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Conduction Mechanism in Arrays of Lead Selenide Nanocrystals[1]

TAMAR MENTZEL, KENNETH MACLEAN, SCOTT GEYER, VENDA PORTER, MOUNGI BAWENDI, MARC KASTNER, Massachusetts Institute of Technology — We perform transport measurements of a PbSe nanocrystal solid which serves as the channel of a field-effect transistor. We find that a simple model of hopping between intrinsic localized states describes the conduction mechanism. From the field effect, we see that the majority carriers are holes, which are thermally released from acceptor states. At low source-drain voltages, the activation energy for the conductivity is given by the energy required to generate holes plus the activation over barriers resulting from site disorder. At high source-drain voltages the activation energy is given by the former only. The thermal activation energy of the zero-bias conductance indicates that the Fermi energy is close to the highest-occupied valence level, the $1S_h$ state, and this is confirmed by field-effect measurements, which give a density of states of approximately 8 per nanocrystal as expected from the degeneracy of the $1S_h$ state. Using the Thomas-Fermi screening length in the NC solid, we find that the gate serves to modulate the charge density in the monolayer closest to the gate, while successive monolayers are screened from the field.

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