Graphene as Enabling Material for Infrared Plasmonic Biosensors

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Abstract

We present the first infrared biosensor using graphene and show the potential of the unique opto-electronic properties of graphene for plasmon-enhanced biosensing [1]. In particular, we demonstrate a graphene biosensor with dynamic spectral tunability and with an unprecedent sensitivity in detecting simultaneously the refractive-index and vibrational fingerprints of protein molecules.
A plasmonic resonance is excited in a graphene nanoribbon array (GNRA), appearing as an extinction peak in its infrared spectrum. By applying a biasing voltage, the plasmonic resonance is dynamically tuned across the vibrational bands of proteins. The sensor spectra is monitorized upon the formation of a protein bilayer (protein A/G and IgG antibody), showing dramatic changes that evidence its high sensitivity. The first effect observed is a very strong redshift of the plasmonic resonance, corresponding to the detection of the protein refractive index. The second effect is the formation of two spectral dips at 1660 and 1550cm^{-1}, which correspond to the vibrational bands of proteins (amide I and II). These fingerprints are only detectable when the graphene plasmonic resonance overlaps amide bands enhancing the molecule vibrations. Thanks to the extreme field confinement in graphene, we detect red-shifts and vibrational fingerprints, 6 and 3 times higher than in current state-of-the-art metal-based infrared biosensors.
In conclusion, graphene brings new spectrally-dynamic and highly-confined plasmonics to mid-IR, opening exciting and unforeseen possibilities for biosensing.

References

[1] D. Rodrigo, O. Limaj, D. Janner, D. Etezadi, F.J. Garcia-de-Abajo, V. Pruneri and H. Altug, "Mid-infrared Plasmonic Biosensing with Graphene," Science, vol. **349**, Issue 6244, pp.165-168 (2015)

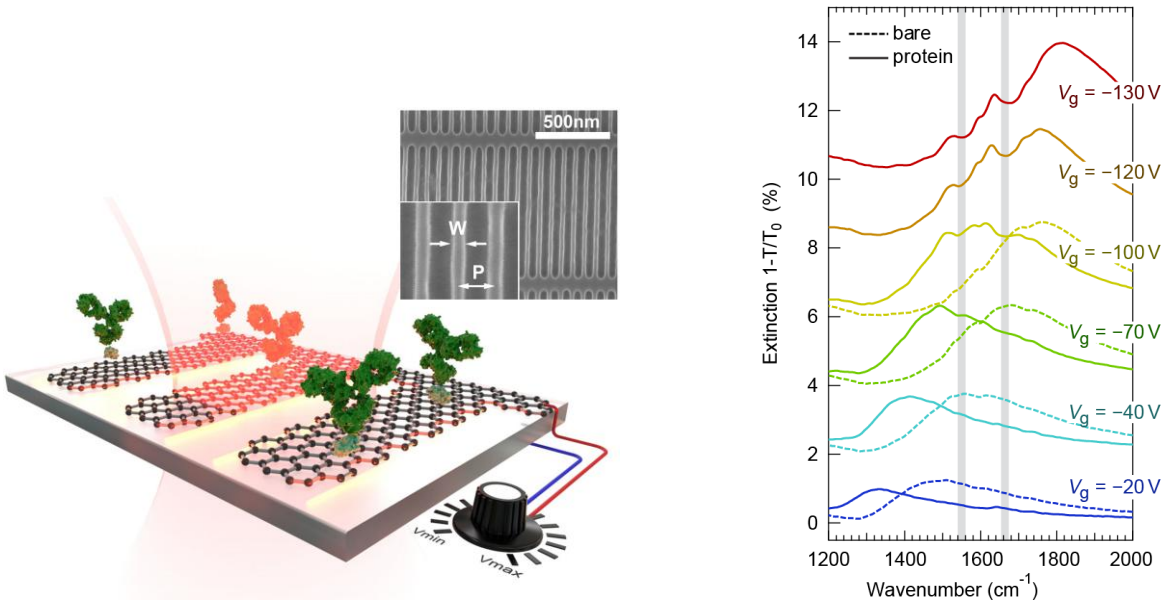

Figure 1. Conceptual representation and SEM micrograph of the graphene plasmonic biosensor. Measured extinction spectra before (dashed line) and after (solid line) protein immobilization