Growth of Sub-millimeter Sized $MgCNi_3$ Single Crystal and Its Superconducting Properties

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Controversial issues on $MgCNi_3$ had triggered the growth of its single crystal. The highly different melting temperatures of Mg, C, and Ni obstructed the synthesis. However, we successfully synthesized sub-millimeter size $MgCNi_3$ single crystals under high-pressure. The X-ray diffraction and tunneling electron microscope experiments showed a simple cubic structure with the lattice constant a ~ 3.81 Å. The composition determined by using EPMA and EDX indicated Mg : C : Ni = 1 : 1 : 3. The superconducting properties were investigated by measuring the temperature and the field dependence of in-plane resistivity. The superconducting transition temperature was 6.7 K with a sharp transition width of 0.2K. Two interesting results were observed from the field dependent resistivity and the temperature dependent upper critical field (Hc2(T)) in contrast to the polycrystalline sample of MgCNi3 reported up to now. First, the peak effect was observed. This phenomenon can be shown in the clean and weak pinned single crystals such as MgB2 and NbSe2. The other is that Hc2(T) showed a clear upward curvature near Tc instead of the linear temperature dependence as in the polycrystals. This can be the evidence of two-gap superconductivity.

Keywords : MgCNi3 single crystals, peak effect, high pressure synthesis.