Project title: Optimization of the thermally pumped terahertz emission from a family of photonic crystals

Project Manager:
Patrick O. Kano, PhD, Senior Engineer, Raytheon, Tucson
Paul Dostert, PhD, Program in Applied Mathematics, UofA, Tucson

Team leader: Casey Irvine, senior, Mathematics, UofA

Team members: Natalie Coston, senior, Math/Envir. Eng., NAU
Veronica Strdanova, senior, Math/CS, UNM

Introduction

This project is concerned with the study of block structured crystals from a family of photonic crystals whose thermal emission in the terahertz regime is optimal. In paper [1], the authors introduced an analytical model for the thermal emission of a family of photonic crystals which are defined by a constraining condition on the materials involved. Paper [1], also provides tools for the photonic crystal analysis software package MPB [2] which can be adapted to an optimization trade study. No optimization study was however performed in the above paper. This project will address this deficiency. Furthermore, reference [3] provides an introduction to the problem and the necessary mathematical machinery to embed the output of the above algorithms as an input to the Matlab genetic global optimization algorithm.

Project goals

The aim of the project is to test the feasibility of using the existing software for engineering design of the optimal photonic crystal thermal emission. To this goal, one must:

a) Record and analyze the turn around times for the optimization runs;

b) Understand the sensitivity of the obtained values with respect to GA algorithm parameters and variations in the objective function;

c) Study of the optimal design within physical regime as well as beyond currently attainable values of the parameters;

d) Investigate the relation of the optimal solution to the band gap structure.

Project development schedule

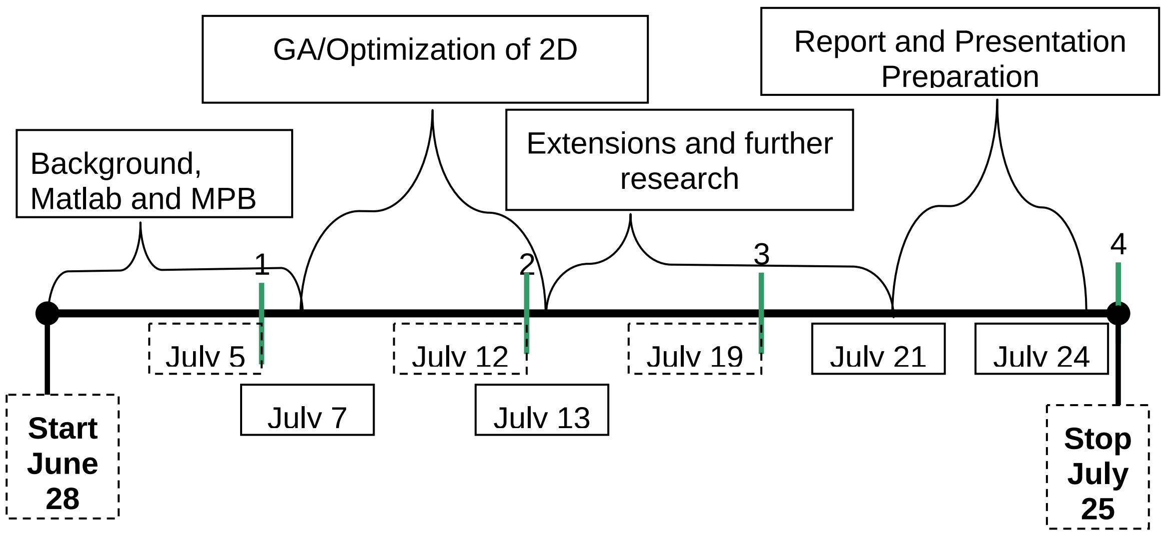
The project assumes that the team members will be able to run and understand the basics of the underlying software, see ref. [3], within the first two weeks of the project. Currently, both analytical and numerical based formulas software are running on sequential/parallel configurations on the mathematics department machines. The remaining time will then be devoted to the study and documentation of the results.

The team members will take the lessons learned from the 2D configuration and extend to 3D or to other interesting cases. The team should modify the software accordingly. The team should comment on the feasibility of running minimization algorithms for more complicated cases, or on the 3D configuration. The team should make suggestions for future studies, perhaps including level sets, as described in [4].

The project is designed to be completed in the four week period allotted. A flexible schedule, tunable to the skill set and interests of the team members, is the following:

- June 28 – July 7 : Mathematical Background, Matlab & MPB introduction
- July 7 – July 13 : Application of genetic algorithm and 2D optimization

- July 13 – July 21 : Extensions (perhaps 3D or other interesting topics)
- July 21 – July 24 : Presentation Preparation



References

[1] P. Kano, D. Barker and M. Brio, "Analysis of the analytic dispersion relation and density of states of a selected photonic crystal", 2008 J. Phys. D: Appl. Phys. 41 185106 (22pp)

[2] Fully-vectorial eigenmodes of Maxwell's equations with periodic boundary conditions were computed by preconditioned conjugate-gradient minimization of the block Rayleigh quotient in a planewave basis, using a freely available software package, http://ab-initio.mit.edu/wiki/index.php/Main_Page

[3] C. Irvine and P. Dostert, "Introduction to global genetic algorithm optimization of photonic terahertz thermal emission", Preprint.

[4] C. Y. Cao, S. Osher and E. Yablonovitch, "Maximizing band gaps in two-dimensional photonic crystals by using level set methods", Applied Physics B: Lasers and Optics, 2005, vol. 81, pp. 235-44.