Flexible all-glass planar structured fabricated by RF-sputtering

Alice Carlotto[a,b], *Osman* Sayginer[c], *Anna* Szczurek[a], *Lam* T. N. Tran[a,d,e], *Rossana* Dell'Anna[f], *Stefano* Varas[a], *Bartosz* Babiarczuk[g], *Justyna* Krzak[g], *Oreste* S. Bursi[h,a], *Daniele* Zonta[h,a], *Anna* Lukowiak[i], *Giancarlo* C. Righini[l], *Maurizio* Ferrari[a], *Silvia* M. Pietralunga[b], *Alessandro* Chiasera[a,*]

[a]IFN-CNR, CSMFO Lab. and FBK Photonics Unit, Via alla Cascata 56/C, Povo, 38123 Trento, Italy
[b]IFN-CNR, P.zza Leonardo da Vinci 32, 20133 Milan, Italy
[c]Chair of Biological Imaging and TranslaTUM, Technische Universität München, Ismaninger Str. 22, D-81675 Munich, Germany
[d]Dept. of Physics, Politecnico di Milano, P.zza L. da Vinci 32, 20133 Milan, Italy
[e]Dept. of Materials Technology, Faculty of Applied Sciences, Ho Chi Minh City University of Technology and Education, Vo Van Ngan Str. 1, Thu Duc District, 720214 Ho Chi Minh City, Vietnam
[f]Center for Sensors and Devices, Micro Nano Facility, Fondazione Bruno Kessler, Via Sommarive 18, Povo, 38123, Trento, Italy
[g]Dept. of Mechanics, Materials and Biomedical Engineering, Wroclaw University of Science and Technology, Smoluchowskiego 25, 50-370 Wroclaw, Poland
[h]Dept. of Civil, Environmental and Mechanical Engineering, University of Trento, via Mesiano 77, 38123 Trento, Italy
[i]Institute of Low Temperature and Structure Research, PAS, ul. Okólna 2, 50422, Wroclaw, Poland
[l]IFAC-CNR, MiPLab, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy, France

Abstract. Flexible SiO_2/HfO_2 1D photonic crystals and active SiO_2–HfO_2:Er^{3+} all-glass flexible planar waveguides fabricated by radio frequency sputtering, are presented. The 1D photonic crystals show a strong dependence of the optical features on the light incident angle: i) blue-shift of the stopband and ii) narrowing of the reflectance window. Nevertheless, the most interesting result is the experimental evidence that, even after the 1D photonic crystals breakage, where the flexible glass shows naked-eye visible cracks, the multilayer structures generally maintain their integrity, resulting to be promising systems for flexible photonic applications thanks to their optical, thermal and mechanical stability. The flexible planar waveguides, fabricated on ultrathin flexible glass substrate, showed an attenuation coefficient lower than 0.2 dB/cm at 1.54 µm, and exibits emission in the NIR region, resulting particularly suitable as waveguide amplifier in the C band of telecommunications.

1 INTRODUCTION

The benefits obtained in terms of costs and applicability by the development of flexible and stretchable electronics, compared to their rigid counterparts, have fostered the birth of the idea of the photonics analogue. A further step in the development of this kind of systems passes through the all-glass flexible photonics, thus exploiting the typical properties of inorganic glasses (transparency, high thermal and chemical resistance, etc.) to produce flexible systems[1,2]. Here, flexible SiO_2/HfO_2 1D photonic crystals and active SiO_2–HfO_2:Er^{3+} all-glass flexible planar waveguides fabricated by radio frequency sputtering, are presented.

2 Flexible SiO_2/HfO_2 1D photonic crystals

The photonic crystals, constituted by 41 alternating layers (20 bilayers + 1) of SiO_2 and HfO_2, were deposited on silicon, vitreous silica slides (v-SiO2, 75mm×25mm×1mm) and ultrathin AS 87 eco SCHOTT glass (75mm×25mm×0.175mm) by RF magnetron sputtering. [2]

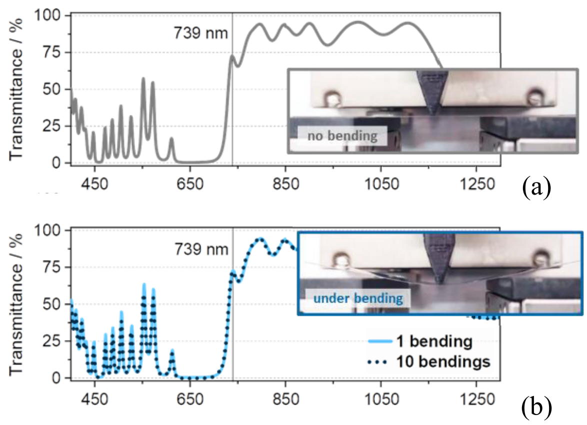

Fig. 1. Picture of the 1D photonic crystal on bending setup a) before and b) during the bending tests (Δd = 2.0 mm). Transmittance spectra of the sample, a) before (grey solid line) and b) after 1 (light blue solid line) and 10 bendings (dark blue dotted line) at a deflection equal to 2.0 mm.

* Corresponding author: alessandro.chiasera@cnr.it

The photonic crystals deposited on ultrathin SCHOTT glass was subjected to 10 banding cycles using the homemade 3-point bending setup at a deflection (Δd) of 2.0 mm, with a loading speed equal to 2.0 mm/min (Figure 1a and 1b). The mechanical deformation, i.e. bending, does not influence the transmittance properties of the dichroic mirror (Figure 1a and 1b), in fact, both position and intensity of the transmittance spectra are almost perfectly superimposable before and after 10 consecutive bending cycles.

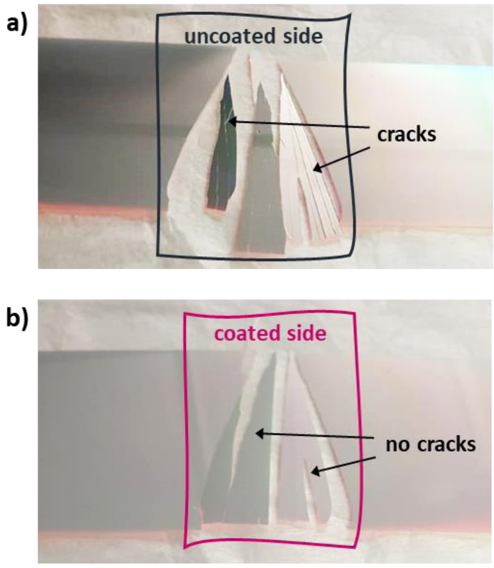

Fig. 2. Illustration photos of 1D photonic crystal after the breakage, showing a) uncoated and b) coated side of AS 87 eco ultrathin SCHOTT glass.

Even where the substrate was intentionally cracked (uncoated side, Figure 2a), the 1D photonic crystal (coated side) can still maintain its integrity (Figure 2b). For this reason, we also exploited Atomic Force Microscopy (AFM) to investigate the sample surface morphology after the ultrathin glass breakage.

3 Active SiO_2–HfO_2:Er^{3+} all-glass flexible planar waveguides

The active SiO_2–HfO_2:Er^{3+} flexible planar waveguide was fabricated via RF-sputtering technique on both ultrathin glass (AS 87 eco SCHOTT glass) and silicon in order to characterize the structure also from the morphological and compositional point of view.

The system, fabricated on ultrathin flexible glass substrate, showed an attenuation coefficient lower than 0.2 dB/cm at 1.54 μm, and the losses do not change after bending the planar waveguide.

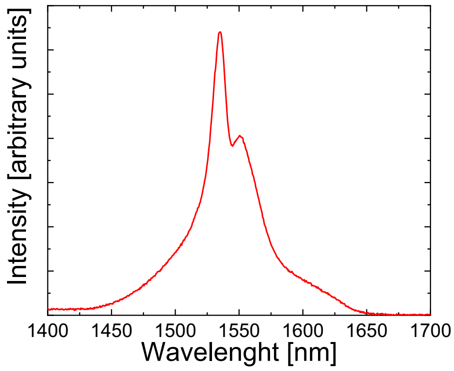

Fig. 3. Normalized photoluminescence spectra obtained exciting at 514.5 nm in prism coupling configuration the flexible SiO_2–HfO_2:Er^{3+} planar waveguide.

To confirm the fabrication of an active waveguide the photoluminescence (PL) properties of Er^{3+} were characterized. In Figure 4, PL emission spectrum in the NIR region is reported. The shape of the NIR PL spectra indicate as the Er^{3+} ions are embedded in a amorphous environment. Further thermal treatment at 400°C does not significantly influence the Er^{3+} spectral features.

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