Metal oxide layer influence on the sensitivity of SPR fiber optic sensor
Dalibor Ciprian and Petr Hlubina
Department of Physics, Technical University Ostrava, 17, listopadu 15, Ostrava 70833, Czech Republic
dalibor.ciprian@vsb.cz, petr.hlubina@vsb.cz

Motivation

- To enhance the sensitivity of SPR fiber-optic sensor based on silver film
- To solve potential problems related to chemical stability of Ag film using protective overlayer (formed by Ag layer oxidation)
- To simulate the response of the sensor with respect to potential application case (ethanol content investigation in ethanol-water mixture)

Theoretical model of the sensor

- Sensing structure is based on step-index, multimode optical fiber (easy coupling and decoupling of the light beam)
- The interogation in the wavelength domain is considered
- The real cylindrical geometry is approximated in frame of planar optics by four-layer thin film structure

- Performance parameters are computed using the normalized power transfer spectrum for the case of excitation by collimated centrosymmetric beam focused at the fiber core center (no skew rays):

\[ P_{in}(\lambda) = \frac{\pi/2}{\lambda A_m^2} \left[ R_{m}(\lambda, \theta)^{2N+1} + (R_{m}(\lambda, \theta)^{2N} \cos \frac{n_{2m}(\lambda) \sin \theta \cos \theta}{1 - n_{1m}(\lambda) \cos^2 \theta} \right] \]

- Sensitivity of the sensor with respect to ethanol mass concentration is defined as:

\[ S = \frac{\delta \theta}{\delta c_{\text{Eth}}} \]

Computed results and discussion

Numerical simulations were performed for step-index, silica core, multimode optical fiber characterized by \( N.A. = 0.22, D = 200 \mu m\), and the sensing part length \( L = 1 \text{ cm} \).

Dip position was computed as a function of ethanol mass concentration:

\[ \lambda_{D} = \frac{\delta \lambda}{\delta c_{\text{Eth}}} \]

Detection accuracy

- Figure of merit is defined as the ratio between the sensitivity and dip width:

\[ FOM = S / \delta \lambda_{D} \]

- At first FOM increases with the outerlayer thickness up to \( x \approx 0.2 \) (see left arrow), then it goes down (right arrow)

- FOM behavior goes on the account of detection accuracy \( DA_{10} \)

FOM increases with the outerlayer thickness up to \( x \approx 0.2 \) (see left arrow), then it goes down (right arrow)

References