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Resistivity anomaly near the superconducting transition temperature of Pb/Co nanocomposite

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Abstract – Lead (Pb) films containing homogeneously distributed cobalt (Co) nanoparticles (mean size 4.5 nm) have been prepared with the help of a cluster source. Resistivity as a function of temperature and magnetoresistance were measured in-situ using the standard four probe method for the as-prepared and annealed samples. The non-annealed sample shows a normal superconducting transition but there is a peak near the transition temperature T_c. The peak disappears in an external magnetic field of 0.2 T. We explain this phenomenon resulting from scattering of electrons by the inhomogeneous local field in Pb/Co nanocomposite.

Recently the superconductor (SC) and ferromagnet (FM) nanocomposites attracted many interests. In these systems the interplay between the mutual exclusive cooperative phenomena SC and FM can be studied and it gives an opportunity to observe some new phenomena [1,2].

We prepared Pb films wherein nanometer size Co clusters are embedded and the interaction between SC and FM has been studied. It is a co-deposition of well-defined, in-beam prepared Co clusters and Pb atoms onto a cold substrate with temperature of ~ 40 K. The low temperature preparation can produce Pb films with much higher quality than that at room temperature. The transport properties have been measured in-situ in the temperature range of 2-300 K and in external magnetic fields up to 1.0 T for both as-prepared and annealed samples. As shown in Fig. 1, the non-annealed sample has a transition from normal state to superconducting state and T_c decreases with increase of external magnetic field. For the same sample but annealed at 300 K for one hour, a peak appears near T_c and the height of the peak decrease with increase of the external magnetic field (see Fig. 2). Magnetoresistance was measured at the temperature near the peak and we found that a very small temperature change (0.05K) can result very different transport behavior in the external magnetic field.

The possible explanations are phase slips, N-SC interfaces, disorder etc. Usually this kind of peak disappears in the external magnetic field of just a few Oersted. However, we need fields of higher than 0.1 T to destroy the peak. We explained this phenomenon by the inhomogeneous local field in Pb/Co nanocomposite.

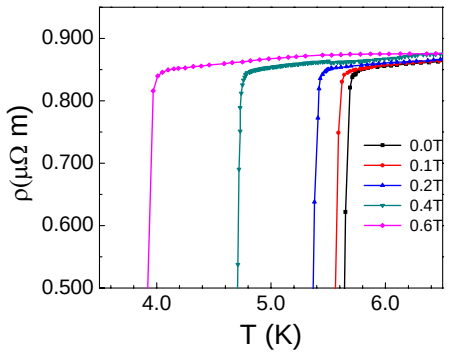

Figure 1: Resistivity as a function of temperature for the as-prepared Pb/Co nanocomposite in different external magnetic field.

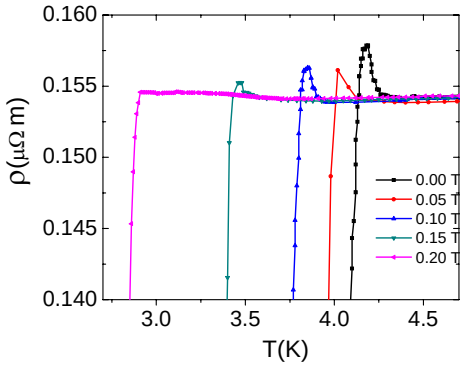

Figure 2: Resistivity as a function of temperature for the annealed (300 K) Pb/Co nanocomposite in different external magnetic field.

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