SOVIET PHYSICS JETP VOLUME 33, NUMBER 1 JULY, 1971

INFLUENCE OF PRESSURE ON THE MAGNETIC SUSCEPTIBILITY OF ALLOYS OF PALLADIUM WITH RHODIUM AND SILVER

I. Ya. DEKHTYAR, A. S. PANFILOV, I. V. SVECHKAREV, and R. G. FEDCHENKO

Physicotechnical Institute of Low Temperatures, Ukrainian Academy of Sciences, Institute of Metal Physics, Ukrainian Academy of Sciences

Submitted August 5, 1970

Zh. Eksp. Teor. Fiz. 60, 340–344 (January, 1971)

The effect of hydrostatic pressures up to 4,000 kg/cm^2 on the magnetic susceptibility at room temperature is investigated in alloys of palladium with rhodium and with silver, by the method of free suspension of the sample with an inhomogeneous magnetic field. The experimental results are discussed within the framework of a simple empirical description of the variation of the electron spectrum of transition metals under pressure, containing deformation of the d-band and a relative shift of the s- and d-states on the Fermi level.

INTRODUCTION

FROM the few published rigorous calculations of the electronic spectra of transition metals under pressure[1] it is difficult to separate the main mechanisms governing the change of the spectrum and the curve of the density of states. Yet it is possible to construct a simple empirical model suitable for the description of the dependence of the density of states on the pressure. With the aid of such a model it is possible to describe satisfactorily the behavior of the magnetic susceptibility of chromium alloys under conditions of hydrostatic compression at room temperature[2], and the parameters of the model are in good agreement with experimental information on other electronic properties of these alloys. In the model, according to the customarily accepted representations, the density of states N is regarded as a sum of the contributions of two bands—a narrow d-band and a band of almost free electrons, called the s-band, while the influence of the pressure is regarded as the sum of the contributions of two mechanisms—the deformation of the d-band and its shift relative to the s-band. Taking into account the inequality $N_d \gg N_s$, we neglect the role of the s-band in all the effects with the exception of the band shift, and assume that $N_s \approx$ const. Thus, the electronic Gruneisen parameter γ_e takes the form

$$\gamma_e \equiv d \ln N / d \ln V = \gamma + \beta \partial \ln N / \partial q. \qquad (1)$$

Here V is the volume and the number of electrons per atom, and the parameters γ and β have the following meaning. The first mechanism—the deformation of the d-band—is described by the parameter $\gamma = \partial \ln N/\partial \ln V$. The second mechanism—the relative shift of the states of the s- and d-bands on the Fermi boundary, $\Delta E_{s\text{-}d}$, leads to a shift of the curve of the density of states N(q) by an amount $\Delta q = 2N_s \Delta E_{s\text{-}d}$ and is described by the parameter $\beta = \partial q/\partial \ln V$. It is assumed that the parameters γ and β can be regarded as constants in a limited interval of the state-density curve.

The present paper is a continuation of investigations of the deformability of the spectra of transition metals by pressure and a verification of the feasibility of the described model. The most interesting result—the separation of the effect of the band shift—can be obtained only by a special choice of the investigated portion of the spectrum—the vicinities of the maximum of the state-density curve. In this connection, we consider the influence of pressure on the magnetic susceptibility of binary alloys of palladium with silver and rhodium, having a maximum of the state density at a rhodium content of approximately 5 at.%.

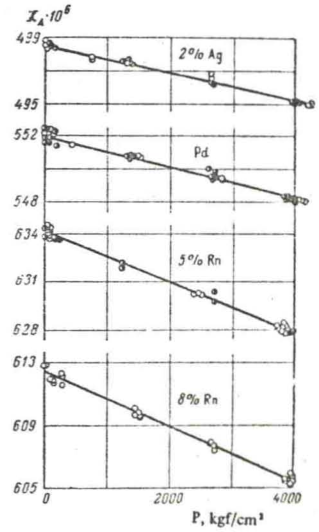

FIG. 1. Typical $\chi(P)$ plots of palladium alloys: reading down—Pd + 2% Ag, pure palladium, Pd + 5% Rh, Pd + 8% Rh. The different sets of points correspond to different samples of the investigated alloy.

SAMPLES, EXPERIMENTAL TECHNIQUE, RESULTS

Binary alloys of palladium (99.9%), containing up to 15 at.% rhodium (99.7%) and 2 at.% silver (99.9%) were prepared in an arc furnace followed by two-hour annealing at 1000°C in vacuum.

The magnetic susceptibility χ under pressure was measured, as in the preceding investigation[2], using propyl alcohol to transfer the pressure to the sample. Typical experimental plots of $\chi(P)$ are shown in Fig. 1 and are similar to those given in[2]. The values of the susceptibility at P = 0 coincide with the data by others (for example,[3]).

The values of $d \ln \chi / d \ln V$ are represented by the points in Fig. 2 as functions of the electron density (the compressibility coefficient of the alloys—linear inter-