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[16]Here we consider the results of Owen and Scalapino [J. Appl. Phys. 41, 2047 (1970)]. For a thin upper film of thickness L, $2\lambda+d$ becomes $\lambda+\lambda\tanh(L/2\lambda)+d$. From the previous oxide results we choose $\lambda\approx 570$ Å, yielding $\lambda+\lambda\tanh(L/2\lambda)+d=935$ Å. In view of the probable unevenness of the thin film and the uncertainty of the thickness, this agreement is satisfactory.

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Low-Temperature Thermal Expansion and Longitudinal Magnetostriction of Palladium-Rhodium Alloys

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The electronic thermal expansion and longitudinal magnetostriction of polycrystalline *Pd*Rh alloys are measured, and the volume dependence of the Coulomb-exchange interaction parameter is deduced.

The alloys *Pd*Rh are of considerable interest since the exchange enhancement of the magnetic susceptibility, which is already large in Pd, becomes even stronger as Rh is substituted for Pd. This increase in the susceptibility is associated with an increase in the density of states at the Fermi surface, which shows in the electronic specific heat. Both the susceptibility and the specific heat have a maximum at about the composition $Pd_{0.95}$-$Rh_{0.05}$.[1]

We describe in this paper measurements of the low-temperature thermal expansion and the longitudinal magnetostriction of polycrystalline samples of pure Pd[2] and the alloys $Pd_{0.99}Rh_{0.01}$, $Pd_{0.97}Rh_{0.03}$, and $Pd_{0.95}Rh_{0.05}$. We have previously assumed the magnetostriction to be isotropic in the cubic transition metals[2,3] and obtained the volume dependence of the susceptibility by taking the volume magnetostriction to be three times the longitudinal magnetostriction. However, Keller *et al.*[4] have recently found that the magnetostriction of polycrystalline samples of Pd and the *Pd*Rh alloys is strongly anisotropic. Since their values for the longitudinal magnetostriction agree reasonably well with ours, we have employed their values for the volume magnetostriction to deduce the volume dependence of the susceptibility for comparison with the electronic Grüneisen parameter obtained from our thermal expansion data.

We measured the thermal expansion and the longitudinal magnetostriction (at 4.2 °K in fields up to 35 kOe) using a capacitance dilatometer.[3] The Grüneisen parameter γ is $3\alpha/\kappa C$, where α is the electronic thermal expansion coefficient (linear in temperature), κ the compressibility (assumed equal to that of Pd[5]), and C the electronic specific heat.[1]

TABLE I. Electronic Grüneisen parameter and magnetostriction of Pd and *Pd*Rh Alloys.

Sample	γ[a]	$\Delta l/l_0H^2$ (10^{-18} Oe^{-2})	$\Delta V/V_0H^2$ (10^{-18} Oe^{-2})	$\frac{\partial \ln\chi}{\partial \ln V}$	S[b]	$\frac{\partial \ln V_c}{\partial \ln V}$
Pd	2.45	−25	100	4.5	9.0	−2.2
$Pd_{0.99}Rh_{0.01}$	2.91	< 1	220	7.2	12.6	−2.5
$Pd_{0.97}Rh_{0.03}$	3.43	95	540	13.3	16.0	−2.8
$Pd_{0.95}Rh_{0.05}$	3.87	140	680	16.0	17.2	−3.1

[a]Our value of γ for Pd is about 10% higher than the value $\gamma = 2.2$ given by G. K. White and A. T. Pawlowicz, J. Low Temp. Phys. 2, 631 (1970), which was measured on the same sample and is probably more accurate.

[b]The Stoner enhancement factor S is evaluated as described in the text from the susceptibility and specific-heat data (interpolated for $PdRh_{03}$) given in Ref. 1, except for the susceptibility of our Pd sample, $\chi = 6.7 \times 10^{-6}$ emu/g, which was measured by E. Bucher.

In Table I, we also give $\Delta l/l_0H^2$ (our value for the longitudinal magnetostriction) and $\Delta V/V_0H^2$ (the volume magnetostriction from Fig. 1 of Ref. 4). It is noteworthy that in pure Pd these are of opposite sign because of the large positive transverse magnetostriction. The volume dependence of the molar susceptibility χ is calculated from the volume magnetostriction by means of the relation $\partial \ln\chi/\partial \ln V = 2(\Omega/\kappa\chi)(\Delta V/V_0H^2)$, Ω being the molar volume.

We see that $\partial \ln\chi/\partial \ln V$ increases rapidly when Pd is alloyed with Rh, while γ increases more slowly.[6] We relate these effects by means of the expression

$$\chi = S\, 2\mu_B^2 N(\epsilon_F) = \frac{2\mu_B^2 N(\epsilon_F)}{1 - N(\epsilon_F)V_c}, \tag{1}$$

which on differentiation gives

$$\frac{\partial \ln\chi}{\partial \ln V} = \gamma + (S-1)\left(\gamma + \frac{\partial \ln V_c}{\partial \ln V}\right). \tag{2}$$

Here V_c is the Coulomb-exchange-interaction parameter, and S is the Stoner enhancement factor for the susceptibility. In Eq. (2) we write $\gamma = \partial \ln N(\epsilon_F)/\partial \ln V$, though strictly the Grüneisen parameter is the logarithmic volume derivative of the electronic specific-heat density of states, $N_{ph}(\epsilon_F)$, which includes phonon enhancement. In Table I, we estimate S simply by assuming $N(\epsilon_F)$, the bare density of states at the Fermi surface, to be smaller than $N_{ph}(\epsilon_F)$ by a constant factor 1.7, obtained from a band-structure calculation of $N(\epsilon_F)$ for Pd.[7]

We conclude that $\partial \ln V_c/\partial \ln V$, given in the last column of Table I, is negative in Pd and *Pd*Rh alloys. As $\gamma = \partial \ln N(\epsilon_F)/\partial \ln V$ increases with Rh concentration, $\partial \ln V_c/\partial \ln V$ becomes more negative and almost cancels the increase in γ, so that most of the increase in $\partial \ln\chi/\partial \ln V$ is due to the increase in the Stoner enhancement factor S.

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