Vertical Wall Affinity Sensor with Polarization Diversity

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Abstract: We propose a highly sensitive biosensor consisting of a vertical metal plane separated from a vertical silicon layer by a narrow gap. The sensor provides high sensitivity and polarization diversity.

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Hybrid waveguide consisting of a metal plane separated from a high index medium by a low index spacer has attracted a lot of interest [1-3]. Since significant fraction of power for this guide is confined in the low index medium, it can be used to implement highly sensitive biosensors. Here we examine the applicability of the hybrid waveguide shown in Fig. 1(a) for biosensing. The structure consists of a silicon film of width \(w\) and height \(h\) separated from a gold film by distance \(D\). The structure is supported by a silica substrate and surrounded by a fluid which may contain the molecules of interest. Figures 1(b) and 1(c) show the guided power density profiles for the two modes supported by this guide. As the electric field arrows show, the modes are not purely TM and TE in nature. One of them is TM like [Fig. 1(b)] and the other one is TE like [Fig. 1(c)]. We call these modes mode A and mode B in this work.

![Figure 1](image1.png)

Fig. 1. (a) Cross section of hybrid plasmon guide. (b) and (c) Power density profiles of the modes supported by the guide for dimensions \(h=340\) nm, \(D=100\) nm, \(w=125\) nm. Wavelength of operation is \(1.55\) \(\mu\)m.

Figures 2(a) and 2(b) show the variations of surface sensitivity (\(\partial n_{eff}/\partial a\)) with silicon film width (\(w\)) and separation between gold and silicon (\(D\)) for the two modes at \(1.55\) \(\mu\)m wavelength. Here \(n_{eff}\) is the effective mode index, and \(a\) is the thickness of the adlayer that attaches itself to the gold surface during biosensing.

![Figure 2](image2.png)

Fig. 2. Variations of surface sensitivity with channel thickness for (a) Mode A (b) Mode B. Gold and silicon film height (\(h\)) is 340 nm.

For \(w=125\) nm, \(D=100\) nm, \(h=340\) nm, the surface sensitivity for mode A and B are \(8.4\times10^{-4}\) (nm\(^{-1}\)) and \(1.6\times10^{-4}\) (nm\(^{-1}\)). The sensitivity is similar to that of single interface surface plasmon [\(2.4\times10^{-3}\) (nm\(^{-1}\))]. Unlike surface plasmon guides the hybrid guide can guide light for both polarizations. This property is important for proper functioning of affinity sensors because it allows the separation of changes in bulk index and adlayer thickness [4].

References