Effect of Pressure on the Resistivity of Ag-Au Alloys

effective impurity potential accounting for electron screening is given by

$$v(q) = v_0(q)/\varepsilon(q) . \tag{5}$$

Here $v_0(q)$ is the Fourier transform of $v_0(r)$

$$v(q) = -4 \pi U \frac{\sin q r_{\rm s} - q r_{\rm s} \cos q r_{\rm s}}{q^3}, \qquad (6$$

and $\varepsilon(q)$ is the dielectric constant in the random phase approximation.

$$\varepsilon(q) = 1 + \frac{4 e^2 m k_{\rm F}}{\pi \hbar^2 q^2} \left[\frac{1}{2} + \frac{k_{\rm F}}{2 q} \left(1 - \frac{q^2}{4 k_{\rm F}^2} \right) \ln \left| \frac{q + 2 k_{\rm F}}{q - 2 k_{\rm F}} \right| \right],\tag{7}$$

where $k_{\rm F}$ is the Fermi wave vector. If it is assumed that the Fermi surface is spherical (i.e. neglecting the neck electrons in the noble metal alloys) the resistivity can be calculated from [16]

$$\varrho_{0} = \frac{c (1-c) m^{2}}{4 \pi \hbar^{3} k_{\rm F}^{3}} \int_{0}^{2 k_{\rm F}} |v(q)|^{2} q^{3} \, \mathrm{d}q , \qquad (8)$$

where c is the concentration of Au atoms.

The volume derivative of (8) is easily shown to be

$$\frac{\mathrm{d}\ln\varrho_0}{\mathrm{d}\ln V} = -5\frac{\mathrm{d}\ln k_\mathrm{F}}{\mathrm{d}\ln V} - 2\frac{\int\limits_{0}^{2}\mathrm{d}x\frac{(\sin\alpha x - \alpha x\cos\alpha x)^2}{x^3\varepsilon^2(x)}\frac{\mathrm{d}\ln\varepsilon(x)}{\mathrm{d}\ln V}}{\int\limits_{0}^{2}\mathrm{d}x\frac{(\sin\alpha x - \alpha x\cos\alpha x)^2}{x^3\varepsilon^2(x)}},\qquad(9)$$

where
$$x \equiv q/k_{\rm F}$$
, $\alpha \equiv k_{\rm F} r_{\rm s}$,

$$\frac{\mathrm{d}\ln\varepsilon(x)}{\mathrm{d}\ln V} = \frac{1}{3} \left[1 + \frac{\pi h^2 k_{\rm F}}{2 m e^2} \left(\frac{x^2}{1 + \frac{(1 - x^2/4)}{x} \ln \left| \frac{1 + x/2}{1 - x/2} \right|} \right) \right]^{-1},$$
(10)

and U is assumed to be independent of volume and concentration. In the free electron approximation d ln $k_{\rm F}/d \ln V = -1/3$. The integrals can be evaluated numerically if $k_{\rm F}$ and $r_{\rm s}$ are known; for both Ag and Au $k_{\rm F} = 1.20$ Å⁻¹ and $r_{\rm s} = 1.59$ Å [18]. Evaluating the integrals yield d ln $g_0/d \ln V = 1.38$ for all Ag-Au alloys. As seen in Table 1 this is in general agreement with the experimental values; however, this model does not predict the concentration dependence. A similar calculation using this model was made for the Cu-Ag and Cu-Au alloys; in these cases the model predicted both the wrong sign and magnitude (in the case of the pseudopotential calculations [15] agreement between theory and experiment was obtained for the Cu-Ag alloys, but not the Ag-Au alloys).

These discrepancies in the theoretical prediction (from both models) are not too surprising because the effect of the low lying filled d-bands on the scattering potential was not explicitly considered. It is well known that the filled d-bands in the noble metals strongly interact with the conduction electrons in certain directions [1, 17]. From optical measurements [19] it has been shown that the d-levels of Cu and Ag do not overlap and form separate d-states in the alloys,

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