COMMENT

Metallic Conductivity near the Metal-Insulator Transition

Recent measurements[1] of the conductivity σ of $Ge_{1-x}Au_x$ films indicate a broader metal-insulator transition region than that[2] in uncompensated Si:P. (See Fig. 1.) We have plotted σ at $T = 300$ K, σ_{300} (rather than density, n, which can be used[3] for Si:P), since σ in $Ge_{1-x}Au_x$ increases with x but decreases with annealing.[1] We have normalized the σ values at the lowest T studied, $\sigma_{L.T.}$, to Mott's[4] σ_{min}. [For $Ge_{1-x}Au_x$, $\sigma_{min} = 100\ (\Omega\ cm)^{-1}$; for Si:P, $\sigma_{min} = 20\ (\Omega\ cm)^{-1}$.]

The variation of $\sigma_{L.T.}$ in $Ge_{1-x}Au_x$ (Fig. 1) is closer than that in Si:P $[\sigma_{L.T.}/\sigma_{min} = 13(n/n_c - 1)^{0.55}]$ to the estimate of scaling theories of localization[5] $[\sim (n/n_c - 1)]$. The variation is also suggestive of percolation[6] $[\sim (n/n_c - 1)^{1.6}]$, which may apply if there is a random distribution of macroscopic metallic clusters larger than the coherence length,[2] ξ. This ξ grows near the transition from the characteristic value, ξ_0, entering σ_{min}. ($\xi_0 = 6$ Å for $Ge_{1-x}Au_x$ and 64 Å for Si:P.)

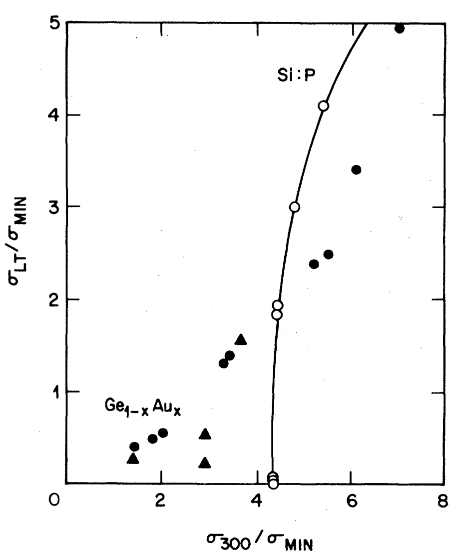

FIG. 1. Normalized, low-temperature conductivity $\sigma_{L.T.}$ vs σ_{300} near the metal-insulator transition. Solid circles and triangles are $Ge_{1-x}Au_x$ at $T = 1.4$ K (from Figs. 2 and 3 of Ref. 1). Open circles are uncompensated Si:P at $T = 0.001$ K (from Ref. 2).

Dodson *et al.*[1] conclude that the clusters which form, and grow with annealing, are smaller than ξ, and thus pose no limitations due to nonrandomness, but the nonmonotonic behavior for $\sigma_{L.T.} < \sigma_{min}$ in Fig. 1 indicates otherwise. Optical studies[7] of Si:P show indirectly that the donors are distributed randomly on a scale $\sim 10^2$ Å, but the sharpness of the transition makes it difficult to rule out rounding effects due to slight inhomogeneity. To the extent that there may be significant nonrandomness, the data do not test the above models for $\sigma < \sigma_{min}$ and leave open the question of a minimum metallic conductivity[8] for quantum localization.

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[1]B. W. Dodson, W. L. McMillan, J. M. Mochel, and R. C. Dynes, Phys. Rev. Lett. 46, 46 (1981). Previous studies of similar alloys are reviewed by K. Morigaki, Philos. Mag. B. 42, 979 (1980).

[2]T. F. Rosenbaum, K. Andres, G. A. Thomas, and R. N. Bhatt, Phys. Rev. Lett. 45, 1723 (1980).

[3]F. Mousti, P. Ostoja, and L. Passari, J. Appl. Phys. 45, 4576 (1974).

[4]N. F. Mott, Philos. Mag. 26, 1015 (1972), and 29, 613 (1974); N. F. Mott and E. A. Davis, *Electronic Processes in Non-Crystalline Materials* (Oxford Univ. Press, New York, 1979).

[5]E. Abrahams, P. W. Anderson, D. C. Licciardello, and T. V. Ramakrishnan, Phys. Rev. Lett. 42, 673 (1979), and references therein.

[6]S. Kirkpatrick, Rev. Mod. Phys. 45, 574 (1973).

[7]M. Capizzi, G. A. Thomas, F. DeRosa, R. N. Bhatt, and T. M. Rice, Solid State Commun. 33, 793 (1980).

[8]Mott (Ref. 4) reviews a number of careful and extensive studies supporting the existence of σ_{min}. See, e.g., F. R. Allen and C. J. Adkins, Philos. Mag. 26, 1027 (1972); C. Yamanouchi, K. Mizuguchi, and W. Sasaki, J. Phys. Soc. Jpn. 22, 859 (1967).

