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Nano-structured metallic thin films as platforms for ultrahigh sensitivity sensors and improved energy devices

In spite of the tremendous research being done on plasmonic nano-materials, the translation to practical applications is still in its infancy. On the other hand, the demand is increasing for highly sensitive biosensors and more efficient energy devices to improve their resolution, specificity, compactness and lowering their cost. Several nanostructured thin film configurations are proposed for this purpose which exhibit ultrahigh sensitivity of the electromagnetic field that can be harnessed to build new improved devices for sensing and energy applications.

Parameters of the nano-plasmonic structure/excitation configuration that govern the concentrated optical field include the wavelength, polarization, penetration depth, shape and size of nanofeatures and their neighborhood, the coupling method, and the material dielectric function. Using several experimental methods and rigorous electromagnetic simulations we have designed and confirmed such structures with ultrahigh optical field enhancement. These include: (i) ultrathin metallic nanoapertures on substrate, (ii) nanosculptured thin films prepared using the oblique angle deposition technique, (iii) nanoparticles on top of closed films of metal, (iv) grating and prism coupling schemes, (v) stack of metal and dielectric nanolayers, (vi) SEF, SERS and SPR detection methodologies. Thick gratings decorated with metal nanoparticles were shown recently to widen the spectral range of the enhancement covering the visible and the near infrared. Having the periodic NPs arrangement on top of thick grating was found to be very significant for both polarizations.

Several improved biosensors with high sensitivity, reliability and low cost are developed and getting closer to the market. This is expected to assist several sectors finding solutions to long standing problems such as fast medical diagnosis, fast bacteria detection and water quality monitoring. On the energy side it should help improve the efficiency of optoelectronic devices such as photovoltaics, photocatalytics and infrared detectors, particularly the widening of the spectrum using gratings coupling.

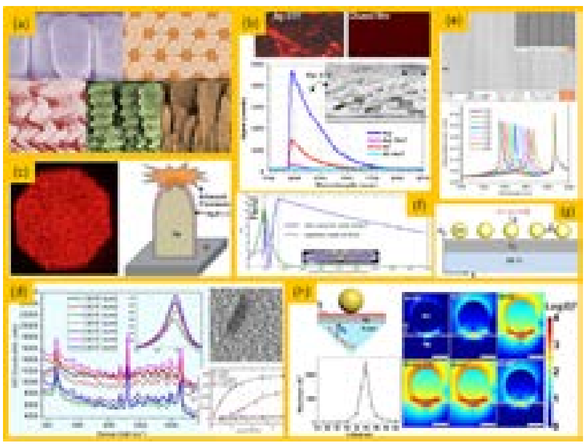

Figure 1: Selection of plasmonic nanostructures and schemes used for improved sensing and energy devices

Recent Publications

1. Abdulhalim I (2014) Plasmonic Sensing using Metallic Nano-Sculptured Thin Films. Small 10, 3499-3514.
2. Li A, Isaacs S, Abdulhalim I, Li S (2015) Ultrahigh enhancement of electromagnetic Fields by exciting localized with extended surface plasmons. J. Phys. Chem. C 119, 19382-9.
3. Li A, Srivastava S.K, Abdulhalim I, Li S (2016) Engineering the Hot Spots in Squared Arrays of Gold Nanoparticles on a Silver Film. Nanoscale 8, 15658-664.
4. Srivastava S.K, Grüner C, Hirsch D, Rauschenbach B, Abdulhalim I (2017), Enhanced intrinsic fluorescence from carboxidized nano-sculptured thin films of silver and their application for label free dual detection of glycated hemoglobin. Opt. Express 25, 4761-72.
5. Abutoama M, Li S, Abdulhalim I (2017), Widening the spectral range of ultrahigh field enhancement by efficient coupling of localized to extended plasmons and cavity resonances in grating geometry, J. Phys. Chem. C 121, 27612-23.

Biography

Professor Ibrahim Abdulhalim is with the Electro-optical Engineering Unit at Ben Gurion University. He worked in academic institutions and companies such as the OCSC in UC at Boulder, the ORC at Southampton University, the Thin Films Center of the University of Western Scotland, in KLA-Tencor, Nova and GWS Photonics. Published over 200 articles, 2 books, 10 chapters and inventor on 20 patents. He is a fellow of IoP and SPIE and an associate editor for the Journal of NanoPhotonics and for the Journal of Imaging.

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