Thermal radiation of a single pair of subwavelength antennas

Loubnan Abou-Hamdan[1], Riad Haidar[2], Valentina Krachmalnicoff[1], Patrick Bouchon[2], and Yannick De Wilde[1]

[1]*Institut Langevin, ESPCI Paris, PSL University, CNRS, 1 rue Jussieu, F-75005 Paris, France*
[2]*DOTA, ONERA, Université Paris-Saclay, F-91123 Palaiseau, France*
Corresponding author: loubnan.abou-hamdan@espci.fr

Understanding fundamental interactions between a small number of thermally excited subwavelength antennas is an essential step to optimize the emission of large-scale metasurfaces. The very weak thermal radiation emitted by such systems of nano-antennas, can be extracted by highly sensitive techniques, such as thermal radiation scanning tunneling microscopy [1], and infrared spatial modulation spectroscopy (IR-SMS) [2]. Here, we characterize the far-field thermal emission of a single asymmetric pair of coupled subwavelength metal-insulator-metal (MIM) patch antennas separated by a nanometric gap g, using the IR-SMS technique [3]. The sample geometry and experimental technique are sketched in Fig.1 (a).

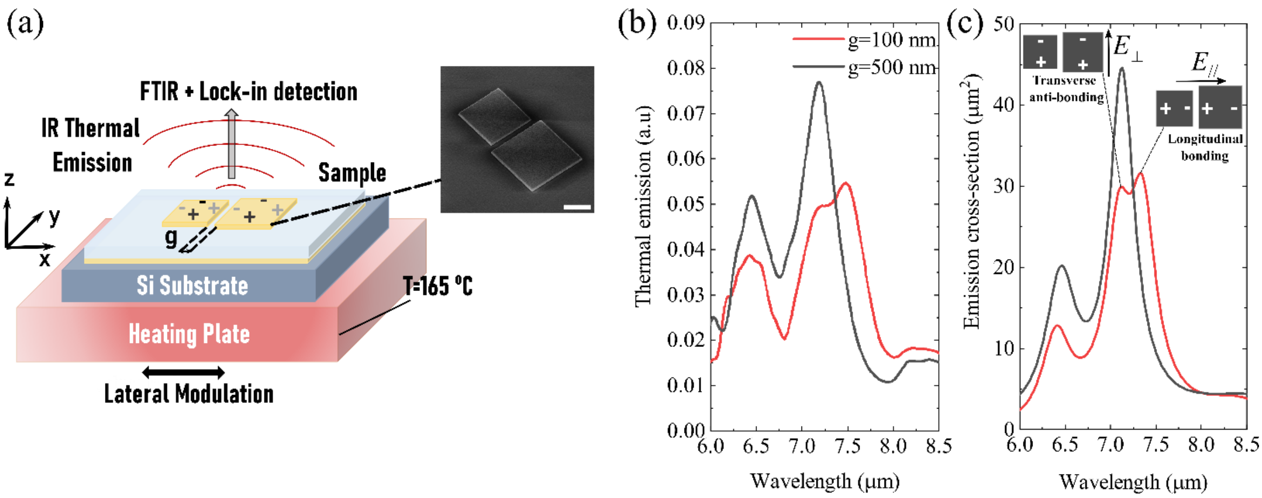

Fig. 1: (a) Schematic illustration of the sample geometry and of the IR-SMS technique. An SEM image of the considered antenna pair is shown in the inset. The scale bar is 1 μm. (b) Measured thermal emission spectra of the antenna pair for different gaps g. (c) FDTD calculations of emission cross-sections corresponding to the measurements. The inset shows a sketch of the dimer geometry showing two of the hybrid modes of the coupled antennas, for electric field polarizations parallel and perpendicular to the dimer axis. The positive (+) and negative (-) signs indicate the surface charge distribution.

As the gap size is reduced to 100 nm (Fig 1(b) and (c), red curve) the two gold patches of the MIM antennas form a dimer pair and a splitting starts to form in the resonance peak between 7 and 8 μm. The observed splitting is a direct result of the simultaneous excitation of the hybrid bonding and anti-bonding modes of the dimer [4], shown in the inset of Fig 1(c). This striking result shows that various coupled modes of a single nano-antenna can be simultaneously excited by thermal fluctuations, an incoherent process arising from fluctuating thermal currents.
The observed interactions in a single pair of thermally excited antennas may guide future efforts to build antenna systems or arrays for various applications.

References:

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