Abstract Submitted
for the MAR10 Meeting of
The American Physical Society

Joule Heating in Ballistic Nano-Contacts T. Y. CHEN, C. L. CHIEN, Department of Physics and Astronomy, Johns Hopkins University, M. MANNO, L. WANG, C. LEIGHTON, Department of Chemical Engineering and Materials Science, University of Minnesota — Joule heat generation and thermal management are important for any electronic devices. While the origin of Joule heat is non-adiabatic inelastic scattering of electrons, the characteristics of Joule heat are very different depending on the whether the transport is diffusive or ballistic, i.e. whether the structural length scale is respectively larger or smaller than the carrier mean free path. Joule heating in the diffusive limit has been well known but not in the ballistic limit. In this work, we have determined the Joule heating relation of $V^2 = \mathrm{C}(T_m - T)$ in ballistic nanocontacts involving the bias voltage V, the ambient temperature T, and the maximum temperature Tm inside the contact by exploiting the ordering temperature of a magnetic solid as a natural thermometer. The relation has been further corroborated using a single contact at one temperature but different magnetic fields. A simple energy transfer model incorporating ballistic transport can account for this relation, which is essential for transport in nanostructures. Ballistic heat transport also provides a novel method for determining the ordering temperatures of magnets, either ferromagnets or antiferromagnets.

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Date submitted: 20 Nov 2009 Electronic form version 1.4