Electron induced heating and molecular phonon cooling in single C60 junctions

Gunnar Schulze, Katharina J. Franke, Jose Ignacio Pascual
Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany
pascual@physik.fu-berlin.de

Resumen

The functionality of single molecules as electronic devices relies on its stability against large current densities. Electronic current generates heat in the molecular junction due to coupling of electrons with molecular vibrations. Using a scanning tunnelling microscope operated at 5 K, we thermally decompose single C_{60} molecules on a metal surface by passing current through them, and investigate the response of the degrading current (and power) to changes in electron energy. The power for decomposition results from the balance of heating and cooling efficiencies. We find that heating varies with electron energy and reflects the molecular resonance structure participating in the transport. Cooling, on the other hand, is a non-resonant process, dominated by the decay of molecular vibrations into electron-hole pair excitations into the metal substrate [1, 2].

In tunnel regime, the decomposition power lies around a constant value that depends strongly on the metal substrate. By comparing this average power for several metal surfaces (Cu(110), Pb(111) and Au(111)) we find that it is related to the amount of charge transfer from surface to molecule, in agreement with a most effective cooling through electron-hole pair creation in those systems with larger density of molecular states at the Fermi level [2]. On the other hand, when the STM tip contacts the fullerene the molecule can sustain much larger currents (up to 100 microamps for Cu(110)). The origin of this is the opening of an additional decay channel by electron-hole pair creation at the tip [1].

Referencias:

[1] G. Schulze, *et al.*, Physical Review Letters **100**, 136801 (2008)
[2] G. Schulze, *et al.*, New Journal of Physics, accepted (2008); arXiv:0803.2222

Figuras:

(Left) Model of our experimental approach. (Right) Hexagonal C_{60} on Pb(111) after thermally decomposing 29 molecules to draw the letters “STM”.