Nanocomposites and nanomaterials

Annealing kinetics of radiation-induced defects in carbon nanotube bundles below room temperature

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Carbon nanotubes (CNTs) still seem to be the promising materials for modern nanoelectronics. Since they are quasi-one-dimensional structures, their properties are strongly affected by the defects and disorders of any type. Therefore, controllable defects introduction can be used for CNT properties modification and, hence, to expand the functionality of CNT-based devices. In order to use the high-energy irradiation for CNTs properties modification, the mechanisms of radiation defects accumulation and recovery in such nanostructures should be ascertained. The prior task is to determine the mobility of induced defects in nanotubes. Up to date, experiments reveal defects mobility in CNTs only above room temperature, with sufficiently large migration energy of ~ 1 eV. While the structure and dynamics of defects at low temperatures are still remains uncertain.

Here the experimental results of low-temperature annealing of radiation-induced defects in carbon nanotubes bundles are presented. We carried out a systematical study of changes in the samples resistance after low-temperature electron irradiation (with energy of 1 MeV) in range $10^{15} – 10^{16}$ el / cm^2. The main feature this work is that the samples temperature during irradiation was not exceed 10 K. A detailed analysis of the resistance change over a wide temperature range (7 – 300 K) enable us to prove partial annealing of irradiation-induced defects below 300 K and determine the activation energy of this process, for the first time.

Results show that the observed annealing process can be described as a first-order reaction in the whole investigated temperature range. At temperatures below 40 K, annealing is nonactivation, tunneling process; while at higher temperatures (100 – 300 K) it becomes activated, with activation energy ~ 0.05 eV. The value of the discovered activation energy is close to the migration energy of the interstitial carbon atom in graphite (~ 0.1 eV) [1]. Therefore, the annealing of radiation-induced defects in CNT bundles below room temperature might be due to by the migration of interstitial carbon atoms between carbon nanotubes.

1. *Telling R. H., Heggie M. I.* Radiation defects in graphite // Philos. Mag. – 2007. – **87. –** P. 4797.