

Multimodal vibrational infrared spectroscopy from 1.1 to 6.5 μm with Aluminum Bowties

M. Najem[§], F. Carcenac[@], F. Gonzalez-Posada[§], T. Taliercio[§]

[§] IES, Univ Montpellier, CNRS, Montpellier, France

[@] LAAS, CNRS, Toulouse, France

Corresponding author: melissa.najem@umontpellier.fr

Vibrational surface-enhanced spectroscopy is a promising application in the plasmonics field, where metallic nanoantennas (NA) are tailored to provide local electromagnetic field localization and enhancement for biomedical applications. [1] To cover a wide IR active range, from 1.1 to 6.5 μm , Al NA were picked as low-cost material with promising optical quality, CMOS compatible, and excellent properties for sensing. Figure A shows a metal-insulator-metal (MIM) with respective thicknesses of 100 nm of Al, 20 nm of SiO₂, and 50 nm Al NAs.

Figure B shows the single unit cell of the NAs array formed of Al Bowties (BTs). To investigate the spectral response of these periodic Al-BTs, a numerical FDTD solver (Lumerical) was employed, where Maxwell's equations were discretized in both time and space. The Al-BT array was always polarized along y-axis to enhance the electrical field, as the gap strongly localizes the field. [2] For a wide-coverage purpose and to tune their localized surface plasmon resonance (LSPR) at different spectral positions, the side length (L) of each Al-triangle was swept from 0.3 to 2 μm with a step of 0.1 μm (Fig.C). The distance, d, between these triangles was maintained at 100 nm. For each L value, one main plasmonic resonance peak was detected which is usually referred to as a strong dipolar coupling. This first-order plasmonic resonance is always situated at the highest wavelength, then higher orders of resonance and other diffraction peaks appear representing the periodicity triggered along y-axis.

Al-BTs array were fabricated by electron-beam lithography followed by metallization and lift-off process; then were characterized under 36x IR Fourier Transform IR (FTIR) spectrometer. Figure D shows a good agreement between simulation (FDTD) and experimental (FTIR). The detected LSPR peaks appear at the exact simulated spectral position. Such a result is extremely encouraging for a lab-on-chip detection vision of functional groups and fingerprints of any bio-molecule in this propitious IR range using a single plasmonic platform.[3]

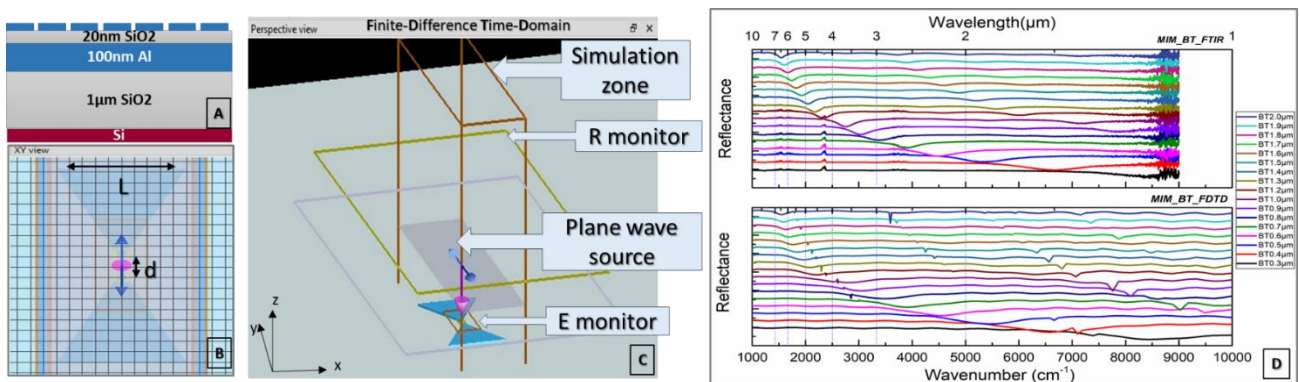


Fig. 1: A) Epitaxial layers from the substrate to the nano-structured Al-BT. B) XY top view from Lumerical simulation software. C) Perspective view of all simulation monitors wrapping up the Al-BT. D) FTIR measurement and Lumerical simulation results of all Al-BTs array sizes.

References:

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