SUPERCONDUCTING NANOTUBES AND THEIR 2D CRYSTALS

V. V. Pokropivny
Institute for Problems of Materials Science of UNAS, Kiev 03142, Ukraine.

Superconductivity in nanotubes (NTs) is reviewed. Unique properties of NTs stem from phase transition connected with change of symmetry 3D - 1D under reducing of tube diameter up to nanoscale - a nanotube become a quasi-1D quantum cylinder, but macroscopic in length. Lattices of 2D ordered bundles or ropes of NTs is expected to be a more unique. Really, a 2D lattice of superconducting noncarbon NTs was at first suggested by combining Little's and Ginzburg’s ideas with recent progress in NTs research to be an ideal superconductor with record room critical temperature Tc [1,2]. Mechanism of superconductivity was proposed on base of a whispering mode of phonon vibration, which is shown to be responsible for a strong enhancement of electron-phonon interaction and for rise of Tc and Jc. Coherent and low attenuated vibrations of all atoms pairs on diameter-opposite walls of NTs induce coherent states of their nearest electrons pairs with opposite impulses (k, k) that provide an ideal conditions for Cooper pairing and Bose-Einstein condensation. However up to recent time a fabrication of such crystals was recognized as very difficult technological problem due to complex composition of conventional high-Tc superconducting ceramics such as YBaCuO, LuNiBC, etc.

Recent discovery of new hexagonal MgB2 superconductor with Tc~39 K and some indications of a possible room-Tc superconductivity with Tc=400 K in carbon NTs bundles are surveyed. Puzzle of MgB2 is hidden in it 2-gap 2-phonon superconductivity on E2g mode related with in-hexagonal-plane vibrations of B ions. From a “structural engineering” point of view the author’s hypothesis [1,2] is here developed further, namely, a novel nanotubular multi-phonon multi-gap room-Tc superconductivity model is suggested on base of whispering gallery of circular quantum zero-points phonon modes (rotors, twistons), in particular E2g, in 2D crystals built from MgB2-type layered NTs.

Examining this fresh results one can conclude that we are now in three-step position from the synthesis of this nanotubular 2D ideal super-conductor. The first step is to obtain the nanotubes rather then nanofibers. The second is to reduce their diameter up to correlation length \( \xi \approx 5 \) nm. And the third is to fabricate their ordered ropes or close-packed 2D crystals with the parameter of order of a London penetration length \( \Lambda \approx 180 \) nm. Four routes is proposed to synthesize such record MgB2-, Bi-, NbSe2-nanotubular superconductors.

1. V.V. Pokropivny, Room-Tc super-conductivity on whispering mode in quasi-1D composite of superconducting nanotubes. Is it possible?// J.Superconductivity 13,607 (2000)