotropy, cylinder-shaped carbon nanofibers, multi-walled nanotubes and multi-layered nanoscrolls reveal cylindrical anisotropy. The structure results in similar anisotropy of their mechanical, thermal and electrical properties [1, 2]. The properties may be evaluated both in terms of continuum thermomechanics and in terms of discrete one. According to the theory of elasticity of an anisotropic body [3] the stress and strain distributions in the structures are inhomogeneous under longitudinal compression and extension, and under heating. So the elastic moduli and linear coefficients of thermal expansion do not coincide generally with those of graphenes, from which nanofibers, multi-walled nanotubes and multi-layered nanoscrolls are made, and with those of graphite. Usually one has to measure the effective elastic moduli and effective linear coefficients of thermal expansion [1, 4, 5]. In particular the effective elastic modulus E_f and the effective Poisson ratio ν_f are derived in terms of continuum mechanics and elasticity for cylindrically anisotropic bodies [3, 4]:

$$\nu_f = \nu_{zr} + \frac{h(k-1)}{k}\left(\frac{E_z}{E_r} - \nu_{zr}{}^2\right)$$

$$E_f = E_z\left(1 + h\frac{k-1}{k+1}(\nu_{z\theta} - \nu_{zr})\right).$$

In addition a good match has been obtained between the values derived in terms of continuum thermomechanics and in terms of discrete one. These should be taken into account while evaluating thermomechanical and electromechanical phenomena for the structures.

Specifically the effective modulus may be used in estimating the G and 2D peaks strain sensitivity for the structures, and to study splitting of the peaks [1, 6, 7]. Evaluations of the sensitivity, based on cylindrical anisotropy, are in good agreement with those obtained elsewhere [1, 5, 7].

Of special interest is the design of composite graphene based nanofibers with radial core and onion shell for space industry. Spatial fibrous structures on the basis of these cylindrically anisotropic carbon structures can be used for space stealth technology over a wide electromagnetic range from visible to microwave.

References

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