Influence of external factors on a spectrum of plasma fluctuations in carbon nanotubes

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Research of plasma fluctuations electrons by electron energy-loss spectroscopy on several sorts of the carbon deposits containing multiwall carbon nanotubes (MWNT) was carried out. For this purpose three different samples containing carbon MWNT and astrolene (like a lentil: slightly lengthened fullerene or very short nanotubes with closed ends) were prepared in air by depositing tubulene soot on ceramic substrates. The MWNT under study were 8 to 16 nm in diameter and averagely ~10 μm in length. All samples were produced by the closed joint-stock company «Astrin», Saint-Peterburg.

The EELS measurements were carried out at the Ioffe Physical Technical Institute by using an electron spectrometer based on original angular-multichannel energy analyzer of a cone-mirror type [1]. This device is designed to measure concurrently energy distributions of electrons emitted from a sample at eight different polar angles. Loss spectra were measured at different energies of primary electrons: E_p=100÷1500 eV with the constant absolute energy resolution (ΔE=0.6 eV) in the pulse-counting mode under high vacuum conditions (P~5·10^{-9} Torr). The electron incidence angle was 45^o. Since the EEL spectra recorded in different angular channels were quite similar, they were summed in order to improve the signal/noise ratio. The analyzer was adjusted on energy of transmission 10 eV. The error at determination of plasmon energy thus made 0.11 eV.

It is established, that clearing of the deposit by various ways influences a spectrum of plasma fluctuations electrons.

Detailed experimental studying influence ion bombardments (Ar^+) on a spectrum of plasma fluctuations π-electrons is carried out (fig.1 and fig.3). Additional information was obtained by analyzing EEL spectra of samples bombarded with energetic (2 keV) Ar^+ ions. It was found that even a relatively small ion dose (~1.4 10^{13} ions/mm^2) changes drastically the EEL spectra of carbon MWNT.

It is established, that modification of carbon nanotubes by ion irradiation results to broadening of a spectrum of plasmons and to displacement of a maximum of plasma losses of π-electrons aside smaller energies (or frequencies) (fig.2). Destruction of nanotubes surfaces is characterized by constant τ_0≈60÷70 minutes.

It is shown, that thermal processing initial and irradiated with ions carbon nanotubes results in increase of energy plasmons.

Complex influence on carbon deposits (purification, modification by ions and thermal treatment) are methods for influence on their electronic structure.

1.V.V.Shnitov, V.M. Mikoushkin, A.V. Zacharevich. 14th Europ. Conf. On Surface Science (ECOSS-14), Leipzig (1994). Abstracts. P.76.

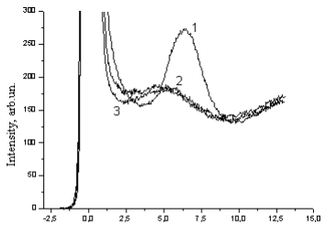

Fig.1.ELSS carbon nanotubes on a dose of an irradiation: 1 - initial spectrum, 2 - spectrum in two minutes after the beginning of an irradiation, 3 - spectrum in four minutes after the beginning of an irradiation.

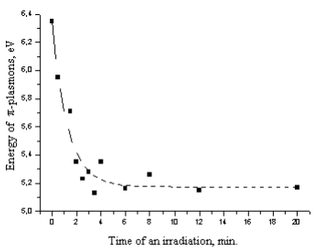

Fig.2.Dependence energy of π-plasmons on time of an irradiation.

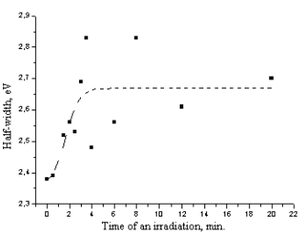

Fig.3. Dependence of the half-width of EELS π-electrons on time of an irradiation.