Interface-Driven Enhancement of Resistivity in Au-Ag Nanohybrids

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Abstract

Recent experiments on nanoclusters of silver (Ag) embedded in a gold (Au) matrix have reported a dramatic enhancement in electronic resistivity—both at zero temperature and in the linear-in-temperature regime—as the Ag volume fraction increases. Notably, at approximately 50% Ag concentration, the residual resistivity increases by a factor of 20 and the linear-T resistivity coefficient by nearly 40, relative to pure Au. While both Au and Ag are weakly coupled electron-phonon (EP) systems in bulk, these results suggest that a significant enhancement of EP coupling emerges at the Ag-Au interface.

To model this behavior, we construct two-dimensional nanocluster configurations with tunable Ag content and implement a Holstein model featuring weak EP coupling in the metallic interiors and strong coupling at interfacial sites. Employing an exact diagonalization-based Langevin dynamics approach, we compute the temperature-dependent resistivity across a range of configurations. Our simulations capture both the large residual resistivity and the ∼30-fold increase in the linear-T coefficient observed experimentally.

Crucially, we find that the interface is highly inhomogeneous: different segments contribute differently to static and thermal scattering. This spatial variation underpins the enhanced resistive response and highlights the critical role of interface engineering in nanoscale transport phenomena.