Absence of Superconductivity in BeB₂
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Abstract
The hexagonal BeB₂ compound has been prepared and found to be paramagnetic down to 5 K. The mixed (Mg,Be)B₂ system has the same Tₐₖ =39 K as pure MgB₂, indicating that Be does not replace the Mg atoms.

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Introduction
The recent discovery¹ of superconductivity around Tₐₖ=39 K in the simple intermetallic compound MgB₂ is particularly surprising for many reasons. This Tₐₖ for MgB₂ is much higher than the highest Tₐₖ values reported for the A₁₅ intermetallic compound (Nb₃Ge Tₐₖ=23.2 K) and the borocarbides (YPd₂B₂C Tₐₖ=23 K). This material available from common chemical suppliers, has been known and structurally characterized since the mid 1950 is that of the well known AlB₂-type which can be viewed as an intercalated graphite structure with full occupation of interstitial sites centered in a hexagonal prism consisting of of B atoms². Our scanning tunneling microscopy measurements have shown that the tunneling spectra exhibit a BCS gap structure, suggesting that MgB₂ is a conventional BCS (s-wave) superconductor³.

In the search of similar intermetallic materials having high Tₐₖ values, BeB₂ is the first natural candidate, since lighter divalent Be atoms may help providing larger phonon frequencies while keeping similar electronic properties. The crystal structure of BeB₂ is similar although not identical, to MgB₂. An earlier report⁴ suggests that BeB₂ is hexagonal (the space group is probably P6/mmm) with the lattice parameters a=9.79(2) and c=9.55(2) Å, whereas the same space group and lattice parameters have been used⁵ to define BeB₃. These parameters have been optimized to a =2.87 and c=2.85 Å for all previous band calculations⁶ of BeB₂, indicating that the interatomic distances should be significantly smaller than those in MgB₂, due to the smaller size of Be atom. On the other hand, BeB₂ is reported to crystallize in the AlB₂ type structure⁷-⁸ similar to MgB₂, and other diboride compounds.

In this paper we report the magnetic properties of BeB₂ synthesized by arc melting. Magnetic studies show definitely that this compound is paramagnetic down to 5 K,
and that superconductivity is absent. In that respect this result is consistent with the prediction of J. E. Hirsh\textsuperscript{8}, that the charge transfer from Be to B in BeB\textsubscript{2} is less than that from Mg to B in MgB\textsubscript{2}, and the Fermi level in BeB\textsubscript{2} is low, beyond the regime where superconductivity occurs. It appears that in the ternary (Mg,Be)B\textsubscript{2} compounds the Be atoms do not replace Mg.

**Experimental details and results.**

Intermetallic BeB\textsubscript{2} was prepared by melting the stoichiometric elements (99.9\% pure) in an arc furnace under an argon atmosphere. Precautions have been taken due to the highly toxicity of Be. Powder X-ray diffraction (XRD) measurements confirmed the crystal structure of the material (Fig. 1). The pattern was analyzed on the basis of a hexagonal structure and a least square fit of the observed peaks yields the unit cell parameters; a = 9.749(4) Å and c = 9.520(4) Å, in good agreement with ref. 4. The pattern contained a few unidentified extra peaks (less than 5\%). The dc magnetic measurements were performed in a Quantum Design superconducting quantum interference device magnetometer (SQUID), and Fig. 2 exhibits the curve measured at 500 Oe. The curve has the typical paramagnetic shape and adheres closely to the Curie-Weiss (CW) law: \( \chi = \chi_0 + C/(T - \theta) \), where \( \chi_0 \) is the temperature independent part of \( \chi \), \( C \) is the Curie constant, and \( \theta \) is the CW temperature. A fit of the CW law in the region of 5<K<150 K yields: \( \chi_0 = 1.4 \times 10^{-7} \text{emu/mol Oe} \), \( \theta = 0 \text{ K} \), and an effective moment, \( P_{\text{eff}} \) equal to 0.048\( \mu_B \). The isothermal magnetization up to 50 kOe is shown in the inset of Fig. 1. Based on these studies, our conclusion is that BeB\textsubscript{2} is paramagnetic.

Mg\textsubscript{1-x}Be\textsubscript{x}B\textsubscript{2} samples were also prepared by a solid state reaction as described in ref 3. Both magnetic and XRD studies indicate that Be does not enter the matrix, and the \( T_C = 39 \text{ K} \) which is obtained is similar that of pure MgB\textsubscript{2}.

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Fig. 1. XRD of BeB$_2$

Fig. 2. Magnetic susceptibility of BeB$_2$. The isothermal M(H) curve measured at 5 K, is shown in the inset.