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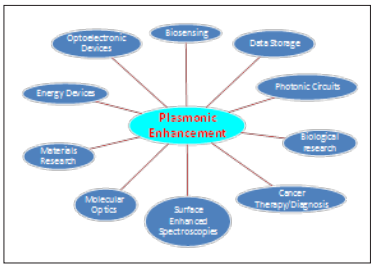
Plasmonic sensors: Miniaturization, self-referencing, tunable penetration and ultrahigh field enhancement



Plasmonic and photonic biosensors are becoming increasingly close to practical use due to the large amount of research and development work being done towards improving their sensitivity, compactness and reliability. During the last few years, variety of innovative plasmonic and photonic structures and reading methodologies were developed in our group, based on which a miniature surface plasmon resonance system for bio and chemical sensing is built. This involve: (i) a self-referenced sensor based on enhanced optical transmission through metal nanoapertures, (ii) a self-referenced ultra-large penetration depth SPR sensor tunable so that small and large bioentities can be detected, (iii) a TIR sensor in which the angular edge is converted into a dip with high figure of merit, (iv) a self-referenced SPR sensor based on thin dielectric grating on top of thin metal film, (v) enhanced sensitivity by combining the metal film with high index dielectric layers, (vi) simplified polarimetric approach that relaxes the tolerances on the metal layer thickness and (vi) ultrahigh field enhancement configurations by coupling extended surface waves to localized ones. The self-referencing provides a more stable measurement compensated for thermal drifts. High penetration helps in detecting large bioentities such as bacteria and cells. Figure of merit is defined as the ratio between the sensitivity to the width of the resonance dip; hence its enhancement also improves the detection limit. Combining all these properties in one system together with a compact reading methodology with unique image processing allows refractive index sensing limits down to 10-5 and with some effort to 10-7. Being miniature this system can be integrated easily with other devices to perform multifunctional tasks and improve reliability. Thanks to the large electromagnetic field enhancement near plasmonic surfaces, the SPR signal measurement can be combined with surface enhanced spectroscopies such as fluorescence and Raman scattering.

Recent Publications

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2. 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.
3. Isaacs S, Abdulhalim I (2015) Long range surface plasmon resonance with ultrahigh penetration depth for self-referenced sensing and ultralow detection limit using diverging beam approach. Appl.Phys.Lett. 106, 193701-4.
4. Srivastava S.K, Ben Hamo I, Kushmaro A, Marks R.S, Gruner C, Rauschenbach B, Abdulhalim I (2015) Highly sensitive detection of E-Coli by a SERS nanobiosensor chip utilizing metallic nanosculptured thin films. Analyst, 140, 3201-3209.
5. Abdulhalim I (2014) Plasmonic Sensing using Metallic Nano-Sculptured Thin Films. Small 10, 3499-3514.
6. Shalabney A, Abdulhalim I (2011) Sensitivity enhancement methods for surface plasmon sensors. Lasers and Photonics Reviews, 5, 571-606.

Biography

Ibrahim Abdulhalim is with the Electro-optics and Photonics 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. His current research activities involve plasmonic and photonic biosensors, liquid crystal devices for imaging, biomedical imaging, optical metrology and energy devices. 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. In 2014 he established Photonicsys Ltd., a company specialized in developing miniature plasmonic and photonic biosensor.

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