Terahertz resonant dipole nanoantennas

Salvatore Tuccio[a,b], Alessandro Alabastri[a,b], Luca Razzari[a], Andrea Toma[a], Carlo Liberale[a], Remo Proietti Zaccaria[a], Francesco De Angelis[a], Gobind Das[a], and Enzo Di Fabrizio[a].

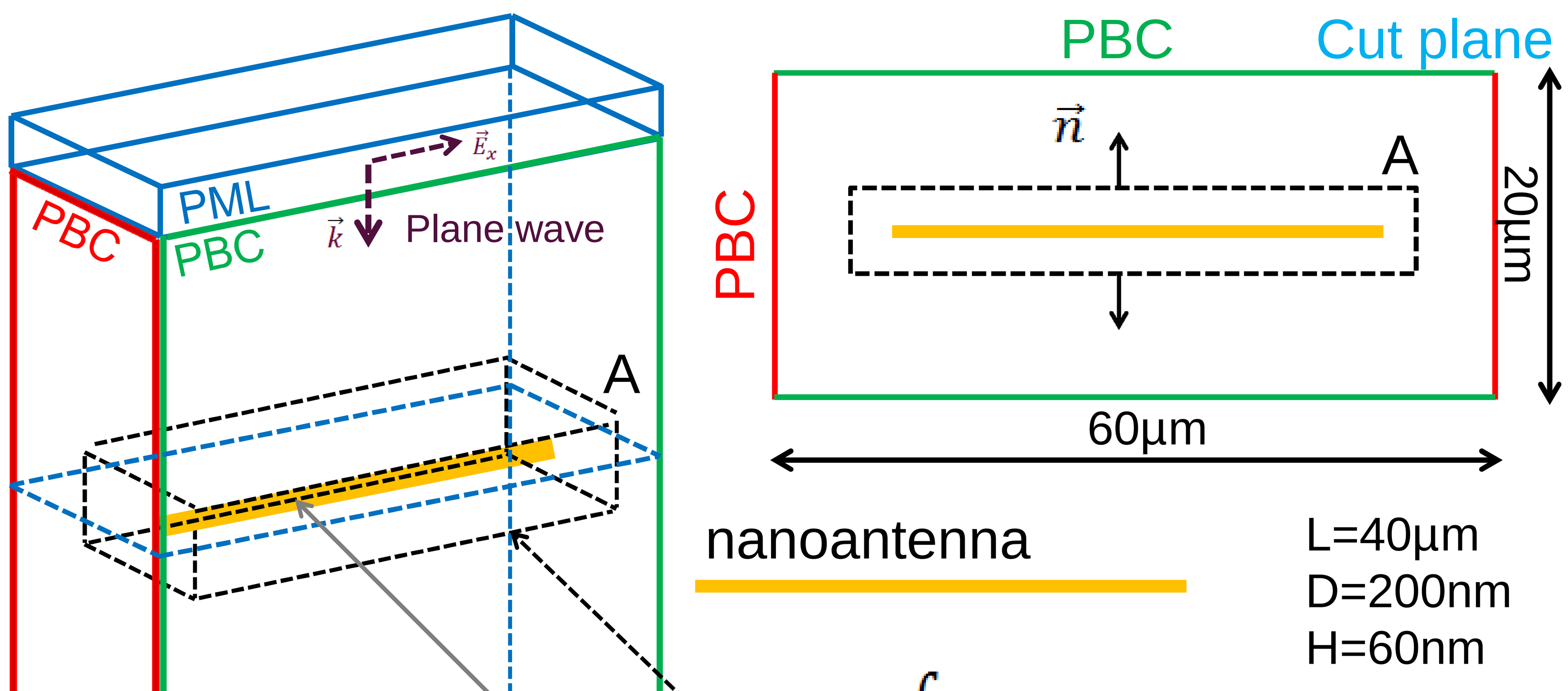
[a]Nanostructures Div., Istituto Italiano di Tecnologia, Via Morego 30, 16163 Genova, Italy

[b]Università degli Studi di Genova, 16145 Genova, Italy

ISTITUTO ITALIANO DI TECNOLOGIA

Introduction: optical nanoantennas have been employed in a wide set of applications. Here we show the possibility to expand usual functionalities in the THz domain, with a resonant gold dipole nanoantenna [1]. Huge near field enhancement indicates potential uses for spectroscopy and nonlinear optics in the terahertz.

Computational Methods: we simulated an array of planar gold nanoantennas over a silicon substrate using periodic boundary conditions. Far field properties are quantified with the resonance frequency position of absorption and scattering efficiencies.



$$P_{sca} = \int_A \left(\vec{P}_{rel} \cdot \vec{n}\right) dA$$

$$P_{abs} = \int_V Q_{rh} dV \qquad \vec{P}_{rel} = \frac{1}{2}\vec{E}_{rel} \times \vec{H}^*_{rel}$$

$$Q_{abs} = P_{abs}/\sigma_{geo} \qquad Q_{sca} = P_{sca}/\sigma_{geo}$$

σ_{geo} is the geometrical cross section of the nanoantenna

Q_{rh} are the resisitive losses in the volume V of the nanoantenna

Results:

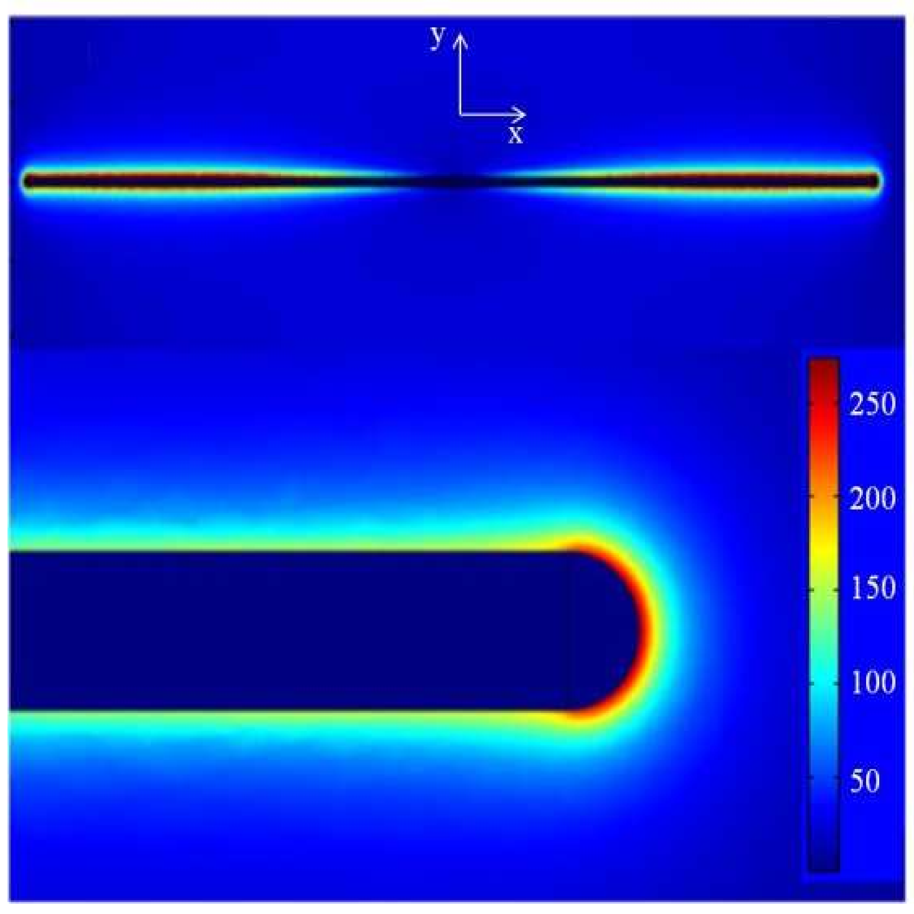


Figure 1. Contour plot of the absolute value of the electric field

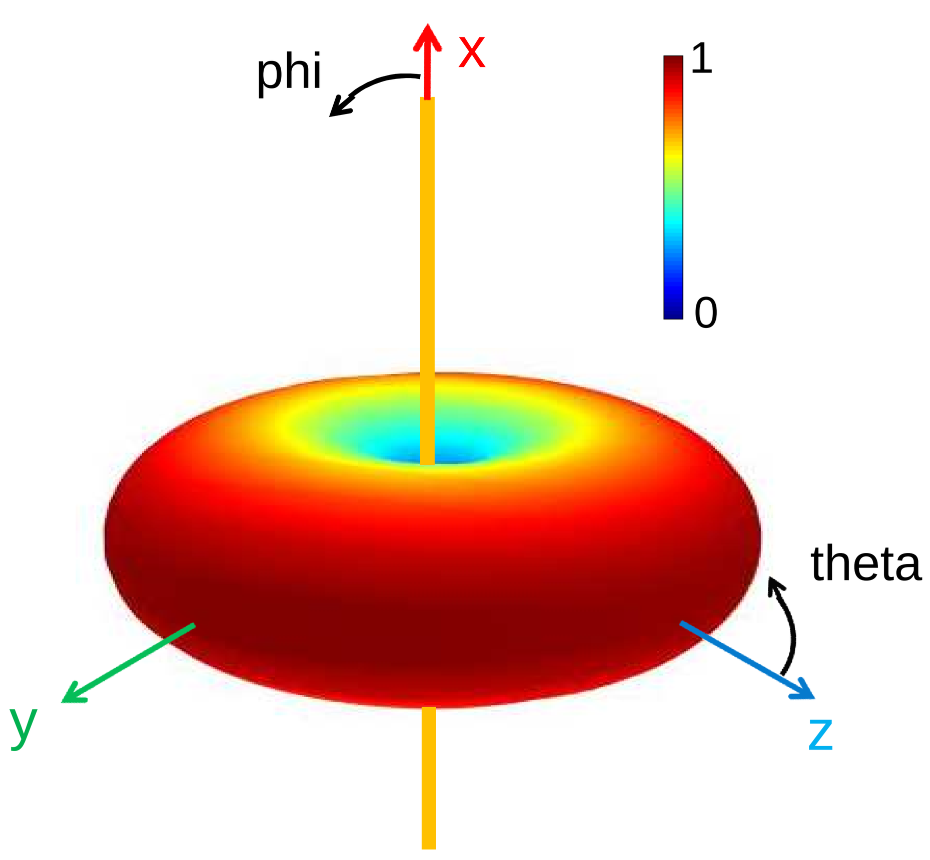


Figure 2. 3D radar cross section of the nanoantenna at 1.5 THz

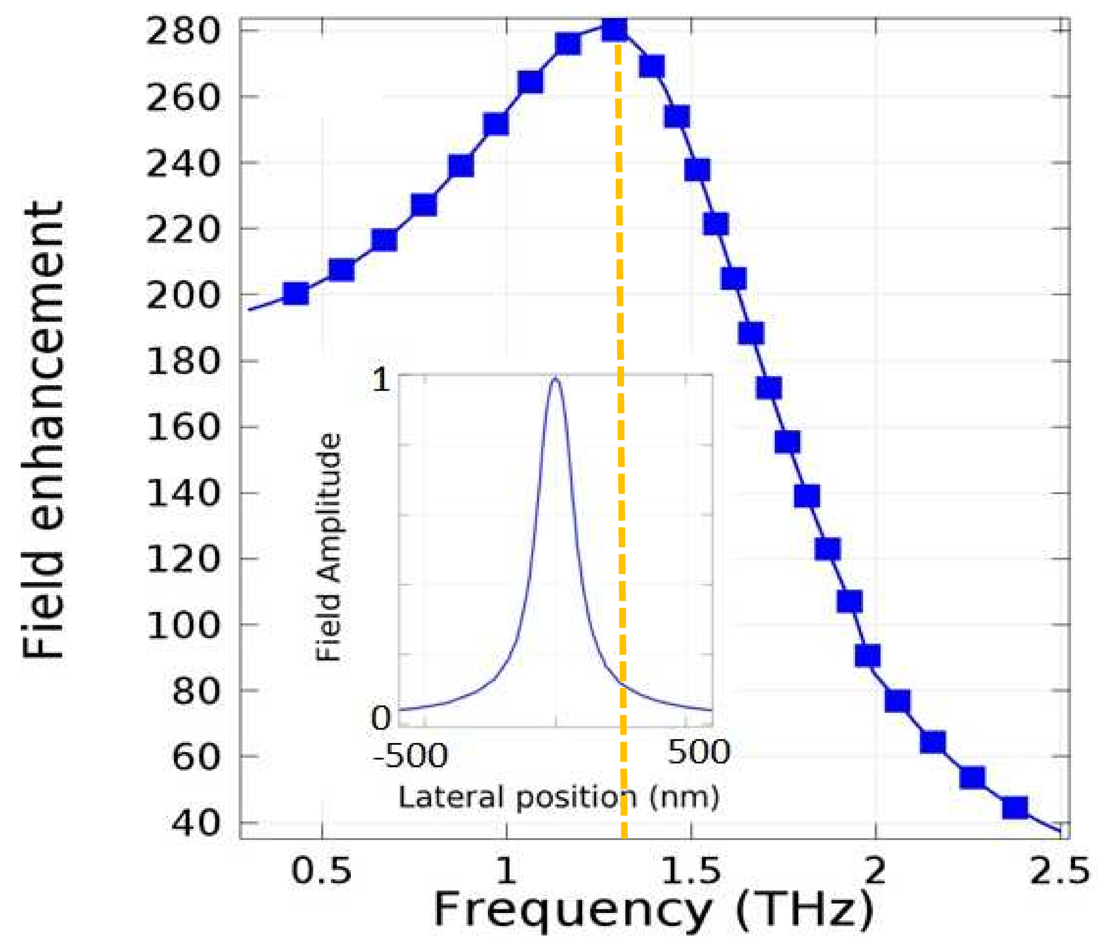


Figure 3. Field enhancement factor at the nanoantenna end as a function of frequency

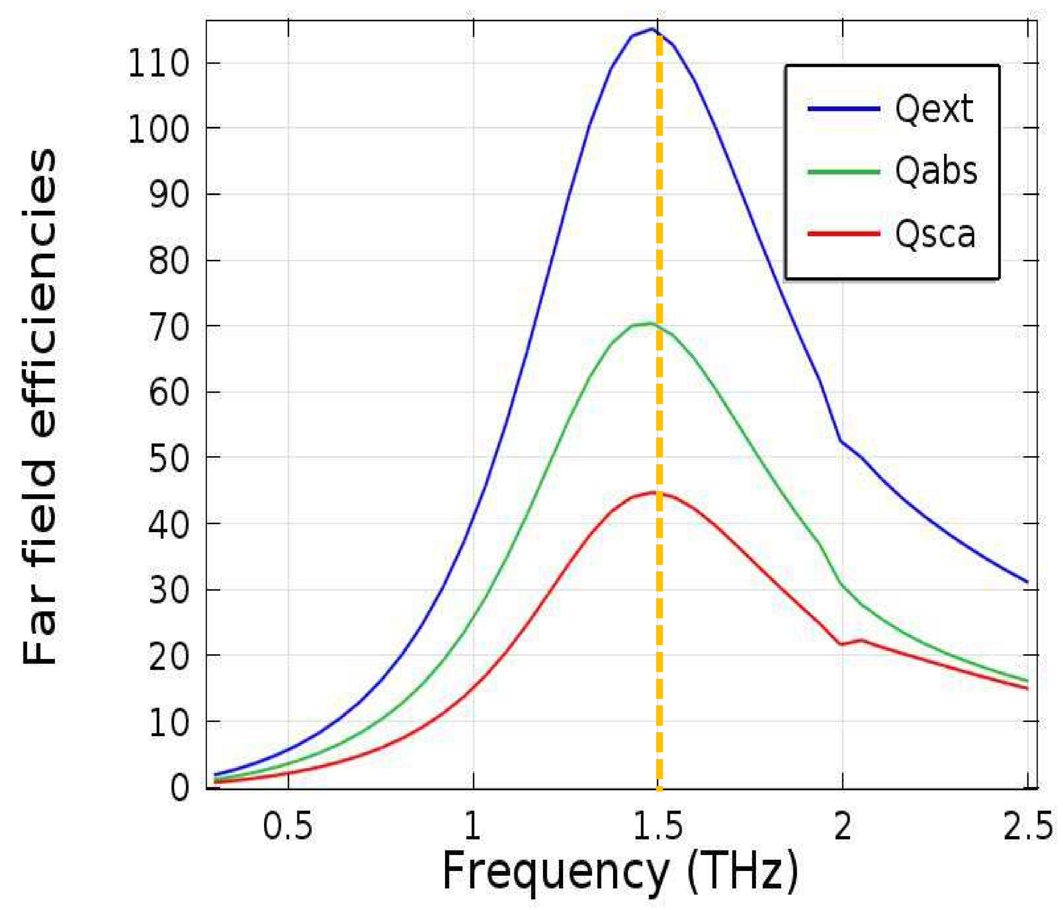


Figure 4. Spectra of the efficiency of scattering (red), absorption (green) and extinction (blue)

Captions:

Fig. 1 : absolute value of the electric field around the nanoantenna on the cut plane.

Fig. 2 : normalized three dimensional radar cross section of the nanoantenna at 1.5 THz.

Fig. 3 : field enhancement factor *F* as a function of frequency. The FWHM of the field distribution 1 nm away from the nanoantenna end is 180nm (inset).

Fig. 4 : spectra of the extinction, absorption and scattering efficiencies.

The near field peak is red-shifted respect to the far field resonance due to the plasmon damping [2].

Conclusions: the high field enhancement could be employed for the detection of few molecules with THz spectroscopy, since the effective absorption cross section of a molecule close to the nanoantenna ends would be greatly enhanced. Also nonlinear interactions at THz frequencies, can be enhanced by resonant nanoantennas.

References:

1. L. Razzari, A. Toma, M. Shalaby, M. Clerici, R. Proietti Zaccaria, C. Liberale, S. Marras, I. A. I. Al-Naib, G. Das, F. De Angelis, M. Peccianti, A. Falqui, T. Ozaki, R. Morandotti, and E. Di Fabrizio, *Opt. Express*, **19**, 26088–26094 (2011).
2. B. M. Ross and L. P. Lee, “Comparison of near- and far-field measures for plasmon resonance of metallic nanoparticles,” Opt. Lett. **34(7)**, 896–898 (2009).

COMSOL CONFERENCE EUROPE 2012

Excerpt from the Proceedings of the 2012 COMSOL Conference in Milan