Integrated Optics refractometry: Sensitivity in relation to spectral shifts

H.J.W.M. Hoekstra*, *MESA+ Institute for Nanotechnology, University of Twente, Enschede, NL*
**h.j.w.m.hoekstra@ewi.utwente.nl*

A new variant of the Vernier-effect based sensor reported in ref. 1 is introduced. Both sensor types may show a huge index induced spectral shift. It will be shown in a poster presentation that with such sensors, as well as with surface plasmon based sensors, the constraints on the spectral resolution of the read out are strongly relaxed, but the sensitivity is not increased (unlike what is often reported in the literature).

Considered sensing devices

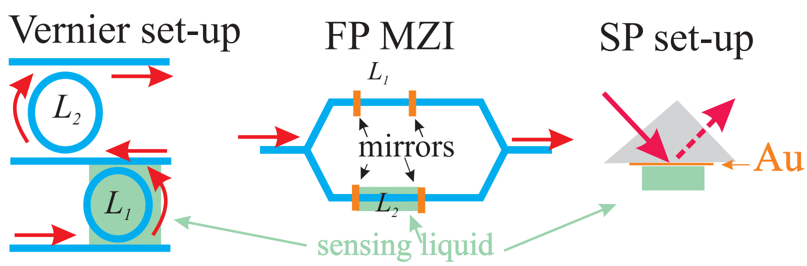

Figure 1. Schematics of the considered devices with potentially huge index-induced spectral shift enhancement.

The considered three sensing devices are depicted in fig. 1. Here we will discuss in some detail only the one based on the Vernier effect [1]. The lengths of the two cascaded ring resonators differ only slightly ($L_1 / L_2 = \eta / (\eta + 1)$; η integer) so that the transmission combs of the resonators have a slightly different free spectral range (FSR, $\Delta\lambda$) and their transmission peaks coincide periodically according to a FSR of $\Delta\lambda_V = \eta\Delta\lambda$ (see fig 2a), corresponding to the spectral spacing of the transmittance maxima of the cascaded cavities (see fig. 2b). For a relatively small spectral shift of the transmission comb of one of the cavities, $\delta\lambda$, the broadened total transmittance shows an enhanced shift of $\delta\lambda_V \approx \eta\delta\lambda$.

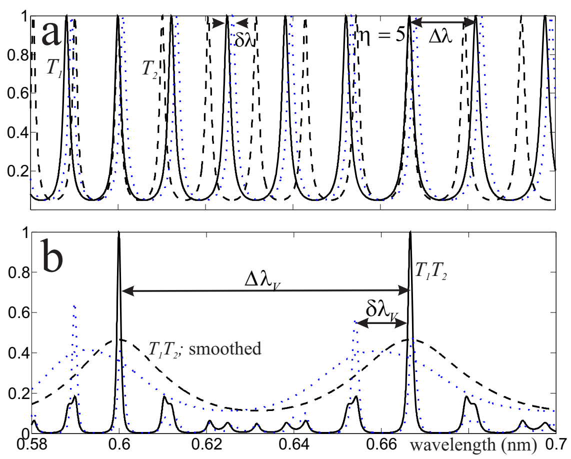

Figure 2. Graphs illustrating the Vernier effect based sensor, with (a) transmittances of the two separate cavities, T_1 (solid) and T_2 (dashed) and T_1 after a spectral shift $\delta\lambda$ (dotted, blue), and with (b) corresponding total transmittance T of the set-up (solid), T spectrally broadened (dashed) and both after the spectral shift (dotted, blue)

About sensitivity and spectral shift

The sensitivity of a device, *S*, can be defined by the maximum value of $|\partial \ln T / \partial n|$ and can be rewritten according to

$$S = |\partial \ln T / \partial n|_\lambda = |\partial \ln T / \partial\lambda|_n |\partial\lambda / \partial n|_T .$$

It is seen from the equation that the sensitivity of the Vernier set-up, with say only T_1 sensitive to index changes, is equal to that of the separate cavity with transmittance T_1. The huge spectral shift of the former is exactly neutralized by the smaller slope, i.e., generally $|\partial T / \partial\lambda| \ll |\partial T_1 / \partial\lambda|$. The key point for the sensitivity seems to be only the magnitude of the interaction between light and sensed matter; a point further elaborated during the poster presentation.

References

[1] T. Claes et al., *Experimental characterization of a Si photonic biosensor consisting of two cascaded ring resonators based on the Vernier effect etc.*, Opt. Expr. 18, 2010.