Superhard nanocluster-based materials synthesized from single wall nanotubes

M. Popov, S. Martyushov, E. Tatyanin, V. Denisov, A. Kirichenko, N. Lvova, B. Mavrin*, A. Zakhidov**, V. Blank*

*Technological Institute for Superhard and Novel Carbon Materials Troitsk, Moscow reg., Russia, popov@ntcstm.troitsk.ru; *Institute of Spectroscopy of the Russian Academy of Sciences, Troitsk, Moscow reg., Russia; **NanoTech Institute and Department of Physics, University of Texas at Dallas, Richardson, USA*

Results of structure and mechanical properties studies (Raman, TEM, X-ray, NanoScan) of different nanocluster-based materials synthesized from single wall carbon nanotubes (SWNT) with mean tube diameters 0.7, 0.9 and 1.2 nm are presented. Samples of SWNT were compressed in shear diamond anvil cell (SDAC) up to pressure 65 GPa. In SDAC controlled shear deformation is applied to the sample under pressure by a rotation of one of the anvils around an axis of load. The application of shear deformation decreases the hysteresis of phase transformations and makes it possible to obtain a homogeneous phase.

Two different types of phases have been studied. High-pressure phases synthesized at pressure above 35 GPa compose from cross-linked (by presumably sp^3 bonds) nanometer-sized graphene flakes. The cross-linked flakes create nanoclusters with size correlated to nanotube diameter. The flakes could create both linear and onion-like structures. The second type of phases synthesized at pressure 15 to 35 GPa are cross-linked nanotubes described earlier [1]. Pressure stability of nanotubes depends on nanotube diameter. Remarkable fact is that 1.2 nm diameter nanotubes still exist after pressure 40 GPa, while nanotubes of lesser diameter (0.7 and 0.9 nm) was not revealed in the samples structure after compressions (combined with shear deformation) to 35 GPa.

All the phases synthesized from SWNT have extremely high hardness comparable or even harder then c-BN. In present study hardness was measured using NanoScan measurement equipment. Obtained hardness measurement results agree well to previous data obtained with Nanoindentation System [1].

[1] M. Popov, et. al. Physical Review B, 65, 033408.