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HIGH-PRESSURE SYNTHESIS OF MgB_2 SUPERCONDUCTOR WITH T_c ABOVE 39 K*

Li Shao-chun(李绍春), Zhu Jia-lin(朱嘉林), Yu Ri-cheng(禹日成),
Li Feng-ying(李凤英), Liu Zhen-xing(刘振兴) and Jin Chang-qing(靳常青)†
Laboratory for Extreme Condition Physics, Institute of Physics, Center for Condensed Matter Physics, and Beijing Center for High Pressure Research, Chinese Academy of Sciences, Beijing 100080, *China*

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We report on the high-pressure synthesis and superconductivity of MgB_2 intermetallic compounds. The compounds have been obtained through high-pressure sintering of the mixtures of magnesium and boron fine powders under 5.0 GPa and at ~1000°C for 30 min. Magnetic measurements using a SQUID magnetometer show the sharp bulk superconducting transition above 39 K; the four-probe dc resistivity measurements indicate the highly-conductive normal state and sharp superconducting transition. The results highlight that high-pressure synthesis would be a promising way to promote the studies of this new kind of intermetallic superconductors.

Keywords: MgB_2, high-pressure synthesis, superconductivity
PACC: 7470, 6250

In January 2001, the research group of Professor Akimitsu in Japan announced the discovery of 39K superconductivity in the MgB_2 intermetallic compound[1], which immediately received worldwide attention. This is quite a surprise as it shows a rather high superconducting transition temperature just after those found in high T_c cuprates[2] and in the C_{60} system.[3] Moreover, MgB_2 ranks, so far, as the record high T_c ever reached in intermetallic superconducting compounds. The T_c value seems to be just around the critical maximum in the framework of the Bardeen–Cooper–Schrieffer (BCS) theory. Thus, the MgB_2 superconductor raises a challenge to both new material development and fundamental research of superconductivity. Here we report on the high-pressure synthesis and superconductivity of the bulk MgB_2 superconductor.

The samples were prepared from the mixtures of fine magnesium (98.5% above purity) and boron (5N purity) powders. The stoichiometric raw materials were carefully ground and introduced into the sample cell under N_2 protection. The sample, having been wrapped with Pt foil to avoid contamination, was put into a BN tube and inserted into a graphite sleeve which acts as an electric heater. The samples were then subjected to high-pressure synthesis with pyrophyllite as the pressure transmitting medium under 5.0 GPa and at ~1000°C for 30 min, followed by a quench from high temperature and pressure release. The synthesized samples are highly dense with metallic lustre and good electric conductivity at room temperature. We performed X-ray diffraction to check the structure, a dc susceptibility measurement using a Quantum Design MPMS SQUID magnetometer and dc resistivity using the four-probe method to qualify the superconductivity.

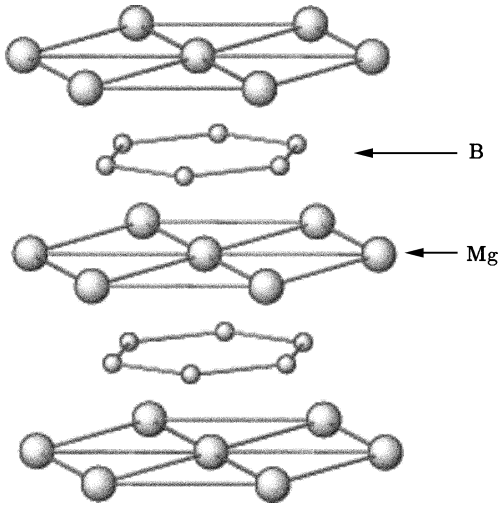


Fig.1. A schematic view of the MgB_2 crystal structure.

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†Corresponding author.

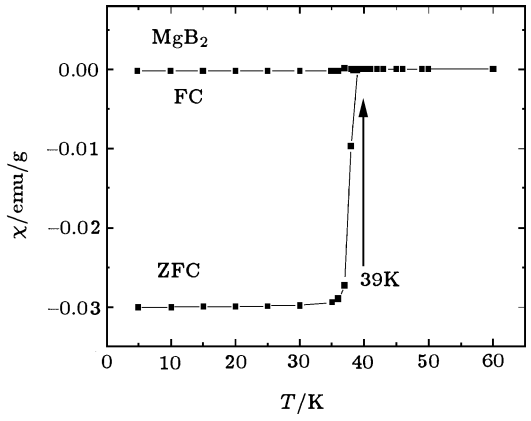


Fig.2. The dc magnetic susceptibility of an MgB_2 sample in both zero-field cooling (ZFC) and field cooling (FC) modes at an 8000 A/m applied field.

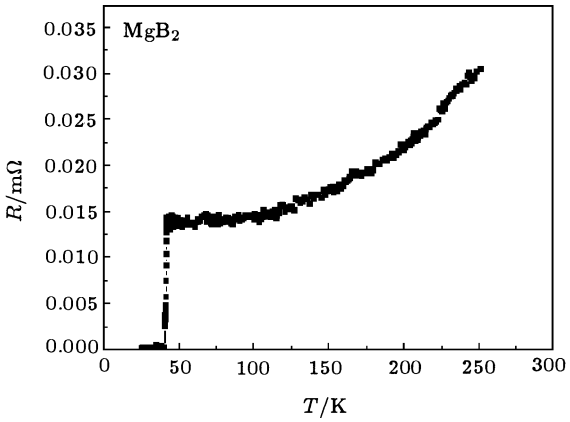


Fig.3. Resistivity versus temperature of the MgB_2 sample.

Figure 1 shows the schematic view of the MgB_2 crystal structure which consists of the graphite-like boron honeycomb layers interlaced with layers of magnesium atoms. Figure 2 shows the SQUID measurement of an MgB_2 sample in both zero-field cooling (ZFC) and field cooling (FC) modes at an 8000 A/m applied field. A sharp bulk superconducting transition was observed at T_c above 39K, indicating the large volume of the superconducting fraction of the synthesized sample. Figure 3 shows the resistivity versus temperature of the sample. The samples are quite conductive at normal state, comparable to good metals, prior to the sharp superconducting transition.

The results manifest that high-pressure synthesis is a ready way to get a high-density bulk MgB_2 superconductor. In particular, the fact that magnesium is relatively volatile and easily oxidized at ambient high pressure provides a natural protection during the synthesis, which warrants the chemical stoichiometry and rapid proceeding of the reaction. High pressure sounds promising in the research of this kind of new intermetallic superconductor and similar novel materials.

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