Department of Physics

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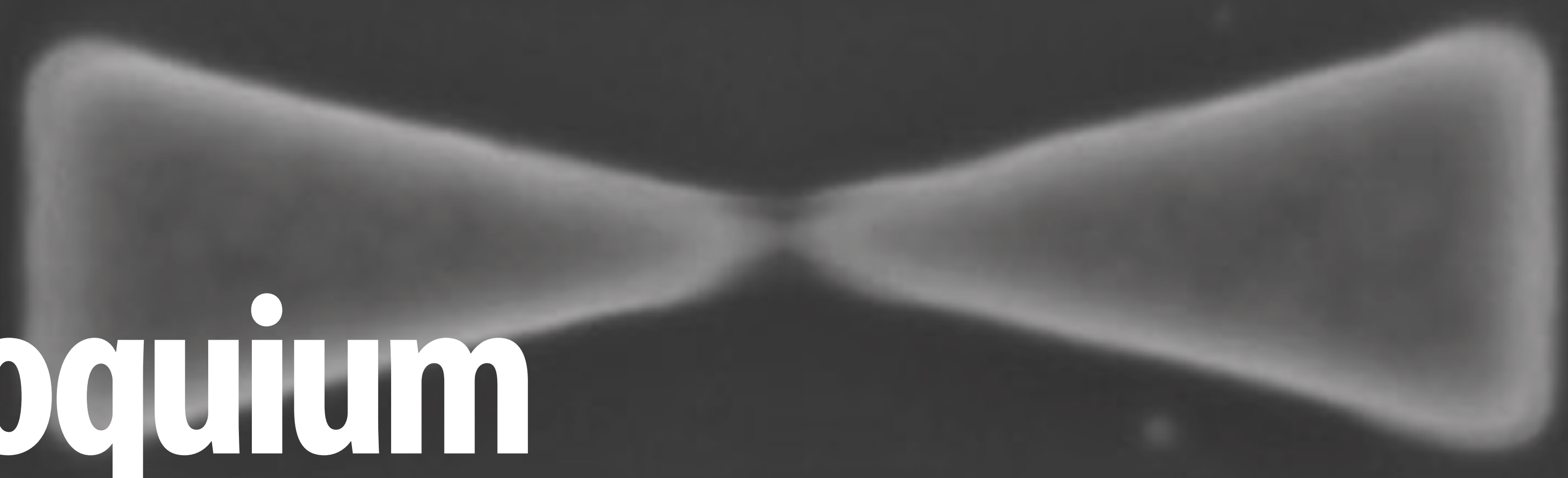
Colloquium



*Novotny L. et al., Nature Photonics **5**, 83–90 (2011)*

FALL 2012

Niek van Hulst
ICFO, Barcelona, Spain

Antennas for Light

day	location	time
DECEMBER 12, 2012 WEDNESDAY	EE01	16:00

ABSTRACT

An optical nano-antenna is the high frequency analogue to the well-known radio-antennas is [1]. Such resonant plasmonic nanostructures allow the control of optical fields at the nanometer scale: super- focussing, local field enhancement, increased radiative rates and angular direction of light emission. The optical antennas have dimensions of typically 20-200 nm, while efficient interaction with active materials (molecules, quantum dots, ..) takes place in the near field, at distances 1 - 10 nm. Clearly nano-control in fabrication and operation is crucial.

First I will address resonant optical nanoantennas positioned at the end of a metal-coated tapered glass fibre near-field probe, thus acting as scanning probes [2]. Direct mapping of the antenna field with single fluorescent beads and molecules reveals a spatial localization of 25-50 nm, demonstrating the importance of such antennas for nanometer resolution optical microscopy [3]. The resonance shows that the antenna is indeed equivalent to its radio frequency dipole analogue.

Next I turn to surface antennas, which are more suitable for large scale fabrication. A quantum dot is placed on the antenna such that it drives the resonance exactly at a point of high mode density. The resulting quantum-dot luminescence is fully emitted in the antenna mode: strongly polarized and with a characteristic Hertz dipole pattern. The directionality emission of the quantum dot is steered by a Yagi-design [4] or even turned into a non-dipolar emission by through multipolar antenna modes.

Finally, antennas are ideal to bring ultrafast photonics to the nanoscale through their support of high-bandwidth excitation, i.e. tuneability [5]. Here, plasmonic antennas are engineered to realize two sought-after applications of ultrafast plasmonics: sub-wavelength phase shaping, and ultrafast hotspot switching. A hotspot switch at sub-100 fs time scale is shown applying only quadratic chirp to the excitation field. This simple, reproducible and scalable approach promises to transform ultrafast plasmonics into a straightforward tool for use in fields as diverse as room temperature quantum optics, nanoscale solid state physics or quantum biology [6].

[1] Lukas Novotny and Niek F. van Hulst, Antennas for Light. Nature Photonics 5, 83-90 (2011), **[2]** Lars Neumann, Yuanjie Pang, Amel Houyou, Mathieu Juan, Reuven Gordon, Niek F. van Hulst, NanoLetters 11, 355-360 (2011) **[3]** T.H. Taminiau, F.D. Stefani, F.B. Segerink, N.F. van Hulst, Nature Photonics, 2, 234 (2008); NanoLetters 7, 28-33 (2007). **[4]** Alberto G. Curto, Giorgio Volpe, Tim H. Taminiau, Mark P. Kreuzer, Romain Quidant, Niek F. van Hulst, Science 329, 930-933 (2010). **[5]** Daan Brinks, Richard Hildner, Fernando D. Stefani and Niek F. van Hulst, Optics Express 19, 26486 (2011). **[6]** Daan Brinks, Fernando D. Stefani, Richard Hildner, Tim H. Taminiau, Niek F. van Hulst, Nature 465, 905-908 (2010).

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