Photonic Crystal Optical Structure Design for Current Applications

Mehmet Furkan AY

Supervisor : Prof. Dr. Çiğdem Seçkin GÜREL

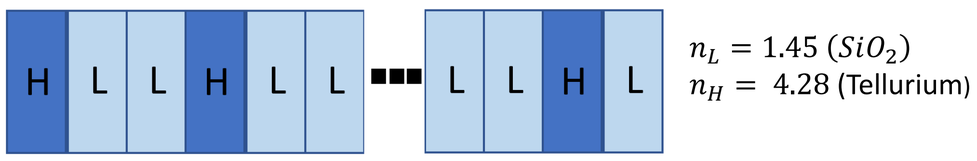
Electrical and Electronics Engineering, Hacettepe University

Introduction

- In this project, the structure of photonic crystals is examined, and new structures are created.
- These photonic crystal structures must be designed with innovative and suitable properties for current applications.
- Multiple methods have been used together in applications using photonic crystals. Bragg reflection and sub-wavelength methods are widely used.

Specifications and Design Requirements

- In the design of such crystal structure some special series are used. The well-known one of them is Fibonacci series. In this study, S6 cell of Fibonacci series is used in the form 'S6*S6'
- S6*S6 : H*L*L*H*L*L*H*L*H*L*L*H*L*H*L*L*H*L*L*H*L*H*L*L*H*L

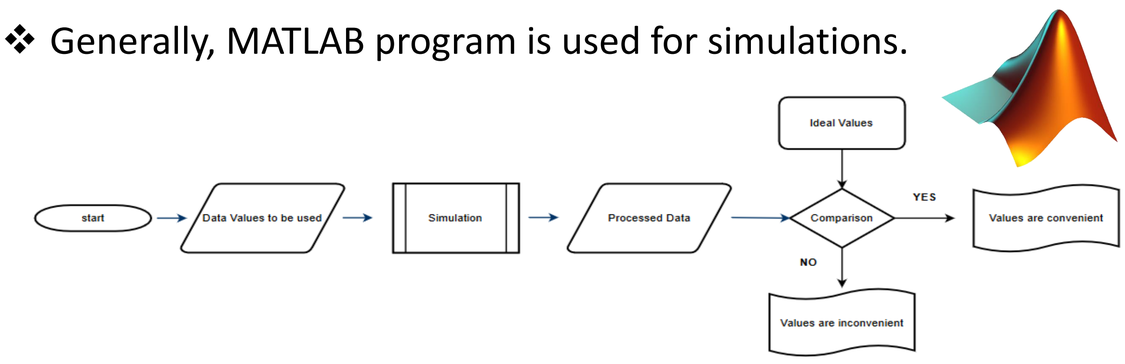


$n_L = 1.45\ (SiO_2)$
$n_H = 4.28$ (Tellurium)

- In this study, H and L indicate two different materials having high and low refractive indices where H is chosen as Tellurium and L is Silicon di Oxide.
- In the analysis, Transfer Matrix Method is used which is suitable for multilayer structures.
- In the analysis, three different layer thicknesses are selected as $d_1 = 175\ nm$, $d_2 = 210\ nm$, $d_3 = 245\ nm$
- And results are discussed in the following parts.

Solution Methodology

- Generally, MATLAB program is used for simulations.



- While preparing this project, certain steps are followed. Briefly, these are:

Comprehensive literature research

Derivation of Transfer Matrix Method formulations

Determining an proper software to simulate

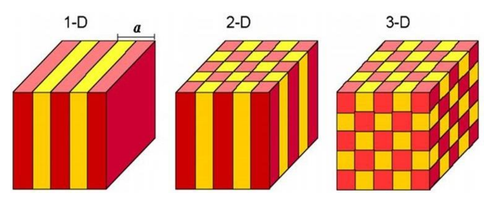
Comparison of the obtained results with previous experimental studies

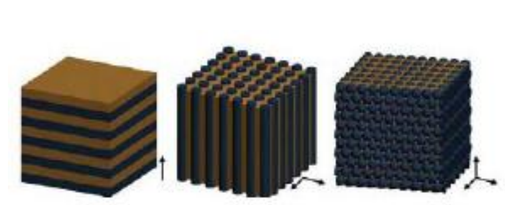
Reflection vs wavelength characteristic of the designed component are obtained for different layer thicknesses

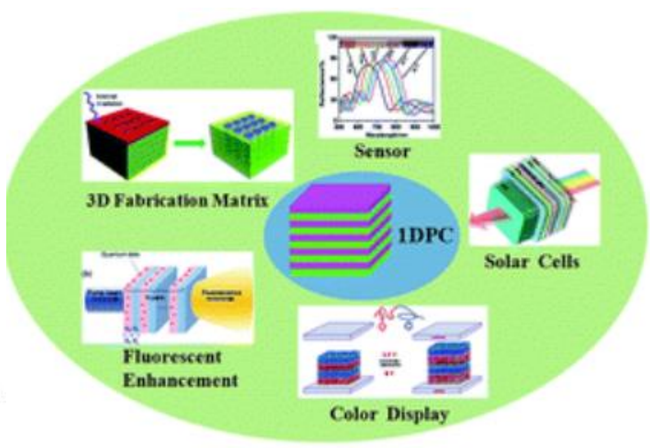
Discussion of the results

Application Areas

- There are many photonic crystal applications. Some of them are lasers, optical insulators, excellent dielectric mirrors building photonic diodes and transistors, metamaterials (negative refractive index materials), superlenses.
- Photonic crystal structures can be designed in 1D-2D or 3D forms.

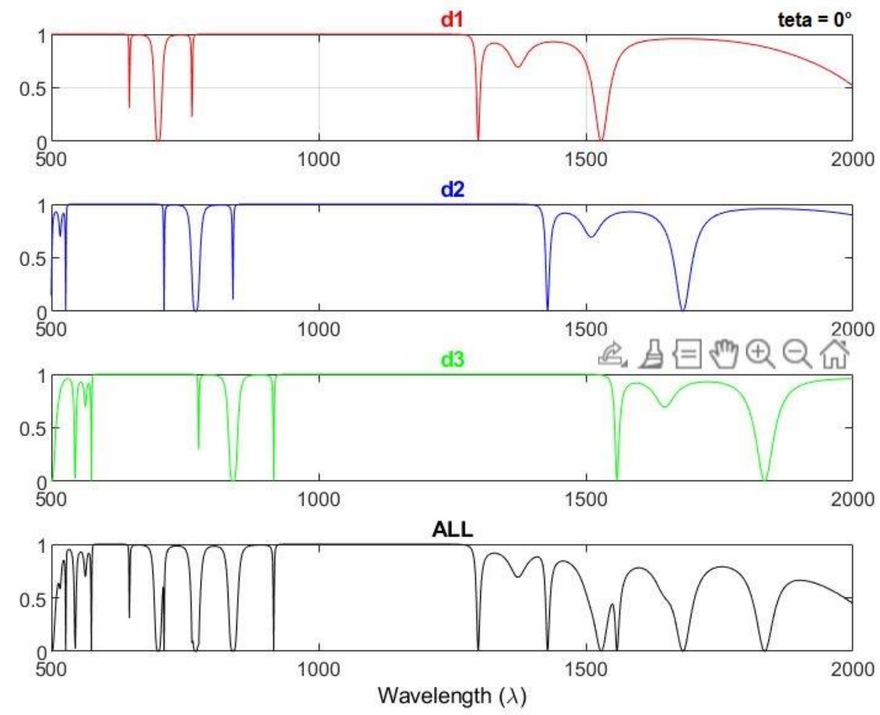




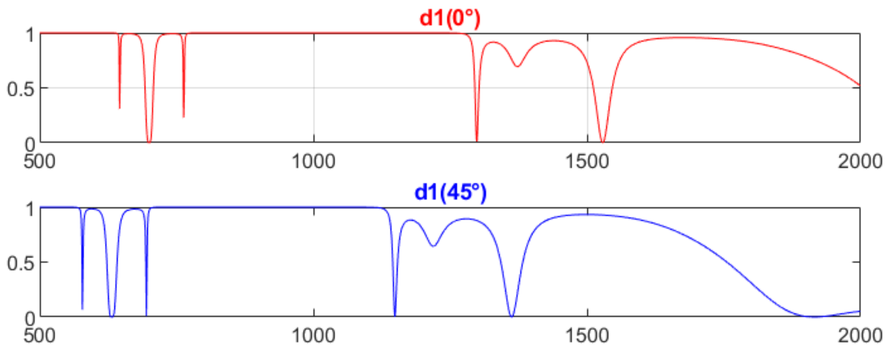


Results and Discussion

- The increase in thicknesses of the layers and incidence angle shift reflection characteristic with increase in noise.



- Reflection characteristic changes with incidence angle.



- In the future, by using this design procedure and different series instead of Fibonacci series, new optical components for different optical applications can be designed.

References

- Rahimi,H 'Wave phase analysis for computing density of states, group velocity, and lateral shift in a 1D quasiperiodic structure containing layers of uniaxial medium and SiO2', *OPTICAL SOC AMER,* pp.8674-8680, *2019.*
- Shen, H. Wang, Z. Wu, Y. and Yang, B. 'One-dimensional photonic crystals: fabrication, responsiveness and emerging applications in 3D construction', *RSC Advances,* pp.4505-4520, 2016.

I thank my advisor, *Prof. Dr. Çiğdem Seçkin GÜREL* for her helpful comments and guidance during the project study.