**Detection of Heating in Current Carrying Molecular Junctions by Raman Scattering**

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An important consequence of electron-vibration interaction in molecular-junction-transport is heat generation, i.e., energy transfer to the underlying nuclear motions. In balance with heat dissipation, this has important implications on the issue of junction stability. Advancement in molecular electronics necessitates thorough understanding of these processes in molecular junctions [1]. Such an understanding depends on the ability to monitor non-equilibrium occupancy of vibrational levels at current carrying junctions as a function of bias. We report on the realization of such a capability by utilizing the Stokes (S) and AntiStokes (AS) components of Surface Enhanced Raman Spectroscopy (SERS) to probe the effective temperature of current carrying junctions. Home built confocal Raman microscope was used to map the S and AS Raman spectra of edge fabricated conducting molecular junctions [2]. All Raman active modes show similar heating as a function of bias at room temperature, suggesting fast internal vibrational relaxation processes. These results demonstrate the power of direct spectroscopic probing of heating and cooling processes in nanostructures.

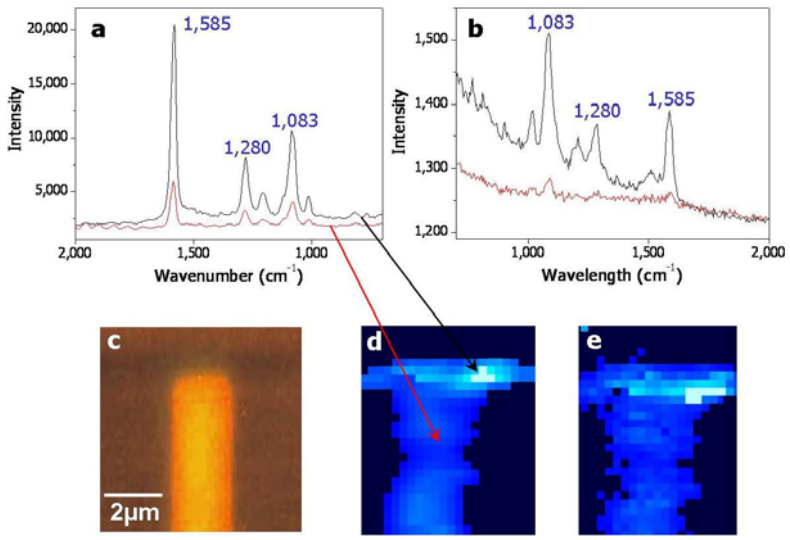


Figure 1: **Raman spectra and maps of a silver molecule junction. (a)** S spectrum (671nm laser) of BPDT molecules in a junction (black) and at an arbitrary spot on the Ag electrode (red). **(b)** The corresponding AS spectra. Analysis of temperature is based on the AS/S ratios of the indicated modes. **(c)** An optical picture of a molecular junction. **(d)** Raman map of the junction (1585cm$^{-1}$ S line) and **(e)** of the AS 1585cm$^{-1}$ line of the same junction.

[1 ] Galperin, M., Nitzan, A. & Ratner, M. A. *Heat conduction in molecular transport junctions.* Phys. Rev. B. **75**, 155312-155325 (2007).

[2] Shamai, T., Ophir, A. & Selzer, Y. *Fabrication and characterization of "on-edge" molecular junctions for molecular electronics.* Appl. Phys. Lett. **91**, 102108-102110 (2007).