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Multilayer Structures With Spectral Darkness For Biomedical Sensor Applications

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Abstract **Phase-sensitive and zero-light reflection can be designed not only for single wavelength and single incident angles, but also for broad spectral regions and for variety of incident angles using multilayer thin film structures with low refractive index *n* semiconductor and dielectric materials, and high *n* metals.**

INTRODUCTION

The point of darkness [**1**] is the function of wavelength λ and incident angle of light θ, and the concept is based on

(1) Phase difference of *p* and *s* polarized light:

δ_p - δ_s $\rightarrow$ from -90° to +270° (phase singularities),

(2) Ratio of the complex Fresnel coefficients $\tilde{r}_p$ and $\tilde{r}_s$ for *p* and *s* polarized light:

$\tilde{r}_p/\tilde{r}_s \rightarrow 0°$ (perfect absorption of light).

APPLICATIONS: biomedical & chemical sensors.

TOOLS: vacuum coater G500M (Sidrabe Vacuum, Ltd.) for YO, Y_2O_3, YOH and ZnO_x thin film fabrication, WOOLLAM RC2 spectroscopic ellipsometry, simulations with CompleteEASER®

It is known that the absence of reflection can be achieved at certain value of the θ_B (Brewster angle) for λ and polarization states. Some examples of complex and simple systems in the table bellow:

	Examples	Comments	
Complex systems	• Ideal optical systems • Light reflection from a single interface • Prism-coupled SPL • Parity-time metamaterial [**2**] • Coherent absorption	The complete suppression of reflection is not possible due to sample fabrication errors (disorder, inhomogeneity, etc) & due to complex nano-patterning processes.	Typically offer darkness at single λ, particular state of polarization and at single φ (**Fig. 1**).
Simple systems	• Ag/Methyl methacrylate/Ge/Ag [**3**]	The system instability through polymers (often are not resistant at UV & humidity), and oxidizing metals.	
	• Metal/dielectric and metal/semiconductor/dielectric stacks ***Current work***	Can be produced with the same thin film technology, The system is robust, it works with thickness errors ± 1-10 nm, refractive index variation ± 0.02, surface roughness ± 5 nm. Can be designed with multiple points of darkness (**Fig. 2, 3**)	

RESULTS

Ag/SiO2 (62 nm)/ZnOx (47 nm) with 50% patterning

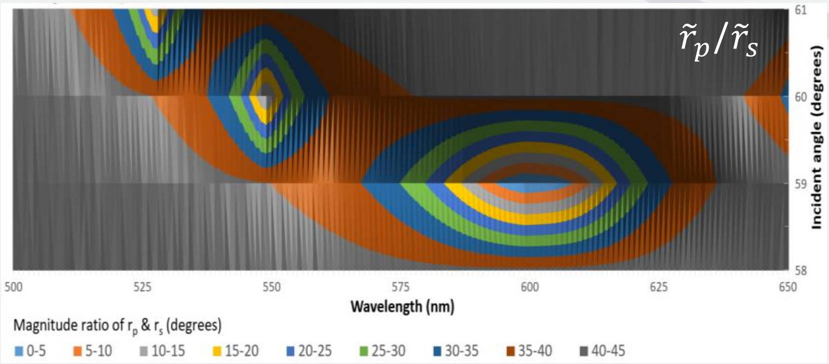

Fig. 1. The 3D representation for the r_p/r_s as a function of λ and θ. No reflection of light for patterned ZnO_x thin film at ~600 nm and at 59° of θ.

Ag/SiO_2 (21 nm)/YOH (24 nm)/Au (9 mn)

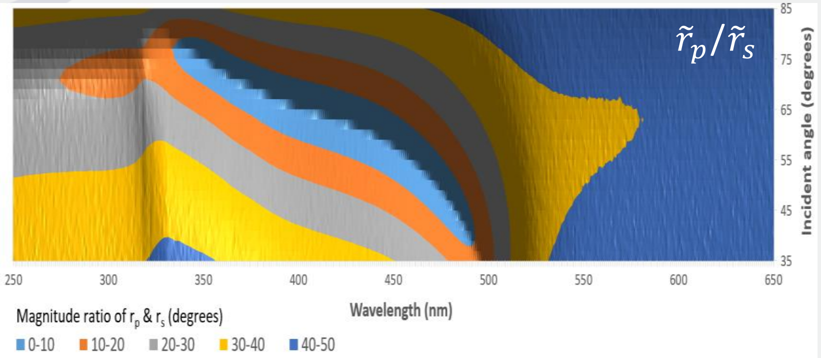

Fig. 2. The 3D representation for the r_p/r_s as a function of λ and θ. No reflection of light at broad spectral range ~340-490 nm for various θ ~ 36-75°.

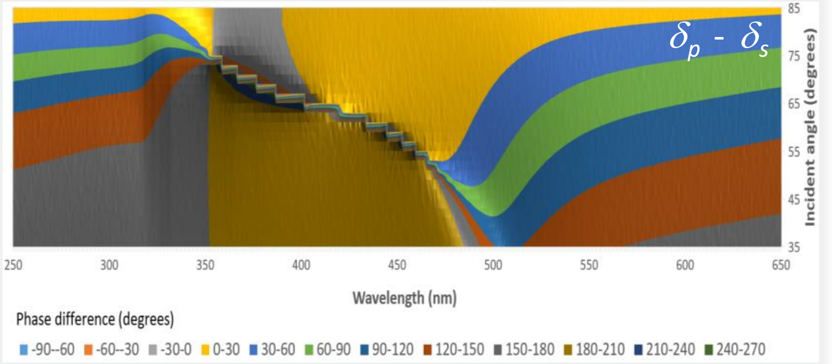

Fig. 3. The 3D representation for phase difference as a function of λ and θ. No reflection of light at broad spectral range ~350-465 nm for various θ ~ 55-75°.

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