Synergistic plasmonic effects of nanostructured gold surfaces in combination with 2D nanomaterials for sensing applications of biomarkers

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A large variety of bioanalytic applications exploit plasmonic effects in signal transduction, enabling sensing devices for food safety and environmental monitoring. Common techniques are surface plasmon resonance spectroscopy (SPR) and Surface Enhanced Raman Spectroscopy. Despite manifold sensor applications for monitoring a wide range of analytes, detection of very low concentrations and especially of small molecules (< 400 Da) is still challenging.
Here we present a combination of nanohole arrays and graphene as a general and promising concept to overcome these limitations.
Nanohole arrays are characterized by the presence of localized and propagating surface plasmons. Such structures were fabricated by nanosphere lithography. The variation of the diameter- to-periodicity ratio of the holes allows to tailor the penetration depth of the electromagnetic field. Hence, nanostructured substrates improve the surface sensitivity and provide plasmonic hotspots [1]. Graphene, as a 2D-nanomaterial, empowers binding in close proximity to the surface and a combination of the present photonics with plasmonic properties of the nanohole array amplifies the sensitivity [2]. Additionally, graphene can be chemical modify with (bio)chemical receptors. The linkage of nanostructured substrates and 2D-nanomaterials provokes a higher sensitivity for label-free detection of low concentration of small molecules.
SPR characteristics were analyzed using the Kretschmann configuration at a fixed wavelength (Figure 1). In comparison to sensor substrates consisting of a continuous metal film the surface sensitivity is enhanced for nanohole arrays, depending on the dimensions and density of these nanostructures. Proof of concept studies demonstrated the enhanced sensitivity for the detection of small molecules like plasticizers [3] and purine-based biomarkers.

References

[1] M. Couture, K. K. Ray, H.-P. Poirier-Richard, A. Crofton, and J.-F. Masson, ACS Sensors, 3 (2016), 287-294
[2] F. Bonaccorso, Z. Sun, T. Hasan, A. C. Ferrari, Nature photonics, 9 (2010), 611-622
[3] C. Genslein, P. Hausler, E. M. Kirchner, R. Bierl, A. J. Baeumner, T. Hirsch, Beilstein Journal of Nanotechnology, 1 (2016), 1564-1573

Figures

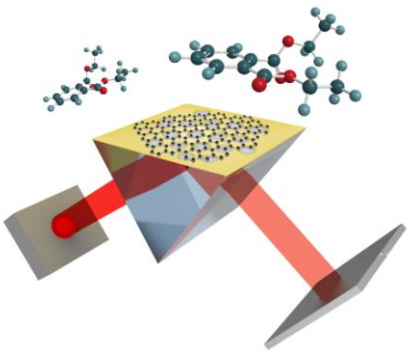

Figure 1: Scheme of the SPR setup with a plasmon-graphene hybrid as substrate used for small molecule detection.