Hybrid Structures Based on Nanoporous Anodic Alumina for Optical Detection of Alcohol-Containing Fluids

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The use of hybrid metal/dielectric nanostructures has inspired the use of Tamm plasmon resonance in the design of novel optical detection systems. In this work we combined materials with plasmonic and photonic properties for this purpose. For this purpose, we fabricated gradient-index filters based on nanoporous anodic alumina (GIF–NAA) using the pulse-like anodization nanofabrication technique with sinusoidal current density profile and coated the fabricated samples with gold using the sputtering technique[1]. This material is a one-dimensional photonic crystal made of aluminium oxide[2 – 4]. The sensing capabilities of our samples (Au–coated GIF–NAA) were examined by monitoring the Tamm plasmon resonance in surface adsorption experiments using the reflectometric interference spectroscopy (RifS) technique. The experiments were developed in a flow cell in real time by infiltrating various alcoholic fluids into the nanopores. The results highlight the application of Au–coated GIF–NAA as a potential platform for optical sensing of volatile organic compounds by monitoring the Tamm plasmon resonance.

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References

[1] Rojas Gómez, A.; Acosta, L. K.; Ferré-Borrull, J.; Santos, A. and Marsal, L. F.; ACS Appl. Nano Mater., (2023), DOI: 10.1021/acsanm.2c05356

[2] Acosta, L. K.; Law, C. S.; Lim, S. Y.; Abell, A. D.; Marsal, L. F.; Santos, A, ACS Appl Mater Interfaces, 13 (2021), 14394–14406

[3] Acosta, L. K.; Bertó-Roselló, F.; Xifre-Perez, E.; Law, C. S.; Santos, A.; Ferré-Borrull, J.; Marsal, L. F.; ACS Appl Mater Interfaces, 12 (2020), 19778–19787

[4] Santos, A.; Vojkuvka, L.; Alba, M.; Balderrama, V.S.; Ferré-Borrull, J.; Pallares, J. and Marsal, L.F.; Physica Status Solidi (A), 10 (2012), 2045-2048

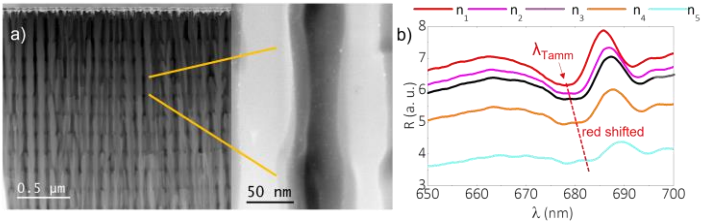

Figure 1: a) Cross–section TEM image of Au–coated GIF–NAA with magnified view of the sinusoidal nanopore created through pulse-like anodization nanofabrication technique with sinusoidal current density profile; b) Minimum wavelength in reflectance spectrum corresponding to the Tamm plasmon resonance (λ_{Tamm}) is red shifted by infiltrating fluids into the nanopores created in increasing order of refractive index.