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Single Crystal Growth and Study of MgB_2 and $Mg(B_{1-x}C_x)_2$ Superconductors

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Here, we summarize the results of our activity in a single crystal growth and study of MgB_2 superconductor. It included the development of high-pressure technique for crystal growth of MgB_2 in Mg-B-N system, optimization of P-T conditions for reproducible crystal growth, study the role of liquid phases and the effect of growing instabilities on crystals size and morphology. Extensive experiments have been carried out on single crystals with slightly different lattice constants and defects concentration, which revealed and possible effects of Mg-deficiency, lattice strain and accidental impurity doping on the superconducting properties of MgB_2 (T_c, H_{c2}, residual resistivity, electronic anisotropy etc). Then, we focused on study of C-substitution in MgB_2. Using high-pressure technique series of $Mg(B_{1-x}C_x)_2$ crystals were grown and solubility limit of x=0.15(1) was attained that is two times larger than in the polycrystalline samples synthesized at ambient pressure. Superconductivity was completely suppressed for a carbon concentration of x>0.12 (doping of 0.25 electron per unit cell) in good agreement with the results of band structure calculations. Structure refinement performed on the heavily C-doped crystal with x=0.125 confirmed a high quality of as-grown crystals and no evidence of microscopic phase separation or superstructure was found. At the same time, resistivity and magnetization measurements preformed on several batches of as-grown and post-annealed crystals showed a possibility of inhomogeneous C distribution during crystal growth that was maximal for the intermediate C-concentrations (x=0.05-0.1). Partial substitution of B by C has a pronounced effect on the reduction of electronic anisotropy and giving highest H_{c2} and H_{irr}>30 T in moderately C-substituted compositions (x=0.02-0.05), which make them very promising for practical application.

keywords : MgB_2, single crystal, substitution, superconductivity

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