Impact of Substrate on Optical Properties of 1-D Photonic Crystals for White LEDs

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INTRODUCTION

White light generation (WLG) was achieved by using 1D photonic crystal structures (Bragg mirrors (BM) and Fabry-Pérot microcavities (MC)) on different substrates. Samples with tunable light emission spectra were created by exposing them to different laser light angles, optimizing emission characteristics.

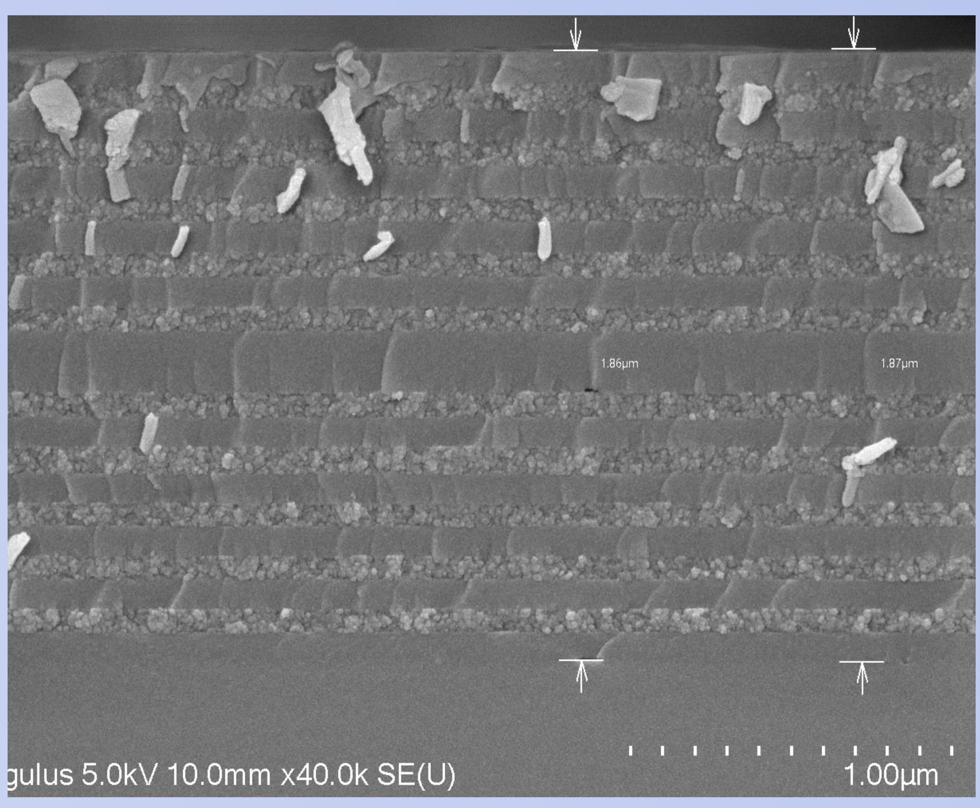

Figure 1: SEM image of MC structure

MATERIALS & METHODS

- Sol-gel process:
  - High refractive index solution = Titania sol
  - Low refractive index solution = Aluminosilicate sol with 0.3/0.5/5.0 mol. % of (Tm^{3+}/Er^{3+}/Yb^{3+}) doping materials
- Substrates:
  - p-type Silicon (100) wafer, SiO_2 (vitreous silica) wafer, Gallium arsenide (GaAs)
  - Substrate material significantly impacted the adhesion and optical properties of the deposited layers, affecting light emission spectra.
- Spin Coating was used for the deposition of thin layers
- Characterization techniques:
  - Ellipsometry, FTIR, SEM, Photoluminescence (PL), Reflectivity

Figure 2: Substrates before deposition; from left to right:
a) SiO2 wafer, b) Silicon wafer, c) GaAs, d) MC deposition on Silicon substrate

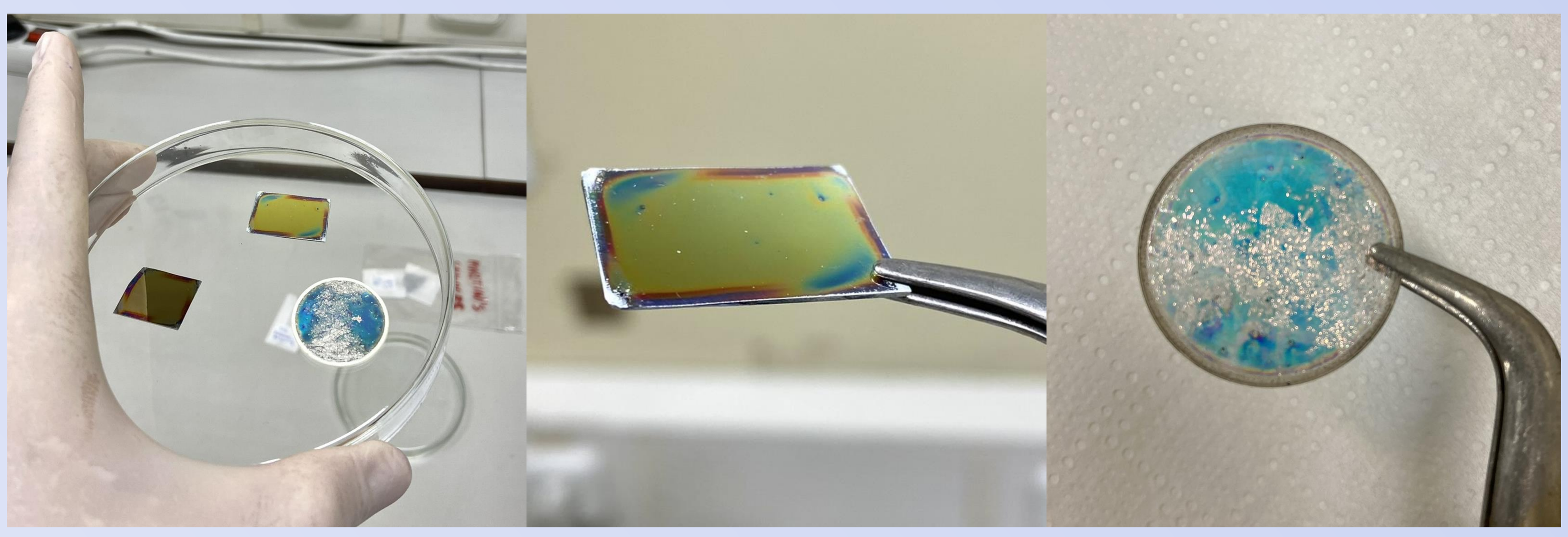

Figure 3: Substrates after deposition; from left to right:
a) Deposited samples on different substrates, b) MC deposition on Silicon substrate, c) BM deposition on Silica substrate

RESULTS

- Calibration curves presenting layer thickness as a function of ethanol volume

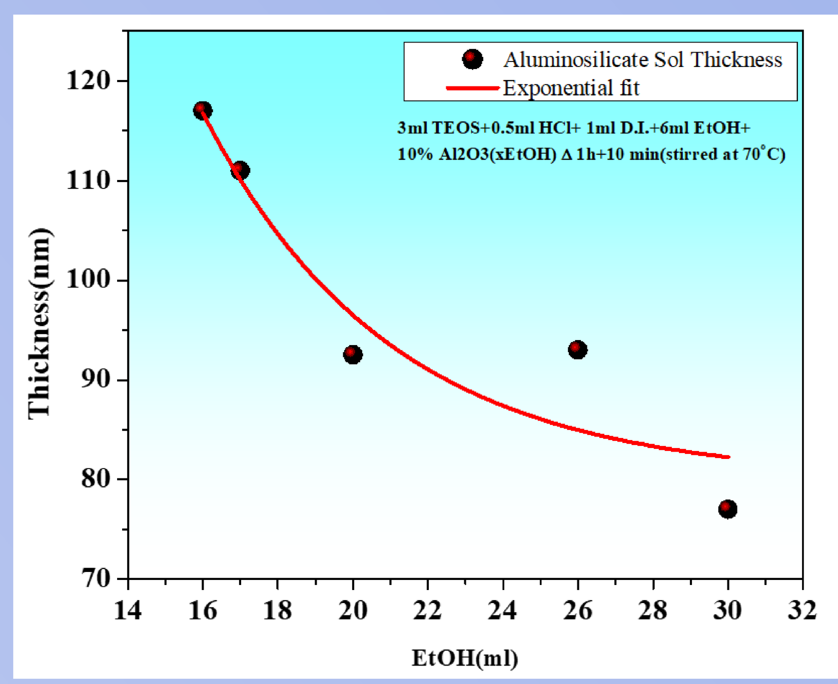

Figure 4: Aluminosilicate sol, layer thickness calibration

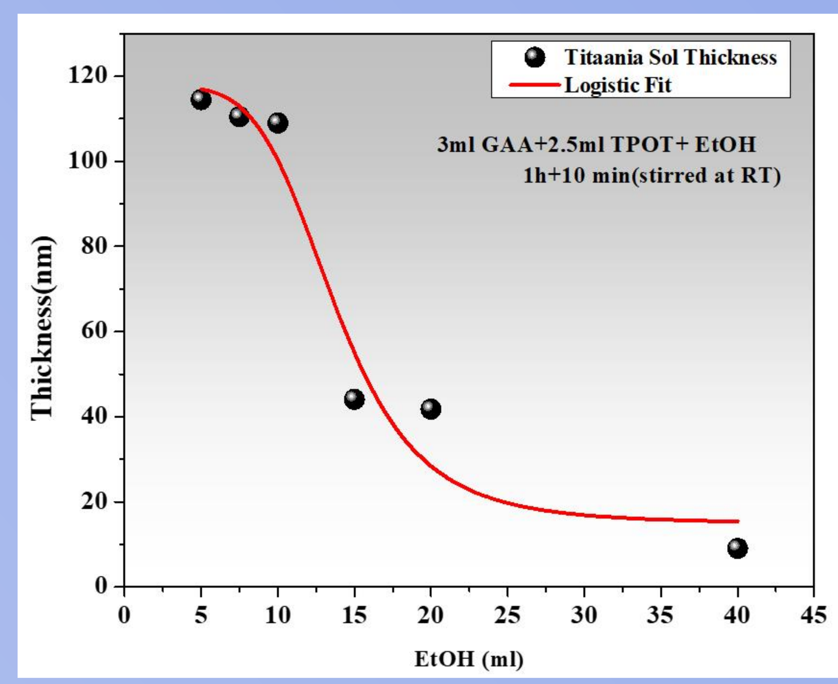

Figure 5: Titania sol, layer thickness calibration

- Reflectivity measurements (on SiO_2 substrate):
  - Lower angle → red emission spectra
  - Higher angle → blue emission spectra

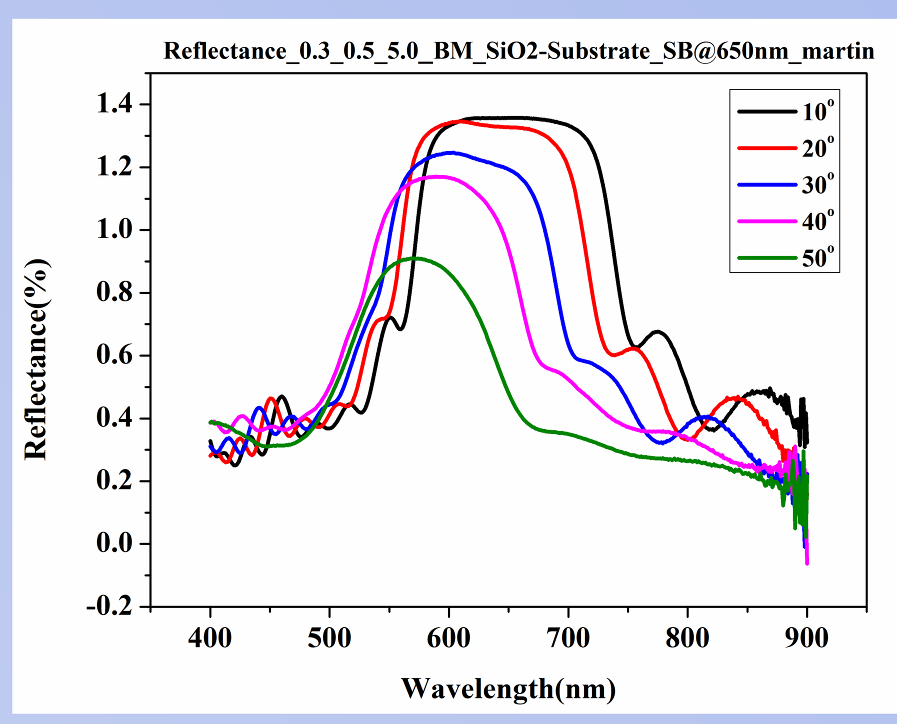

Figure 6: Reflectivity measurements of BM structure on SiO2 substrate

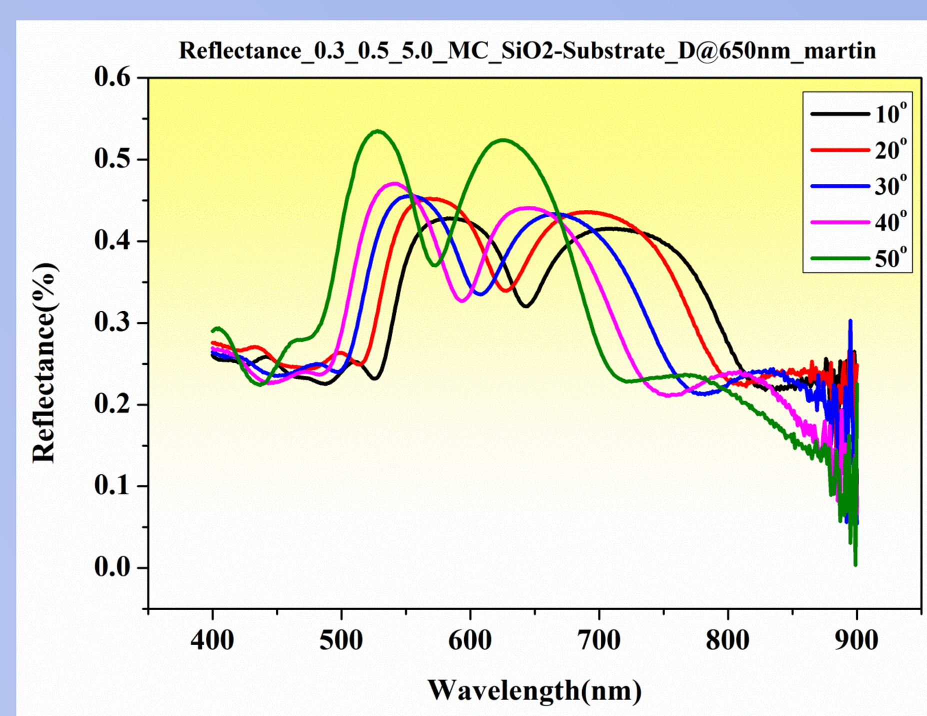

Figure 7: Reflectivity measurements of MC structure on SiO2 substrate

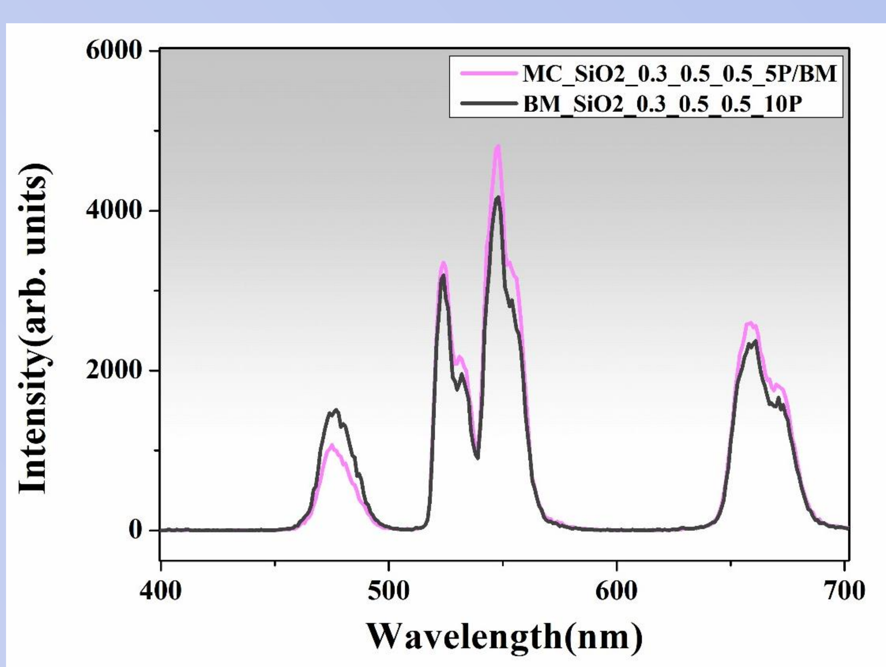

Figure 8: PL spectra of BM and MC structures on SiO2 substrate

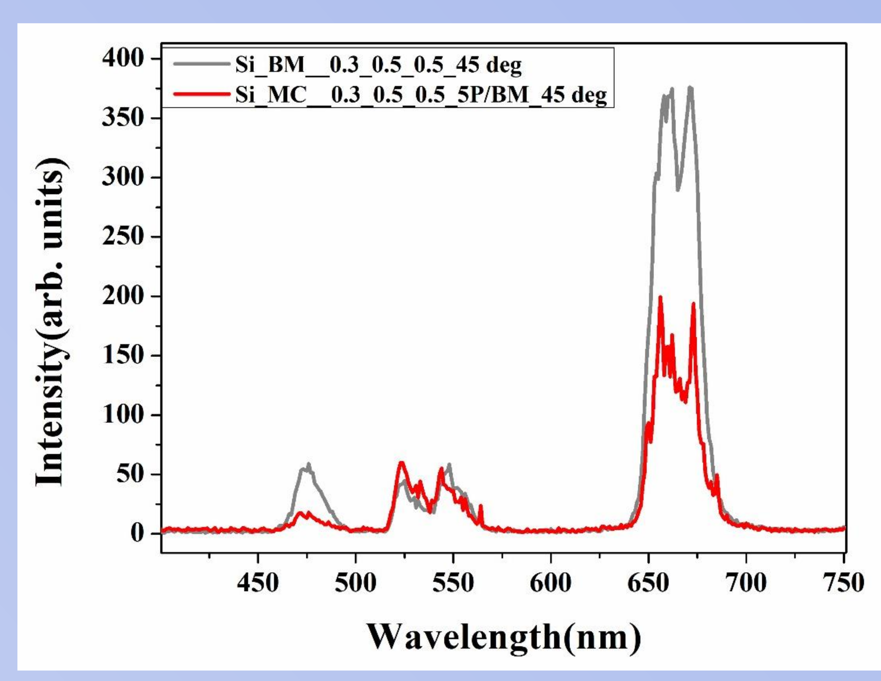

Figure 9: PL spectra of BM and MC structures on Si substrate

CONCLUSION

SiO_2 substrate demonstrated superior performance among all three studied substrates, providing the most intense photoluminescence (PL) spectra and peak values at reflectivity measurements within the white light range. Lower angles of laser exposure resulted in red-shifted emission spectra, while higher angles produced more blue-shifted emissions. GaAs was excluded from further research due to poor thermal stability and reactivity with deposited layers during heat treatment.