Optimized all-dielectric interference coatings for sensing applications

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Abstract

To fit more and more severe requirements, modern design techniques allow producing complex multi-dielectric devices with nearly 1000 layers. Due to these progresses, deposition technologies are now democratized enough to produce huge quantity of coatings for affordable costs. In this context, the problematic of the development of consumer technologies for sensors based on optimized multidielectric coatings can now be addressed.
The use of sensitive coatings is based on the enhancement of electromagnetic fields at the interface between the probed medium and the component when it is illuminated under total internal reflection. As a consequence the optimization and tunability of field enhancement is a key to allow the development of this new generation of sensors. For this reason, several works were devoted to resonances of all-dielectric multilayers in total internal reflection, to build a huge over-intensity at the substrate interface. However, design optimization was not fully achieved, due to a lack of analytic formulation; indeed numerical data are used to identify the reflection poles of the structure, without any additional control.

We address the question here with optical interference coatings analytical design tools and we introduce the concept of zero-admittance layers (ZAL) [1] so as to increase the degrees of freedom and extend the design technique to enhancement optimization. The ZAL are standard dielectric materials whose optical thicknesses are adjusted to the total multilayer. Several ZAL can then be introduced for a multi-wavelength or multi- angle optimization. We first show how these layers allow designing the depth field distribution within a stack, and provide tunable giant field enhancement, and so, tunable sensitivity for sensors applications. Moreover the designed enhancement also generates an optical resonance which can be detected with basic camera.

The second part will be devoted to the fabrication and the qualification of such an optimized component for ultrasensitive sensing applications. A special care will be given to the 3D modeling of the deformation of the reflected beam induced by the resonance. Then the quantification of expected detectivity will be detailed taking into account experimental conditions of use. At last, an example of application will be presented.

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