Abstract Summaries

SPIE Photonics West

Conferences: 24-29 January 2009

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Contents

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also be developed in a reliable and repeatable manner. Further challenge lies in the development of these substrates on a wafer scale and still capturing the functionalities of large SERS enhancement factors and reproducibility of the SERS substrates. Based on finite difference time domain (FDTD) calculations, we fabricated highly efficient plasmonics-active one-dimensional (1D) and two-dimensional (2D) nanowire structures, on entire 4-inch wafers, for achieving a substantial electromagnetic enhancement of the SERS signals. Moreover, we were able to fabricate sub-5 nm nano-scale gaps in these SERS substrates over the wafer by a process that is not time consuming and that is compatible with large-scale development of these SERS substrates on a wafer-scale and the existing silicon technology.

To carry out SERS sensor measurements of the gold nanowire-based SERS substrates, samples with the fabricated nanostructures were coated with SERS active dye molecules such as p-mercaptobenzoic acid (pMBA) and cresyl fast violet (CFV), as well as a mixture of these molecules. The effect of decreasing the nano-scale spacing between adjacent gold-coated nanowires on the SERS signals, from the different molecules present on the substrates, was evaluated. The SERS substrates were also employed to detect small quantities of chemical and biological agents.

7192-32, Poster Session

Optical neural signal detection using surface plasmon resonance (SPR) sensing system

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In this study, a surface-sensitive optical detection method utilizing surface plasmon resonance (SPR) is proposed to provide a label- and artifact-free optical method for recording neural signals. Since a resonance condition in SPR characteristics is sensitive to variations of the medium surrounding a metal surface, a small change in refractive index caused by neural activities can be quantitatively analyzed by calculating a resonance shift in SPR curves. We developed a low noise SPR neural recording system and its sensitivity was evaluated by measuring the dependence of SPR characteristics on various ethanol concentrations. From these results, a minimum value of measurable refractive index variation was determined to be small enough to measure the neural activity. For a current stimulation over a threshold, evoked neural responses obtained from rat sciatic nerve were successfully measured without any artifact noises. Moreover, the optical responses were highly correlated with the simultaneously recorded electrical responses. Verification studies using varied stimulation amplitudes and a lidocaine solution showed that the signals measured with our SPR sensing system were neural in origin. In this study, we intend to provide a basis for application of an SPR structure to optical detection of neural activity and furthermore to prove its feasibility by introducing the relevant experimental results.

7192-33, Poster Session

Sensitivity enhancement by phase sensitive surface plasmon resonance biosensors using periodic nanowire structures

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Surface plasmon resonance (SPR) is widely used as a biosensing technique because it provides a way to measure biomolecular interactions on a quantitative basis in real time without using labels. Numerous attempts have been made to improve SPR sensing characteristics such as sensitivity. One such approach is to measure phase variation that involves SPR in the process of a biomolecular interaction of interest. On the other hand, nanostructure-mediated excitation of SPR has been known to improve sensitivity of an SPR biosensor due to much enhanced localized field effects induced by the hot spots created in the nanostructure. In this paper, as an evolutionary approach to SPR sensitivity enhancement, we address the use of nanostructures into phase sensitive SPR scheme.

In particular, we calculated the plasmon characteristics of nanowire-based phase sensitive detection using rigorous coupled wave analysis and compared the data with a conventional thin metal film based sensor system. The calculation was performed with DNA hybridization and water-glycerin mixture as target materials. The results indicate that the nanowire-based phase detection allows an order-of-magnitude increase of sensitivity for detecting DNA hybridization compared to a conventional scheme at the expense of somewhat reduced dynamic range. The enhancement was also observed numerically for water-glycerin mixture at about five times. The performance generally deteriorated if an additional attachment layer was considered.

Periodic nanowire samples were fabricated using electron-beam lithography at 300 nm period corrugated on a thin gold film. Their biosensing performance was tested using a differential phase interferometer. Further experiments on the development of two-dimensional biosensor arrays using a phase imaging setup were also conducted.

7192-34, Poster Session

Performance analysis of extinction-based localized surface plasmon resonance biosensors in the presence of surface roughness

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In this study, the impact of surface roughness on the sensor performance of extinction-based localized surface plasmon resonance (LSPR) biosensors was investigated. The LSPR sensor measures resonance wavelength shifts in extinction spectra due to biochemical interactions that are amplified by periodic metallic nanostructures. The numerical computation was conducted using rigorous coupled-wave analysis with Gaussian random surface profiles. The results suggest that, when a surface is of roughness smaller than 2 nm in height deviation, the sensitivity of an LSPR biosensor is not significantly influenced regardless of correlation length (CL). However, we have found that extinction peak amplitude and curve width are affected substantially with a decrease in CL. Especially, at CL smaller than 100 nm, surface roughness may induce interference between localized surface plasmons excited by the surface and nanowires, which can lead to major degradation of sensor performance. This study suggests that surface roughness must be taken into consideration when designing and fabricating an extinction-based LSPR biosensor for desired sensor performance.

7192-35, Poster Session

A new parallel scan spectral SPR 2D sensing system

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2D surface plasmon resonance (SPR) is a promising sensing technique for biochips without labeling. In this letter, we describe a new parallel scan spectral SPR 2D sensing system. We demonstrate experimentally, with a line-shape light illumination, that an image acquired with area CCD detector provides both SPR wavelength information and one-dimensional spatial distribution. Thus, two-dimensional distribution of refractive index of the entire sensing plane can be obtained with one-dimensional optical line parallel scan. The technique offers advantages of both high sensitivity and high throughput. A low-density DNA biochip is used for testing and the result implies that the system could have potential applications in biochips analysis.