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Effects of Hydrostatic Pressure on the Curie Temperature of Ni-Based Alloys (Ni-V, -Cu, -Pd, -Pt and -Rh)

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Effects of Hydrostatic Pressure on the Curie Temperature of Ni-Based Alloys (Ni-V, -Cu, -Pd, -Pt and -Rh)

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Hydrostatic pressure effects on the Curie temperature $\Delta T_c/\Delta p$, have been investigated for Ni-based alloys, Ni-V, -Cu, -Pd, -Pt and -Rh, over a wide composition range. The Curie temperature was determined as an inflection point of self-inductance vs temperature curve. For all the alloys, $\Delta T_c/\Delta p$'s decrease monotonically accompanying with a change in sign as solute concentration increases. $\Delta T_c/\Delta p$'s as a function of T_c are classified into two types. The data on Ni-V, -Cu and -Pd alloys almost lie on a line and rather rapid decrease in a concave downward curve has been obtained for Ni-Pt and -Rh alloys. It is concluded from qualitative arguments that the d-band widening with pressure almost counterbalances with compression-induced $s-d$ transfer for the former type and the widening overcomes the transfer effect for the latter type.

§ 1. Introduction

Effects of pressure on the Curie temperature $\Delta T_c/\Delta p$, as well as on the spontaneous magnetization is an important project associated with the investigation of the electronic structure of 3d transition metals and alloys at normal pressure through the pressure effect. Previously our group had tackled with this project and the data on Ni-Cu[1] and -Pd[2] alloys have been briefly reported. Since then, the theoretical analysis based on the itinerant electron model has been made for Ni and Ni-Cu alloys by Lang and Ehrenreich[3] (referred to as L.E. hereafter) by considering the compression-induced conduction band effect ($s-d$ transfer) as well as the d-band widening effect with pressure, where both effects are related essentially to the state density at the Fermi level and the correlation energy. Similar but rather simple estimations have been successively made by Shiga[4] for Invars and by Edwards and Bartel[5] for $MnAs_xSb_{1-x}$ without taking $s-d$ transfer effect into account. And results obtained by them that $\Delta T_c/\Delta p$ consists of two terms which are proportional and inversely proportional to T_c at first sight, have been currently employed. Moreover, the interest on $\Delta T_c/\Delta p$ near the critical concentration where ferromagnetism disappears has also been increasing, associated with the problem of the homogeneous alloy system.

Therefore, the investigations of $\Delta T_c/\Delta p$ for other Ni-based alloys over the entire ferromagnetic composition range seem to be valuable both experimentally and theoretically. A series of experiments has again started in such circumstances and the results of Ni-V[6] and -Pt[7] alloys have been briefly discussed in previous notes and it has been noted that Ni-V, -Cu and -Pd alloys, and Ni-Pt and -Rh alloys belong to different types in the functional form of $\Delta T_c/\Delta p$ against T_c.[8]

In the present paper, the data on $\Delta T_c/\Delta p$ for Ni-V, -Cu, -Pd, -Pt and -Rh alloys are summarized and qualitative discussions are made from the standpoints mainly of the competition between d-band widening and $s-d$ transfer effects. The pressure was applied hydrostatically up to 8 kb and $\Delta T_c/\Delta p$ has been determined from the self-inductance vs temperature curve.

§ 2. Experimental

Alloy ingots of Ni-V, -Pt and -Rh were prepared by melting in a plasma jet furnace in argon atmosphere. The purity of the starting material was 99.99% except vanadium. An ingot was turned over and remelted several times during the melting process and subjected to the subsequent annealing at 1000°C for 24 hours so as to homogenize the composition. The cylindrical specimens, 3 mm in diameter and