Nonvolatile Band Switching Using Transparent Phase-Change Materials on Bragg Structures

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INTRODUCTION

High speed modulation in the optical domain has enabled communications exceeding >1Tbps data transfer speeds via overcoming the electrical energy-bandwidth tradeoff. The weak photon interactions give rise to wavelength-division multiplexing (WDM) which has multiplied the capable capacities across many optical devices via bus waveguides. However, many integrated photonic filters & demuxes depend on continuous heating elements being applied to large ring resonators to control their add-drop functionality, potentially limiting the device density and power efficiency of these systems.

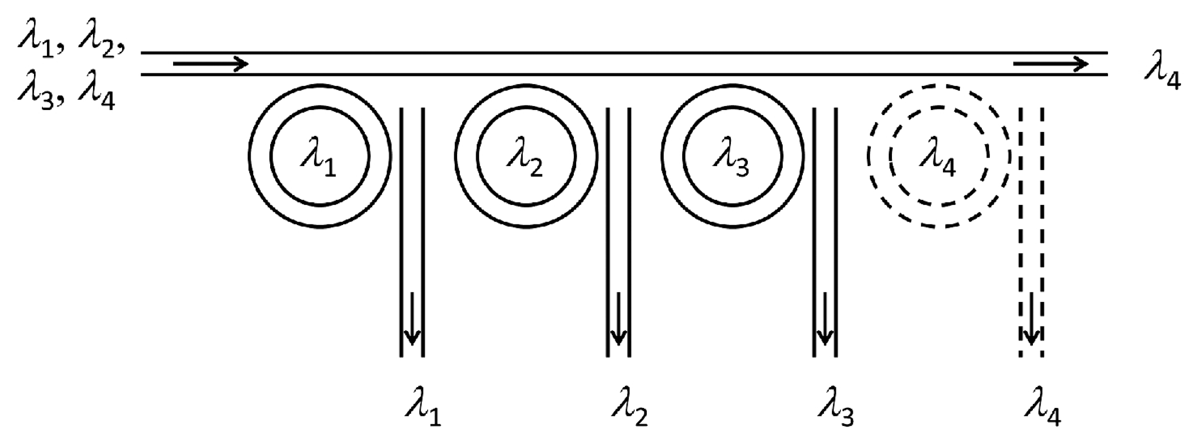

Fig. 1 Common Passive WDM Demux Topology[1]

A Bragg grating is formed by a periodic pattern of changes in the refractive index of a material. When light is incident on a grating, some of the light is reflected, while the rest of the light passes through it. The wavelength of light that is reflected by the grating is determined by the period of the pattern. Bragg gratings are easily integrated onto a photonic chip by varying waveguide widths.

Novel research of transparent Phase-Change Materials (PCMs) like Sb_2Se_3 show promise for high-contrast, nonvolatile refractive index modulation. Here, we present possible topologies for the formation of small-footprint, configurable demux topologies using transparent PCMs.

METHODS

Values for n_{eff} were obtained using MODE measurements in Ansys Lumerical. These parameters were then used to develop filters via the Transfer Matrix Method (TMM) in MATLAB.

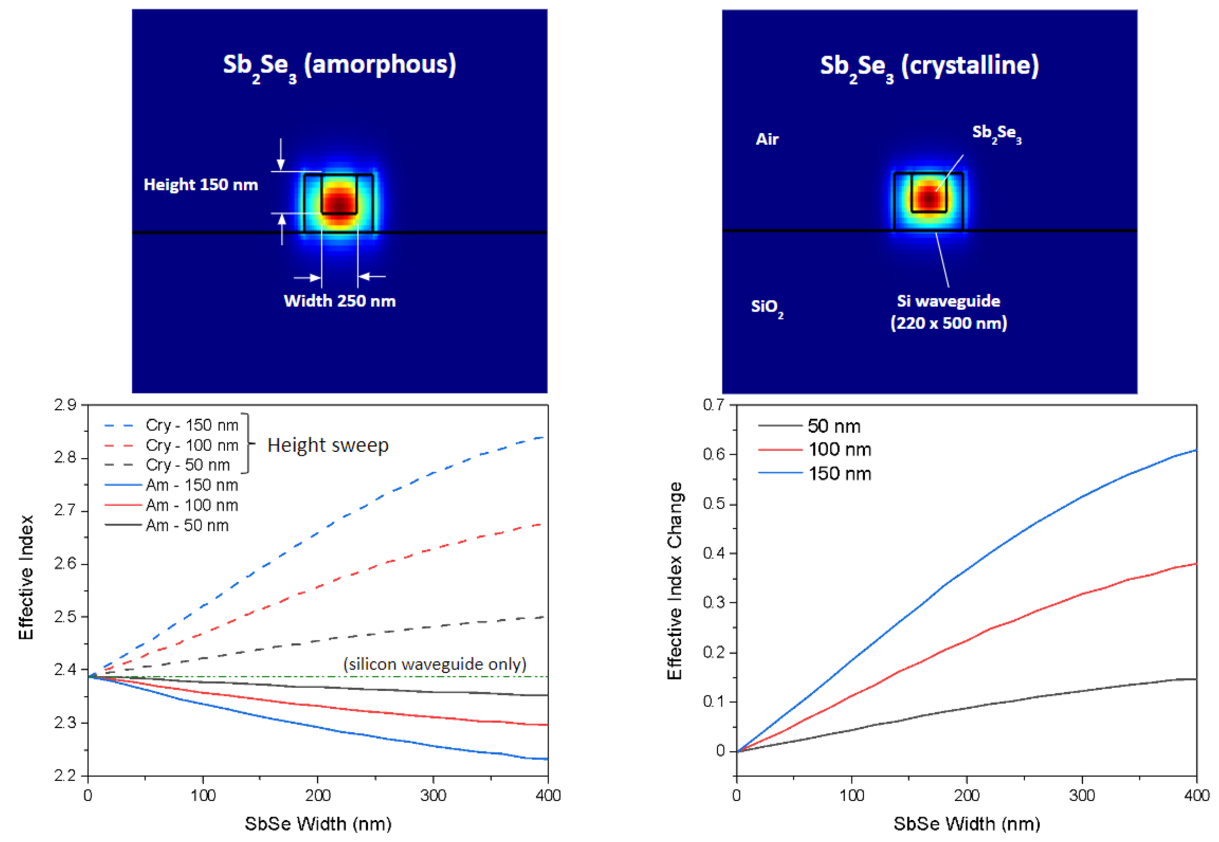

Fig. 2 PCM mode effects, Effective refractive indices by PCM trench dimension, & Overall usable effective refractive index contrast due to phase change

The Initial Bragg Device topology shown below utilizes 480nm wide passive segments and 500nm wide PCM segments that employ 120nm deep by 120nm wide trenches filled with Sb_2Se_3. The segments each have ~50% duty cycle and a period of 318.3nm across 100 periods.

The FP Device uses Bragg Gratings with passive segments that are 480nm and 520nm wide respectively. The segments each have ~50% duty cycle and a period of 325.3nm across 100 periods each. The PCM defect sits in a waveguide segment 520nm wide by 2357nm long and uses a 120nm deep by 120nm wide trench filled with Sb_2Se_3.

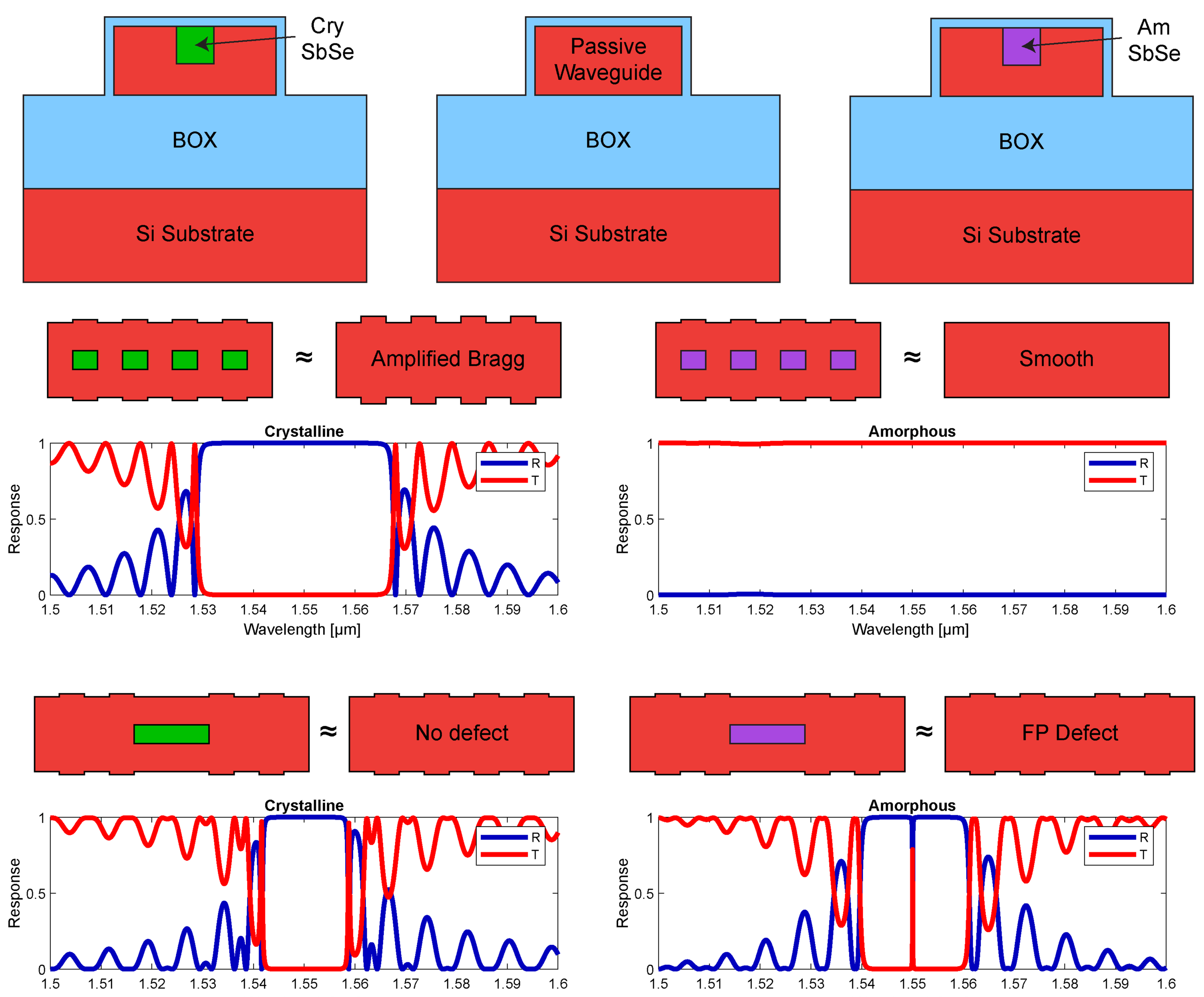

Fig. 3 Initial Device Topology. Low-Loss PCM is embedded within the waveguide to create switchable stop-bands & FP defect pass-bands

RESULTS

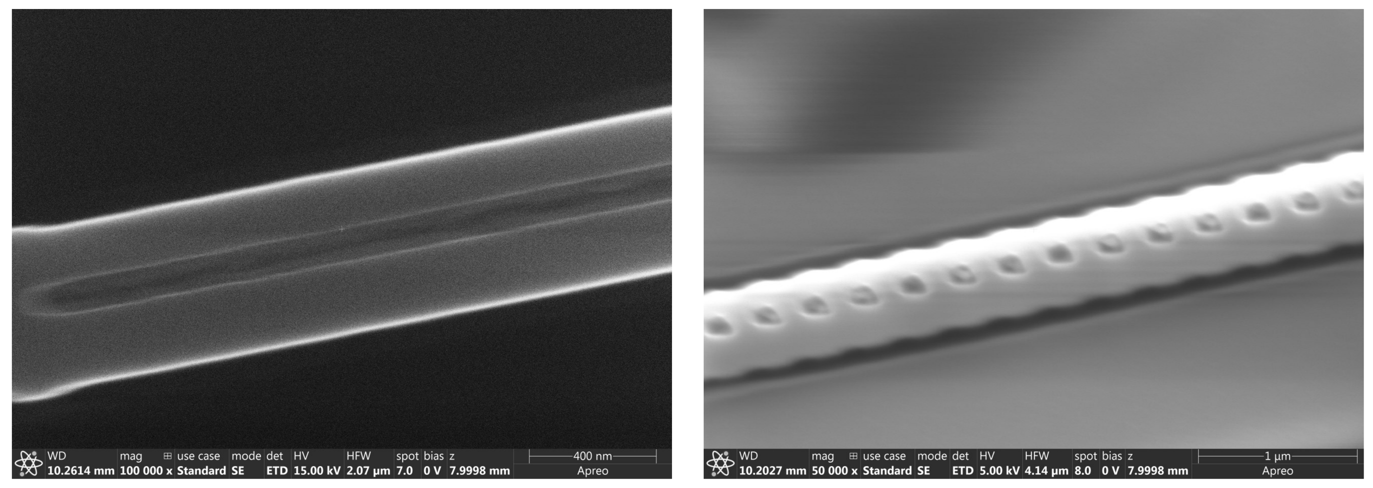

Fig. 4 SEM Images of Initial Devices after unsuccessfully attempted PCM deposition & passivation

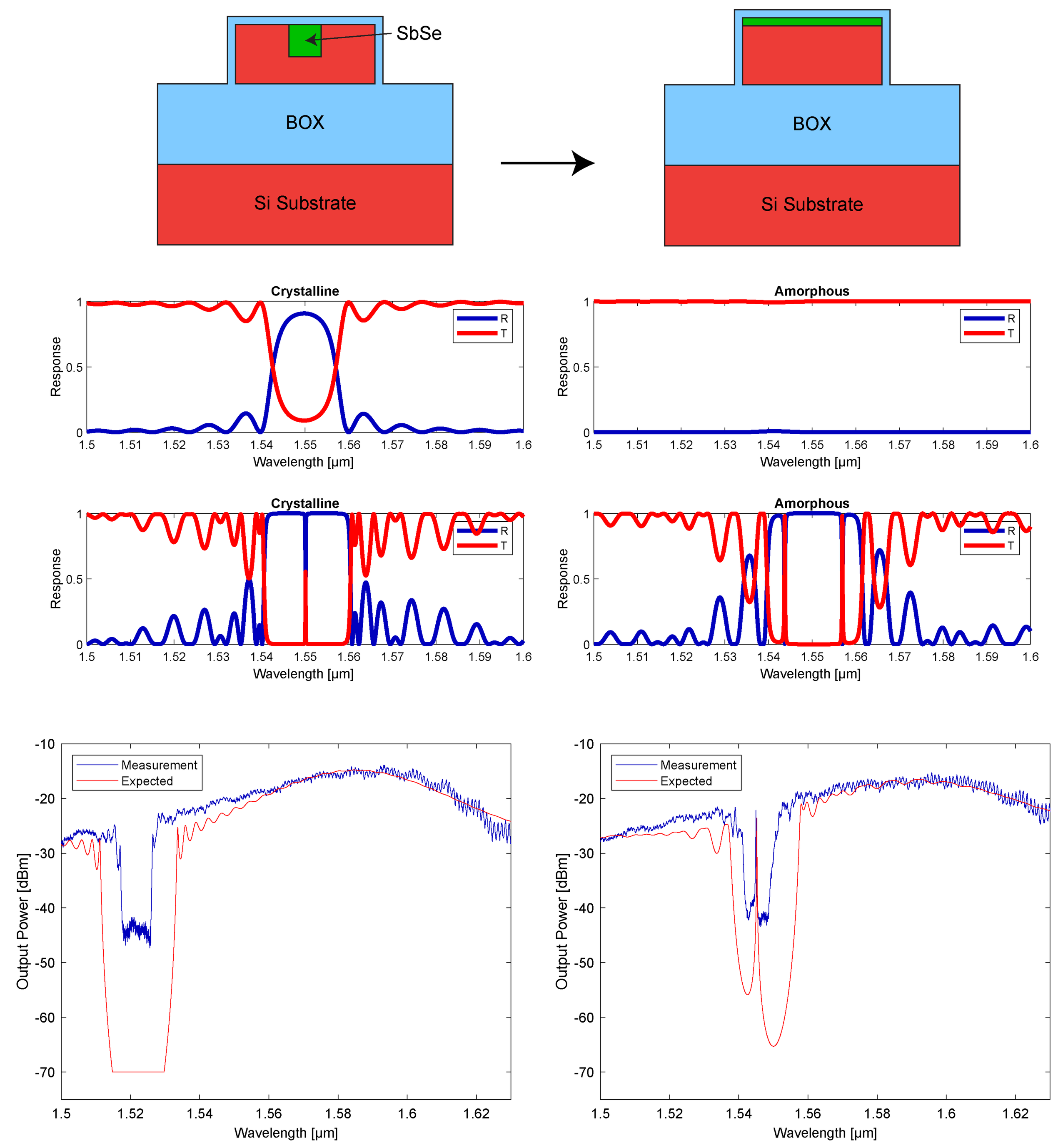

Fig. 5 Modified topology using superior PCM, the reduced effects, & Measurements of each device type before superior PCM deposition

CONCLUSIONS

Intra-waveguide use of transparent PCMs for Bragg Reflectors is attractive since it can modulate a stopband of >4.7THz and extinction ratio >50dB using a segment <35μm, no ring resonators, and not requiring constant electrical or thermal bias. However, filling small intra-waveguide trenches with width to height ratios ≥1 proves problematic. Conventional superior placement of PCM results in lower Δn_{eff} for reduced performance/larger topologies but retains non-volatile benefits over other demuxing strategies.

REFERENCES

[1] David A. B. Miller, *J. Opt. Soc. Am. A* 30, 238-251 (2013)