Focused surface plasmon sensing of anisotropic sample towards cell characterization

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1. Introduction

Focused surface plasmon (FSP) sensing [1] has been widely used to characterize various samples pertaining to the high spatial resolution and single shot measurement of local refractive index. The theoretical analysis of surface plasmon with the consideration of the anisotropy in the sample is sparse in literature and is the motivation for the present work. In this study, we calculate the spatial frequency distribution of the reflected light as a response of FSP against the anisotropic sample by assuming that the fast axis of the anisotropic sample lies on the substrate surface which replicates cellular conditions. The influence of a thin layer of silica coated on the metal film is evaluated as the morphological property of the biological sample cultured on the substrate can be affected by the chemical effect (hydrophobic property) of the metal surface.

2. Theory

The four layered structure was considered as shown in Fig. 1.

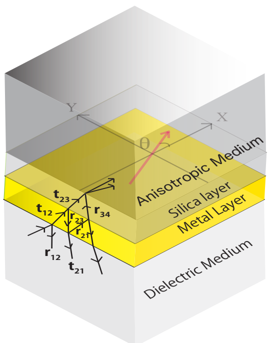

Fig 1: Four layered structure

The overall reflectance from the four layered structure as shown in Fig 1 can be written as

$$r_{1234} = r_{12} + t_{21}r_{23}t_{12}e^{i\phi_1} + t_{21}t_{32}r_{34}t_{23}t_{12}e^{i(\phi_1+\phi_2)} + t_{21}t_{32}r_{34}t_{23}r_{21}r_{23}t_{12}e^{i(2\phi_1+\phi_2)} + \cdots$$

where r_{ij} and t_{ij} are the matrices representing the reflection and transmission from the i^{th} to the j^{th} medium when illuminated with plane polarized light, ϕ_i is the phase change in the i^{th} medium. The reflection matrix from the anisotropic layer to the silica layer is given by $r_{34} = \begin{pmatrix} r_{34}^{pp} & r_{34}^{ps} \\ r_{34}^{sp} & r_{34}^{ss} \end{pmatrix}$

and the components, which describe the reflectance depending on the polarization of the incident and reflection light are calculated using the 4×4 matrix method [2].

With FSP the change in the position of the reflection minima can be observed along the direction pertaining to θ equal to 0° and 90° as the thickness of the silica layer is varied as shown in Fig. 2. The effect of the birefringent layer can be seen at the exit pupil of the objective in the form of the dark elliptical absorption patterns. With the addition of the silica layer the change in the shape of the absorption pattern can be observed as shown in Fig. 3.

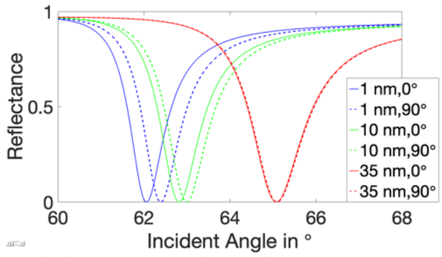

Fig. 2: Observation of shift in the reflection minima along θ=0° (solid line) and θ=90° (dashed line) when the thickness of the silica layer was 1nm, 10 nm and 35 nm.

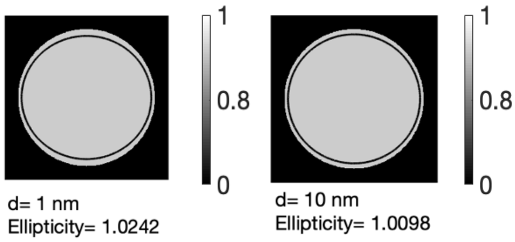

Fig. 3: Observation of changes in the exit pupil when the thickness of the silica layer was d=1nm and 10nm, respectively.

3. Conclusion

In this study, the emphasis was on the integration and feasibility of the thickness of a medium like silica to balance and maintain the cellular characteristics during culture which is otherwise affected by metallic surface. As the thickness of the silica layer is increased the absorption pattern becomes circular and the effect of the anisotropic sample becomes difficult to comprehend. The calculations indicated that 10 nm silica film can be coated on the metal film to extract the information of the birefringence of the sample with reliability.

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References

[1] H. Kano, S. Mizuguchi, and S. Kawata, "Excitation of surface plasmon polaritons by a focused laser beam," J. Opt. Soc. Am. B, **15**, 1381 (1998).
[2] R. Azzam and N. Bashara, Ellipsometry and Polarized Light (Elsevier Amsterdam, 1987), Chap. 4.