Electronic Supplementary Material (ESI) for Nanoscale.

Electronic Supporting Information

3D Plasmonic Nanoantennas Integrated with MEA Biosensors

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Raman spectroscopy.

Figure S1 shows the raw data of two Raman spectra acquired on living neurons pointing the laser source either on the planar gold substrate (S1 A) or on the gold nanoantenna (S1 B). Both spectra were obtained using a source power of 2 mW and 10 s acquisition time. As already known from literature[1,2], in addition to increased counts of Raman peaks, plasmonic enhancement also increases the spectrum background counts. Nevertheless, in the case of nanoantenna, the magnification of vibrational features is stronger than the one on the substrate. This means that a background correction is possible without loss of information.

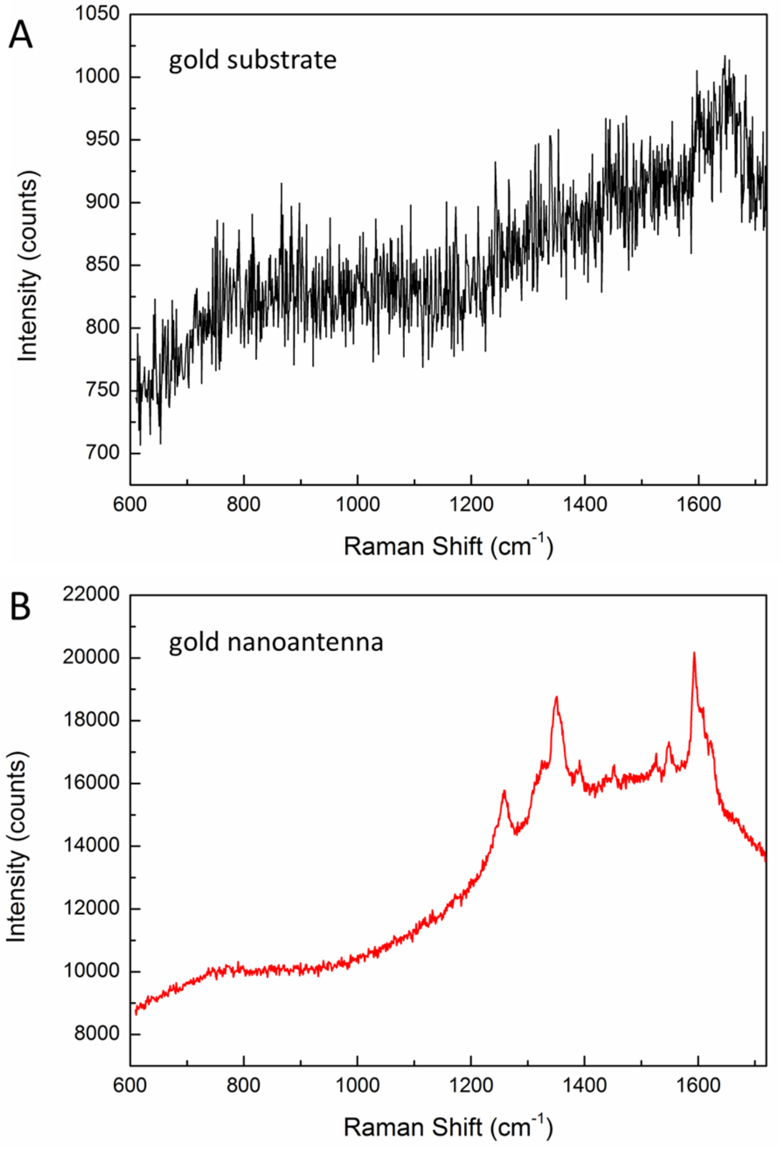

Figure S1. Raw data of Raman measurements acquired with the same conditions (source power, acquisition time) on neurons laying on the gold substrate (A) and on the gold nanoantenna (B).

FEM numerical calculations.

Electromagnetic simulations of the plasmonic nanoantenna were performed by means of the software COMSOL multiphysics, implementing the Finite Elements Method (FEM). The layout of the simulation is shown in Fig. S2.

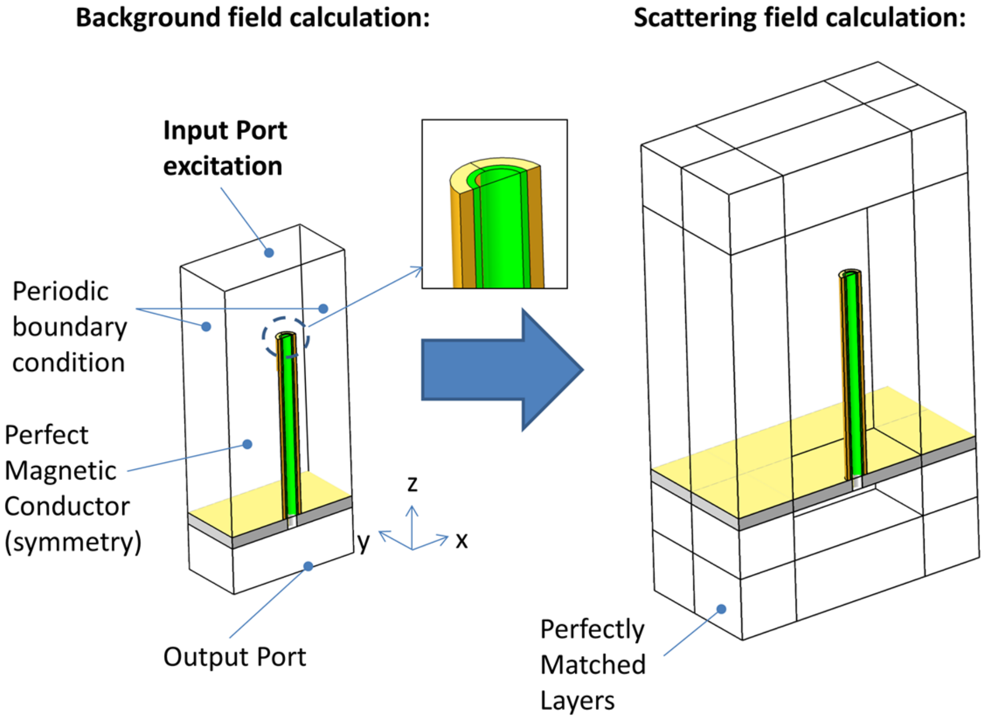

Figure S2. FEM Simulation layout of a nanoantenna.

The scattering simulation of an insulated antenna followed a two-step calculation process. First the electromagnetic field in absence of antenna is calculated by means of a full-field simulation. A port boundary excitation condition is set at the top boundary to excite a TM polarized plane wave impinging at 5° incidence angle with scattering plane parallel to the x axis (see Fig. S3). A second port is set at the bottom boundary to absorb transmitted light. Bloch-Floquet periodic boundary conditions are set at the vertical boundaries orthogonal to the x axis, while Perfect Magnetic Conductor boundary conditions are set at the vertical boundaries parallel to the y axis, in order to exploit the symmetry of the exciting field. The field in absence of the scattering element (namely the antenna) is then set as the background field to a scattering simulation including the nanoantenna. Perfectly matched layers are set all around the antenna in order to absorb the scattered field and thus simulate open boundaries.

All material properties involved are taken from literature (Gold, water and Si_3N_4 permittivities are taken from E. D. Palik[3], while that one of inner polymer is taken from the vendor datasheet). A tetrahedral mesh is used to discretize the computational domain. A maximum mesh element equal to 1/5 of the wavelength is set in dielectric materials, while a maximum of 20nm size is set for the mesh in metal domains. These parameters were verified to ensure solution convergence.

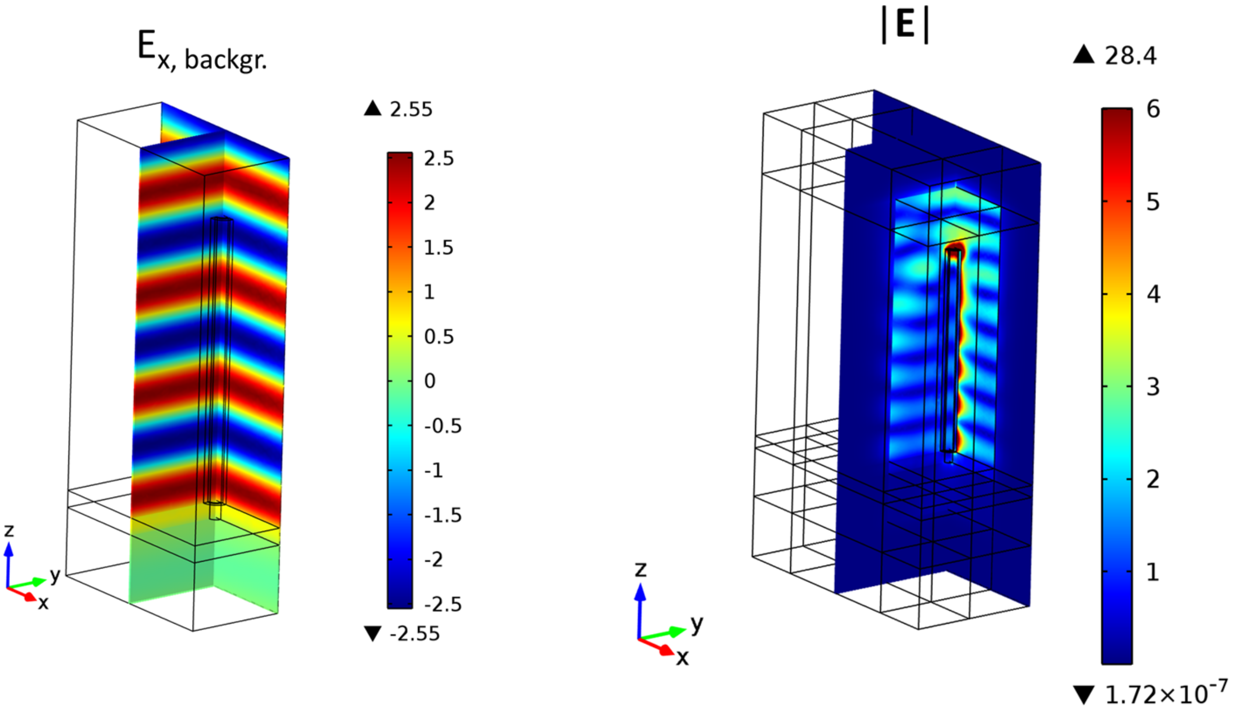

Figure S3. Electromagnetic field distribution without (left) and with (right) the nanoantenna.

References

1. B. Pettinger, K. Domke, D. Zhang, R. Schuster, and G. Ertl, *Phys. Rev. B*, 2007, **76**, 113409.

2. S. Mahajan, R. M. Cole, J. D. Speed, S. H. Pelfrey, A. E. Russell, P. N. Bartlett, S. M. Barnett, and J. J. Baumberg, *J. Phys. Chem. C*, 2010, **114**, 7242–7250.

3. E. D. Palik, Ed., *Handbook of Optical Constants of Solids*, Elsevier, 1991.