Fabrication and assessment of mechanically flexible 1D photonic crystals

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Abstract. Flexible glass photonics is a cutting-edge technological and scientific research field that, thanks to a very broad spectrum of applications, has tremendously grown during the last decade and is now a strategic topic. Here, we present the results of the spectral transmittance and reflectance of a 10-layer SiO_2/TiO_2 1D photonic crystal deposited on a flexible polymeric substrate under different bending conditions, obtained with a home-made adjustable sample holder.

1 Introduction

Thin-film optics is a key technology for the fabrication of miniaturized photonic devices, spanning from optical waveguides and photonic-integrated-circuits for optical signal processing, to multi-layered resonant structures and cavities for the confinement and spectral selection of the optical field [1]. Active optical waveguides and photonic crystals are among the most versatile examples. One further step to add versatility to thin-film photonic structures involves the use of flexible materials. In fact, by adding mechanical flexibility to the standard rigid photonic systems, the range of applications greatly expands. However, passing from rigid to flexible substrates requires the development of suitable fabrication protocols, to preserve the optical and spectroscopic properties of the systems under mechanical deformation.

We present the spectroscopic study of a 10-layer SiO_2/TiO_2 1D photonic crystal, fabricated via RF-sputtering [2] on a flexible thermosetting polymer, under different bending conditions, showing interesting results in terms of both optical and mechanical properties, thus making RF-sputtering a promising and scalable technique to fabricate flexible photonic devices [3,4].

2 Photonic crystal's characterization

In order to study the 1D photonic crystal in its operating regime, i.e. under bending, our team designed and built a holder capable of controlling the curvature of the sample, as depicted in Figure 1.

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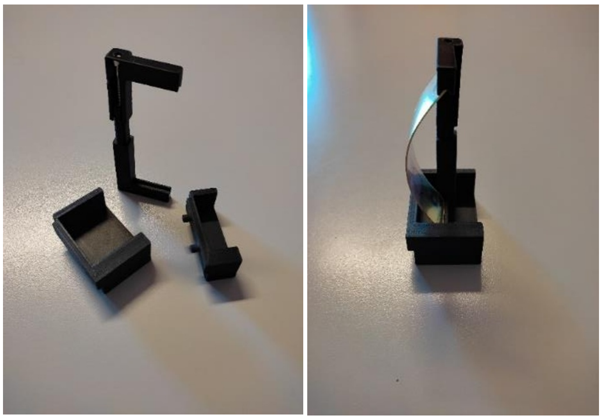

(a) (b)

Figure 1. (a) Picture of the holder with two supports; (b) support and sample holder with the sample mounted in a bent configuration.

This device allowed us to study how the spectroscopic characteristics of the 1D photonic crystal change between different bending conditions. This is just the first step towards a better comprehension of the properties of such flexible devices, as well as a starting point for a more targeted study on all the factors that, combined, result in the observations we made.

We also tested the mechanical characteristics of the 1D photonic crystal, mainly by assessing its resistance against bending wear and tear. Figure 2 shows the comparison between transmittance spectra, in flat configuration, for a point of the 1D photonic crystal before and after repeated bending. It is evident that the system maintains unchanged the original optical properties. The outstanding physical stability observed is not only of great auspice for the practical implementation of this kind of devices, but also confirms RF-sputtering as a suitable technique for their production.

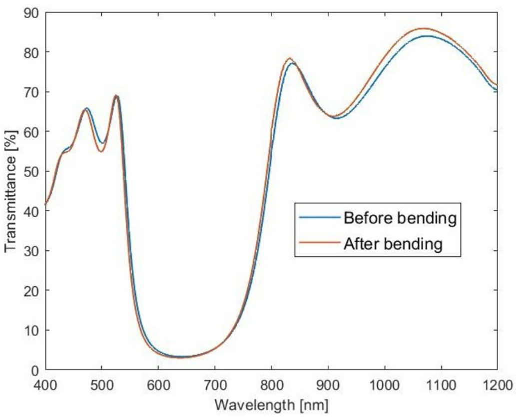

Figure 2. Comparison between transmittance spectra, in flat configuration, for a point of the 1D photonic crystal before and after repeated bending.

3 Conclusions and perspectives

This research represents the basic, yet essential, work required for the practical implementation of flexible 1D photonic crystals. Together with other similar studies and future ones, we aim at giving the phenomenological description of the optical properties of these devices in their intended working conditions, and eventually being able to deploy them as sensors, actuators, mirrors for solar, optical filters and many other applications.

Furthermore, this study is fundamental for the development of a predictive model for the spectral properties of such flexible photonic devices under mechanical deformation.

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