Magnetic Field Effects on the Pressure-Induced Colossal Maximum in Electrical Resistivity of CeSb

Okayama Yasushi [a,1] Suzuki Takashi [b,2] Môri Nobuo [b,3]

[a] *Department of physics, Saga University,Saga 840-8502,Japan*

[b] *Institute for Solid State Physics,University of Tokyo, Kashiwa,Chiba 227-8581,Japan*

Abstract

Pressure-induced sharp maximum in electrical resistivity $\rho(T)$ of CeSb is observed near 35K at pressures above 1.5GPa. The peak value increases rapidly in proportion to the square of pressure up to 6GPa, and at 7GPa it reaches a vaule nearly 23 times as large as that at ambient pressure. We have measured $\rho(T)$ curves of CeSb at 4GPa under various fixed magnetic fields up to 16T. The peak value of this colossal maximum exhibits a very rapid decrease with increasing magnetic field and this peak disappears completely above 6T. This result strongly suggests that the cause of the colossal maximum is attribute to some magnetic origin.

Key words: CeSb; high pressure; electrical resistivity; magnetic field

The family of the semimetallic cerium monopnictides CeX (X=P,As,Sb,Bi) with the NaCl structure have received much attention focusing on the unusual physical properties in connection with their low carrier concentration. Among these compounds, CeSb is well known wtih its variety and complicated magnetic phases. Many of the experimental studies have been performed extensively on CeSb under high pressure and/or magnetic field.In particular,the electrical resistivty measurement under high pressure made it clear that this compound exhibts highly unusual and extaordinary behavior which have never been observed before[1].

Figure 1 shows the electrical resistivity as a function of temperature $\rho(T)$ for CeSb at various fixed pressures P up to 8GPa under zero magnetic field, as a representative example for clarity. As can be seen from Fig.1, in the $\rho(T)$ at ambient pressure, there exists no detectable anomaly around 35K, except for the rapid decrease in resistivity due to a magnetic phase transition at 16K. However, one can see, the $\rho(T)$ curves above

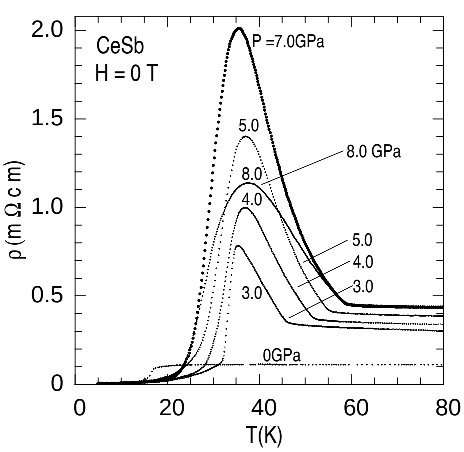

Fig. 1. $\rho(T)$ of CeSb at various fixed pressures up to 8GPa in the temperature range from 4.2 to 80K.

[1] Corresponding author. E-mail: okayamay@cc.saga-u.ac.jp

[2] Present adress:Tsukuba Institute of Science and Technology,Tsukuba,Ibaraki 300-0819,Japan

[3] Present adress:Department of physics,Saitama University, Shimookubo 255,Urawa 338-8570,Japan

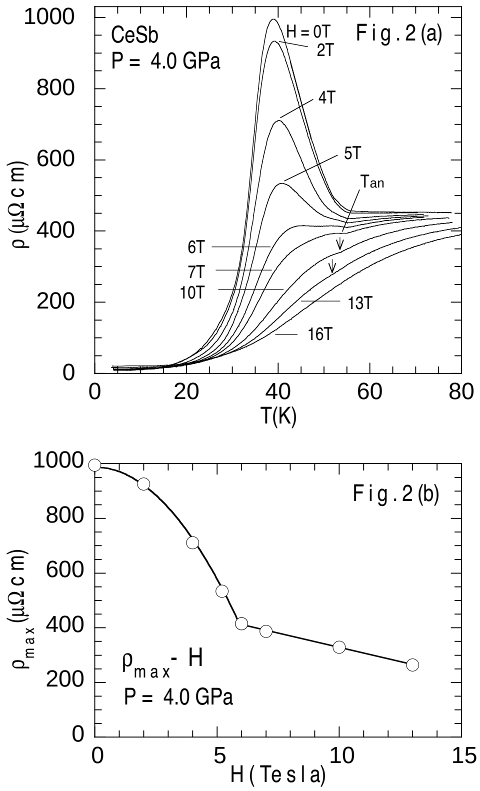

Fig. 2. Fig.2(a). $\rho(T)$ curve of CeSb at 4GPa under various fixed magnetic fields up to 16T in the temperature range 4.2-80K. The direction of the magnetic field is perpendicular to the current:$H \perp I$. Fig.2(b).Magnetic field dependence of ρ_{max} at 4GPa.

3GPa exhibit enormous enhancement of the electrical resistivity near 35K where a very sharp maximum in the $\rho(T)$ appears. The peak value increases remarkably in proportion to P^2 up to 6GPa, and at 7GPa it reaches a vaule nearly 23 times as large as that at ambient pressure, and as applying pressure further, it turns to decrease rapidly[1,2]. In order to obtain the information about the origin of this colossal maximum in resistivity, we have measured $\rho(T)$ of CeSb at maximum pressure 4GPa in our experiment under fixed magnetic field up to 16T perpendicular to the current:$H \perp I$. Masurements were carried out by a standard DC four-probe method using a modified-Bridgman anvil device with a fluid pressure-transmitting meduim enclosed in a Teflon capsule.The details of the high pressure techniques and the sample preparation are described elsewhere[3,4].

The $\rho(T)$ curves of CeSb at various fixed magnetic fields H up to 16T under a constant pressure of 4GPa are summarized in Figure 2(a). As one can see the $\rho(T)$ of 0T in Fig.2(a), an enormus enhancement of resistivity as a colossal maximum is already induced at around 40K.More surprisingly,with incerasing magnetic field, this colossal maximum is supressed remarkably and disappers above 6T, while the peak position T_{max} exhibits a notable shift towards high temperatures. In the $\rho(T)$ of 6T, the maximum is supressed until a slight trace of resistivity around 45K. As applying magnetic field further, the complete disappearance of the peak occurs simultaneously with the appearance of the anomaly in resistivity at T_{an} which is determined by taking derivative of the $\rho(T)$ respect to T , as is indicated by the arrow T_{an} in the $\rho(T)$ of 7, 10 and 13T. At a magnetic field 16T, there exists no detectable anomalies in $\rho(T)$ in the whole tempetature region. The magnetic field dependence of the peak value ρ_{max} at T_{max} under a fixed pressure 4GPa is plotted in Figure 2 (b). However,in the $\rho(T)$ under the magnetic field from 7 to 13T, we determained the ρ_{max} as a resistivity at T_{an},because of the complete disappearance of the peak in $\rho(T)$. Quite remarkably,with increasing magnetic field, the ρ_{max} shows the very steep decrease being proportional to the square of magnetic field up to 6T,whereas at a magnetic field above 6T, it changes to decrease monotonously. The qualitative defference in behavior of ρ_{max} observed in the crossover region of 6T clearly indicates the occurence of a some phase transition, however the nature of this transition is an open question. It seems probably that the external field effect of the highly unusual colossal-maximum is attribute to a characteristic electronic structure affected by the change of complicated magnetic phases. To confirm the mechanism which brings this peculiar behavior, further investigations such as ,the electrical resistivity measurement at exteisive pressure range up to 10GPa under megnetic field by using a diamond anvil cell are in progress.

In summary, we have found the the attractive relation that application of the pressure enormouly enhances the resistivity being proportional to P^2 and produces the colossal maximum whereas for that of the magnetic field remarkably supresses this maximum in proportion to H^2.

References

[1] Y.Okayama, H.Takahashi,N.Môri,Y.S Kwon,Y.Haga,T.Suzuki,J. Magn. Magn. Matr.**108**(1992) 113.

[2] N.Môri, Y.Okayama, H.Takahashi, Y.Haga and T. Suzuki, Physica B**186&188**(1993) 444.

[3] N.Môri, T.Nakanishi,M.Ohashi,N.Takeshita,H.Goto,S.Yomo,Y.Okayama, Physica B**265**(1999) 263.

[4] T.Suzuki,Actinide and Rare Earth Compound ed .T.kasuya (Jpn.J.Appl.Phys.,Tokyo,1993) JJAP Series**8**(1993) 44.