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Au Nanoparticle Clusters: A New System to Model Hopping Conduction

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Abstract: We study electrical transport through self-assembled Au nanoparticle clusters which can be viewed as a new model system to study hopping transport. The physics of such systems is governed by two parameters: the charging energy and tunnel coupling between the particles. The charging energy is determined by the size of the nanoparticles. When the diameter of the nanoparticles is less than 4-5 nm the charging energy is large enough that Coulomb blockade effects were observed in electrical transport even at room temperature. The magnitude of the tunnel coupling between the particles was determined by the thiol coating used. To study a wide range of tunnel couplings, we have synthesized gold nanoparticles with various thiol coatings, including 1-octanethiol, 1-dodecanethiol, 1-octadecanethiol, 4-mercaptodiphenylacetylene, 4-nitro-4'-mercaptodiphenylacetylene, and 3,5-dinitro-4'-mercaptodiphenylacetylene. Current-voltage characteristics were found to be strongly dependent on both the coating and the size of the nanoparticles. At low temperature we have observed nonlinear I-V characteristics with a threshold voltage that was significantly larger in gold nanoparticle clusters where the thiol coating had weak tunnel coupling.

Key Words: nanoparticles, Coulomb blockade, hopping conduction

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