Tamm resonances in nanoporous anodic alumina photonic structures for sensing applications

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Nanoporous anodic alumina (NAA) is a versatile and promising nanoporous material obtained by the electrochemical anodization of aluminum. It is based on a cost effective technology, and is fully scalable, and compatible with conventional micro and nanofabrication processes. Under specific conditions of fabrication, we can get a self-ordered hexagonal distribution of nanopores and well-defined cylindrical nanopores with high aspect ratio and diameters between 10 and 400 nm [1-4]. The precise control over the diameter of the nanopore allows to create periodic variations of nanopore's diameter in deep and obtain different photonic structures, e.g.., photonic crystals, microcavities, Distributed Bragg Reflectors, etc.

The optical and photonic properties of NAA depend on intrinsically on its nanoporous structure and as well its surface functionalization. NAA can also be applied to develop new hybrid photonic structures by gold coating on nanoporous anodic alumina photonic structures (photonic crystal) [5]. In this metal-dielectric photonic structure, can be observed effects of an enhancement of the surface plasmon resonance due to absorption of the light at the interface of metallic layer and the NAA photonic crystal. This type of surface plasmon resonances is called Tamm plasmon resonances (TPR).

Figure 1 shows an example of the reflectance spectrum for a Tamm–photonic crystal structure. The spectrum shows the photonic bandgap and the absorption narrow-line associated with the strong resonant recirculation of light within the plasmon-photonic system [6].

Tamm plasmon resonance can be precisely tuned by engineering the properties and characteristics of the metal film and the porous photonic structure, providing new opportunities to achieve unique plasmonic−photonic structures for different applications (optical switching, lasing, light emission, surface-enhanced spectroscopy and sensing). One promising application of TPR is the use as a sensing platform taking advantage of its exceptional optical properties to confine/amplify the light-matter interactions [7].

In this work, we analyze the influence of the structural properties of the photonic crystal and the thickness of the gold layers coated by sputtering on reflectance spectra. Also, we performed sensing experiments by analyzing spectral shifts in the position of the TPR due to the variation of the effective medium (infiltration of different analytical solutions). TPR based on nanoporous anodic alumina offers an opportunity to explore new platforms for developing more sensitive sensor systems.

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Figures

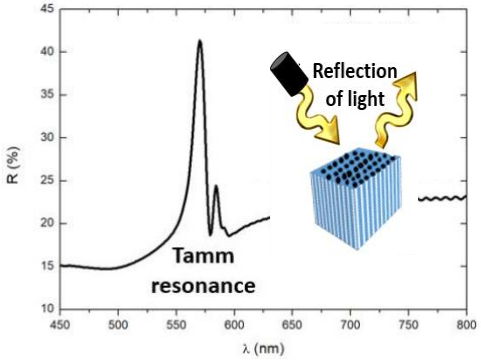

Figure 1. Reflectance spectrum of NAA-Photonic Crystal coated with gold showing the characteristic dip corresponding to a Tamm resonance signal.