

Superconductivity and unusual magnetic behavior in nano amorphous carbon

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Traces of superconductivity (SC) up to 65 K were observed by magnetic measurements in three different inhomogeneous sulfur doped amorphous carbon (a-C) systems: (i) commercial, and (ii) synthesized powders and in (iii) a-C thin films. (i) Studies performed on commercial (a-C) powder which contains 0.21% sulfur, revealed traces of two non-percolated superconducting phases around T_c 34 and 65 K. The SC volume fraction is enhanced by the sulfur doping. (ii) Another a-C powder obtained by pyrolytic decomposition of sucrose, did not show any sign for SC above 5 K. However, mixing of this powder with sulfur and synthesis of the mixture at 400 °C (a-CS), yields an inhomogeneous products which show traces of SC phases at T_c = 17 and 42 K. (iii) Non-superconducting a-C thin films were grown by electron-beam induced deposition. SC emerged at T_c = 34.4 K only after heat treatment with sulfur.

Other parts of the same commercial a-C and pyrolytic a-CS powders, show unusual magnetic features. (1) Pronounced irreversible peaks around 55-75 K appear in the first zero-field-cooled (ZFC) sweep only and they are totally suppressed in the second ZFC run measured a few minutes later. Their origin is not known. (2) Around the peak position the field-cooled (FC) curves cross the ZFC plots ($ZFC > FC$). These peculiar magnetic observations are connected to each other. All SC and magnetic phenomena observed are intrinsic properties of the a-CS materials.

It is proposed that the a-CS systems behave similarly to the high T_c cuprates and/or pnictides in which SC emerges from magnetic states. In addition, the a-CS system resembles the sulfur hydrides (H₃S) material which becomes SC at T_c = 203 K under high pressure (>200 GPa). SC in H₃S is explained by the interaction between the electrons and the high frequency hydrogen vibrations. This model may also be applied to a-CS. The relatively light nonmetallic carbon atoms and their high vibration frequencies as simple harmonic oscillators induce SC even at ambient pressure with T_c as high as 67 K. Alternatively, it is possible that the a-C and a-CS powders contain a small amount of hydrogen and that the observed SC states are repressed H₃S embedded or adsorbed in the a-C matrix.

Biography

Israel Felner has completed his PhD at the Hebrew University (HU) of Jerusalem, Israel and his postdoctoral studies at UCSD, San-Diego, California, USA (1979). Since then he works at the "Racah" Institute of Physics at the HU. He became a full professor in 1995. During 2003-2006 he served as the chairman of physics studies at the HU. He has published more than 480 papers in reputed journals and serves as an editorial board member of three prestige scientific journals.