Frequency analysis of magneto-optical SPR signals

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Materials with combined magneto-plasmonic elements allow for a highly improved sensitivity of the SPR measurements when applying an oscillating magnetic field across the sensor’s magneto-optical surface.
The aim of this work is to investigate the sensitivity of a magneto optical surface plasmon resonance (MOSPR) sensor chip, to refractive index variations of the medium above its surface in a microfluidic set-up.
The system comprises an SPR measuring unit, custom made MOSPR chip, flow chamber and magnetic field generator.
The SPR measuring unit provides via an array of photodetectors the reflectivity of the incident light for a series of incident angles in total internal reflection conditions providing an SPR curve (reflectivity vs. incidence angle).
The custom made MOSPR sensor chip has alternating gold and cobalt layers and is prepared by thermal evaporation in a PVD system. The metallic structure Ti/Au/Co/Au [1], with no intermediate adhesion layer between Co and Au proved stable under flow conditions. Titanium and Gold were evaporated from tungsten boats while Cobalt was evaporated from an Al_2O_3 crucible.
A 100 µm deep flow chamber ensures the flow of the liquids above the surface of the sensor chip and is connected to a flow injection system with automatic valves.
The oscillating magnetic field is applied via a custom made electromagnet, perpendicular to the plane of the propagation of the incident light within the SPR measuring unit.
In contrast to the “classical” approach where the refractive index of the media above the surface of the sensor is related to the angle corresponding to the minimum value of the SPR curve, for MOSPR determinations, the angle pertaining for the largest reflectivity variation within the SPR curve is selected via the corresponding photodetector in the detection array.
The data from this photodetector is collected at a high rate and analyzed using the Fast Fourier Transform. Since the frequency of the oscillating magnetic field is known, from the amplitude of the oscillation of the light intensity for the chosen angle of incidence one can straightforwardly derive the reflectivity for each direction of magnetization $R_{pp}(M)$ and $R_{pp}(-M)$, respectively.
The data is processed using the formula $\frac{\Delta R_{pp}}{R_{pp}} = \frac{|R_{pp}(M) - R_{pp}(-M)|}{R_{pp}(0)}$ [2], where $R_{pp}(0)$ represents the reflectivity without magnetization.
For comparing the sensitivity of both “classical” SPR and MOSPR methods as function of the refractive indices of the media presented at the surface of the sensor, the values are normalized using the formula: $V\% = \frac{|V_i - V_1|}{V_1} \times 100$, where V_i is the current value and V_1 is the value corresponding to the

measurement of the solution with the lowest refractive index. The results are presented in figure 1 and demonstrate a steeper slope and, correspondingly, ~4 times higher sensitivity of the MOSPR data in comparison to the classical SPR sensor chip and data processing. Adding a functionalization layer of self assembled thiols has no effect on the increased sensitivity of the MOSPR chip paving the way for biosensing applications.

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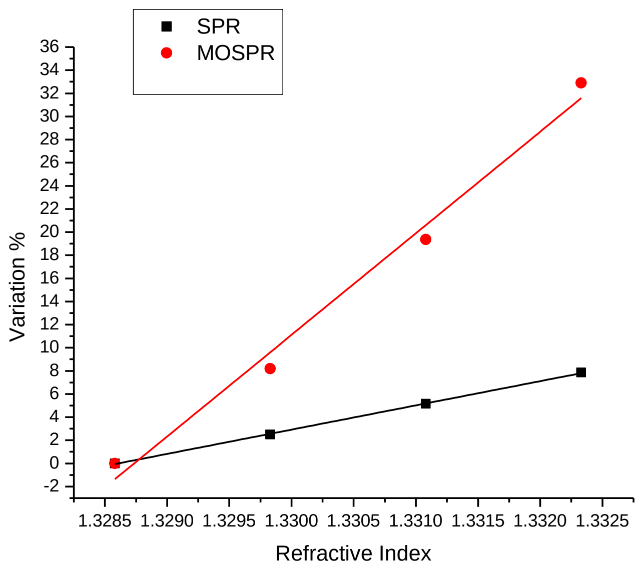

Fig. 1 Calibration curves for SPR (Black) and MOSPR (Red) showing improved sensitivity of the latter

References

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