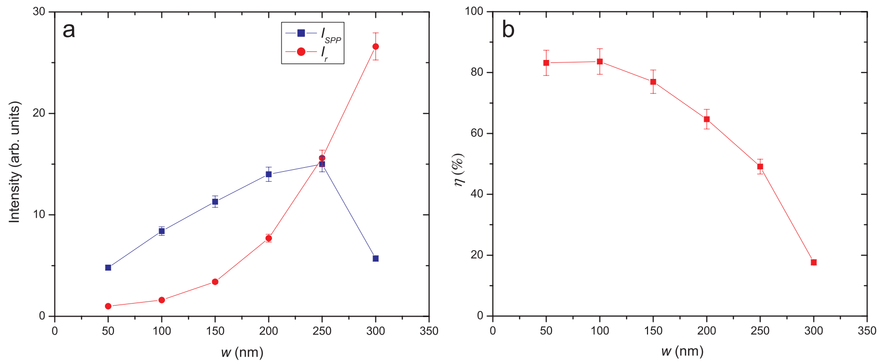

Fig. 9. a) The time-averaged SPP intensity, I_{SPP} (blue squares), and time-averaged radiated intensity, I_r (red circles), and (b) the corresponding SPP coupling efficiency, η, as a function of w. The error bars describe the uncertainties in the measurement of I_{SPP} and I_r due to, respectively, the finite amount of I_r captured by D_1 and D_2 and the finite amount of I_{SPP} captured by D_3.

decreases at $w = 300$ nm. The corresponding SPP coupling efficiency monotonically decreases from $\simeq 0.83$ to $\simeq 0.18$ as the slit width increases from 50 nm to 300 nm.

To investigate the wavelength-sensitivity of the coupling structure, the electromagnetic response of a coupling structure with slit width $w = 200$ nm and dielectric layer thickness $d = 100$ nm is studied over free-space wavelengths ranging from 400 nm to 700 nm, in increments of 100 nm. SPP- coupling efficiencies of 0.66, 0.67, 0.66, and 0.65 are observed at wavelengths of 400 nm, 500 nm, 600 nm, and 700 nm, respectively. The coupling efficiency is largely insensitive to wavelength because the condition $k_{SPP} \simeq k_i$ is achieved via near-field perturbation of the SPP mode using a $d << \lambda_0$ layer. That is, the dielectric layer shifts the k_{SPP} wavevector commensurately throughout the visible frequency range.

6. Summary

In conclusion, we have proposed a method for enhancing the efficiency of slit-coupling from a free-space plane-wave mode into a SPP mode on a metal film. The key element of the coupling scheme involves an ultra-thin dielectric layer placed on the exit side of the metal film. Varying the thickness of the dielectric layer enables tuning of the SPP wavevector. When the SPP wavevector is matched with the wavevector magnitude of the modes exiting the slit, coupling efficiencies $\simeq 0.80$ can be achieved, $\simeq 4$-times enhancement relative to the case without the dielectric layer. In addition to enhancing SPP coupling efficiency, the dielectric layer has the added benefit of passivation and protection of the SPP-sustaining metal surface. The results will find utility in the growing field of plasmonics and help pave the way towards real-world implementation of SPP devices.

Acknowledgements

The authors thank H. Lezec for helpful discussions. This work was supported by the Natural Sciences and Engineering Research Council of Canada.

#130935 - $15.00 USD Received 30 Jun 2010; revised 3 Aug 2010; accepted 3 Aug 2010; published 9 Aug 2010