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Evidence for two-dimensional nucleation of superconductivity in MgB_2

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Abstract. – According to the crystal structure of MgB_2 and band structure calculations quasi–two-dimensional (2D) boron planes are responsible for the superconductivity. We report on critical fields and resistance measurements of 30 nm thick MgB_2 films grown on MgO single crystalline substrate. A linear temperature dependence of the parallel and perpendicular upper critical fields indicates a 3D-like penetration of magnetic field into the sample. Resistivity measurements, in contrast, yield a temperature dependence of fluctuation conductivity above T_c which agrees with the Aslamazov-Larkin theory of fluctuations in 2D superconductors. We consider this finding as an experimental evidence of two-dimensional nucleation of superconductivity in MgB_2.

Introduction. – Recent discovery [1] of a medium-temperature superconductivity in magnesium diboride (MgB_2) raised questions about the origin and properties of superconductivity in this compound. MgB_2 has a hexagonal crystal structure with boron layers interleaved by magnesium layers. Due to this layered structure, normal-state electric transport, as well as superconducting properties should be highly anisotropic. Band structure calculations [2, 3] indicate that electrons at the Fermi level are predominantly derived from boron atoms. MgB_2 may be regarded as sheets of metallic boron with strong covalent intralayer bonding, separated by Mg layers with ionic interlayer B-Mg bonding. The strong B-B bonding induces enhanced electron-phonon interaction, so that the superconductivity in MgB_2 is mainly due to the charge carriers in the boron planes.

Experimental investigations on single crystals and *c*-oriented epitaxial and textured films (see, *e.g.*, the review [4] and references therein) give evidence for a highly anisotropic superconducting gap. Measured critical magnetic fields usually show a pronounced anisotropy for *c*-oriented films and single crystals [4]. Applying the anisotropic Ginzburg-Landau model to