Parallel Hybrid Optimization Algorithm for the Material Composition of Multilayer Thin-Film Structures

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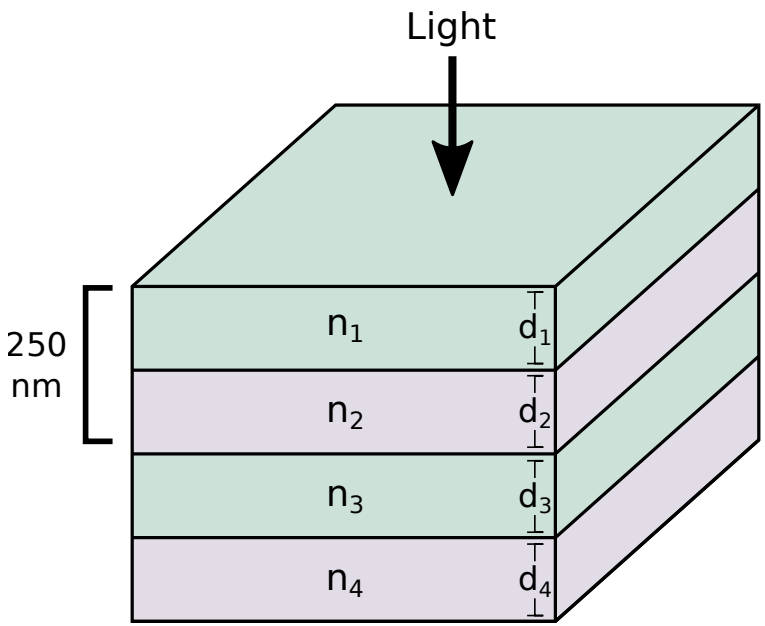
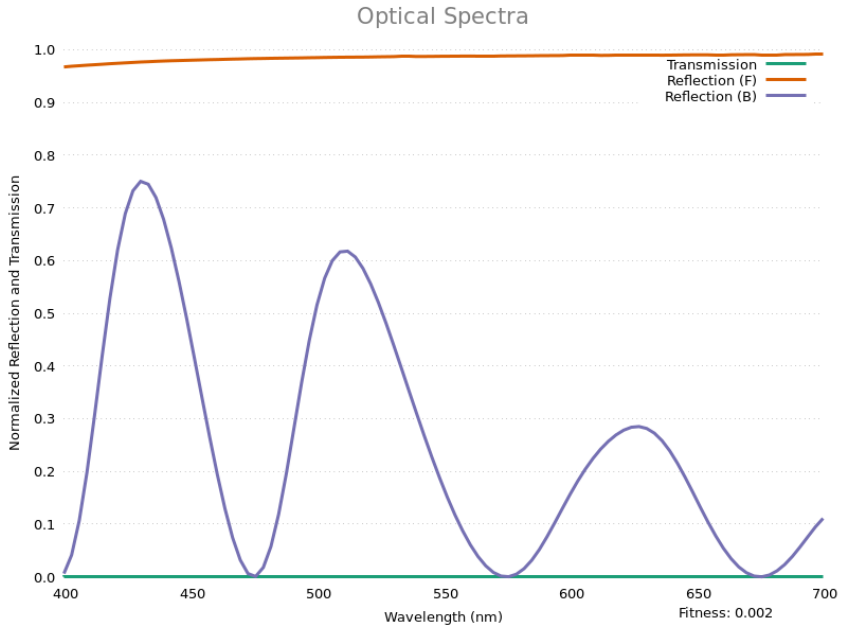
What are Multilayer Thin-Film Structures?

What?



Stacked nanoscale layers of materials (metal, dielectric) with differing optical characteristics.

Why?



Can create arbitrary optical spectra.

Applications: anti-reflective coatings, omnidirectional mirrors, filters, more.

Objectives

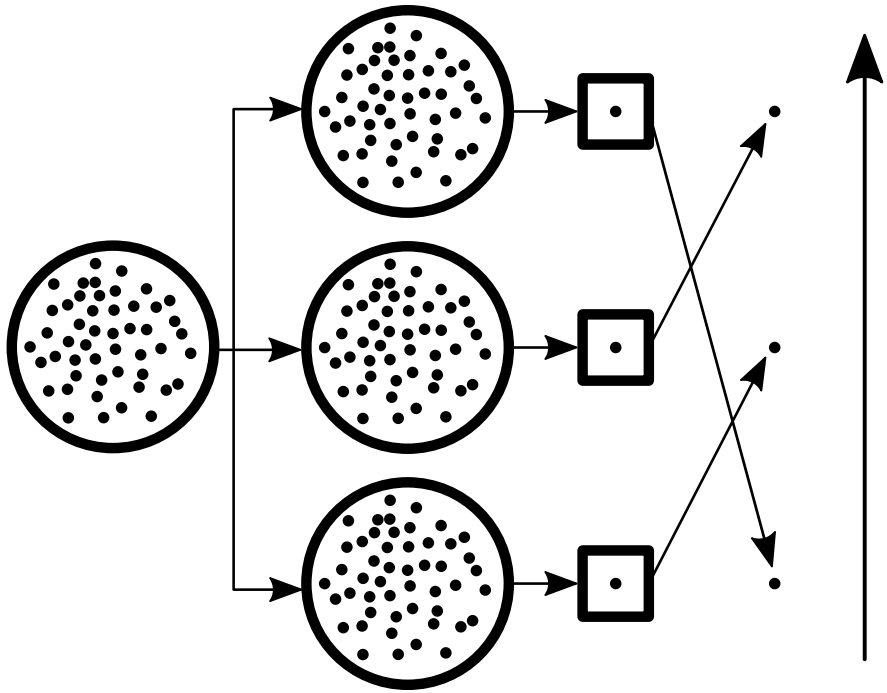
Develop a method that:

- Is general-purpose, not application-specific
- Supports parallelization
- Can choose materials

Algorithm

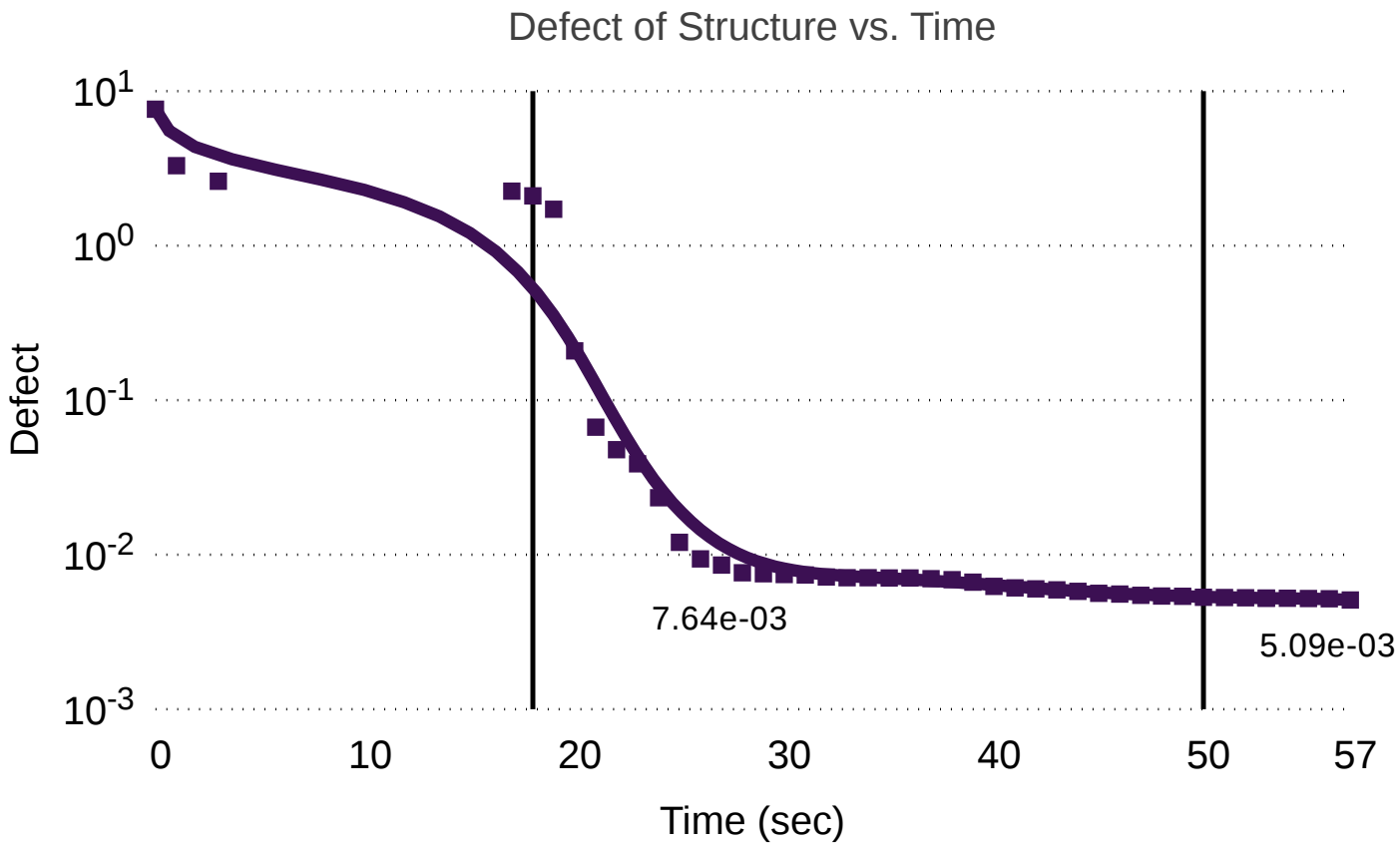
Hybrid algorithm:

1. Monte-Carlo simulation
2. Continuous, adaptive genetic algorithm
3. Pattern search



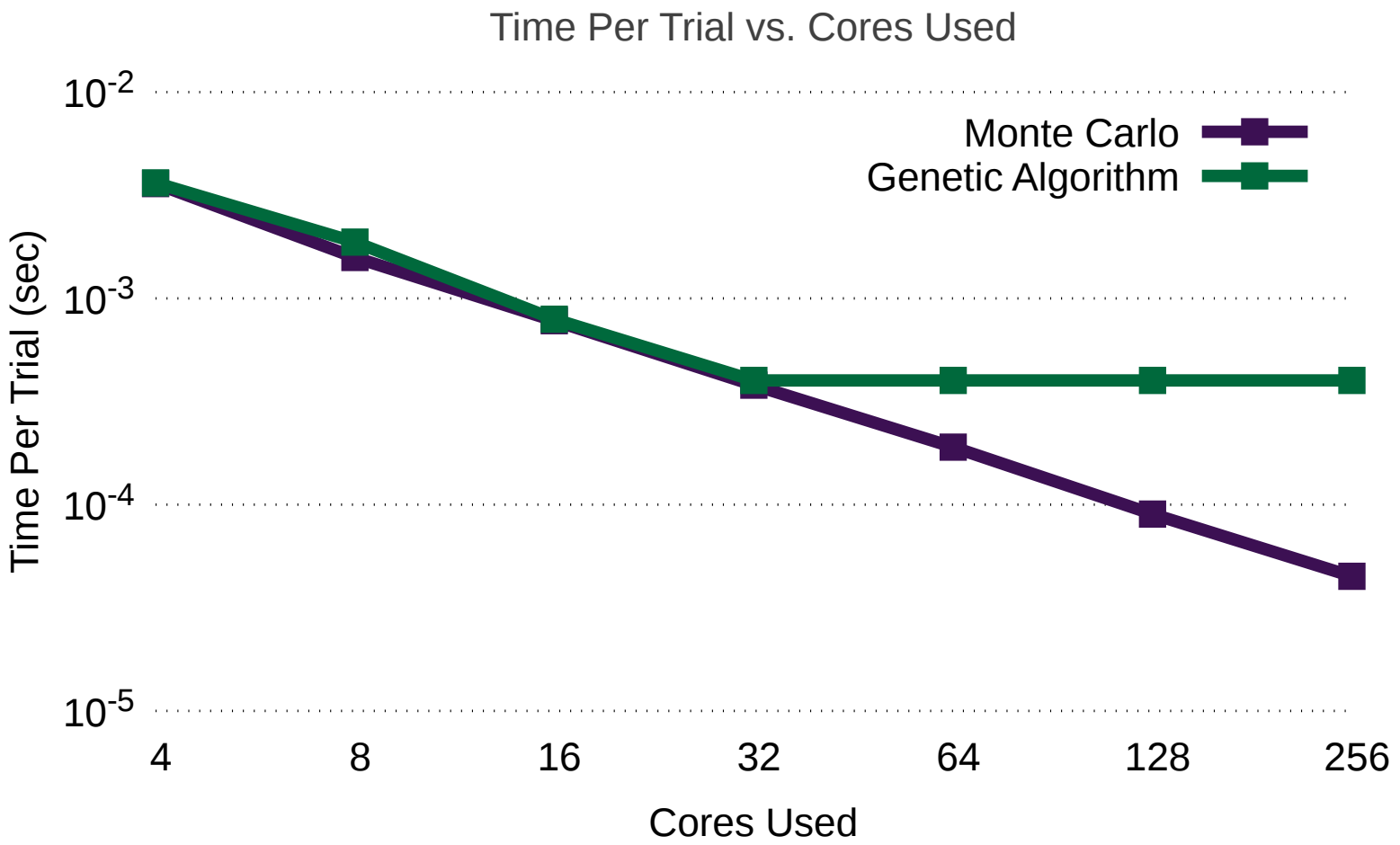
Algorithm Effectiveness

Tested against a sample anti-reflective coating design problem[1].
Improvement: **3.3%** (5.27×10^{-3} to 5.09×10^{-3})



[1] A. J. Thelen and R. Langfeld, "Coating design contest: antireflection coating for lenses to be used with normal and infrared photographic film," (1993), vol. 1782 of Proc. SPIE, pp. 593.

Parallelization

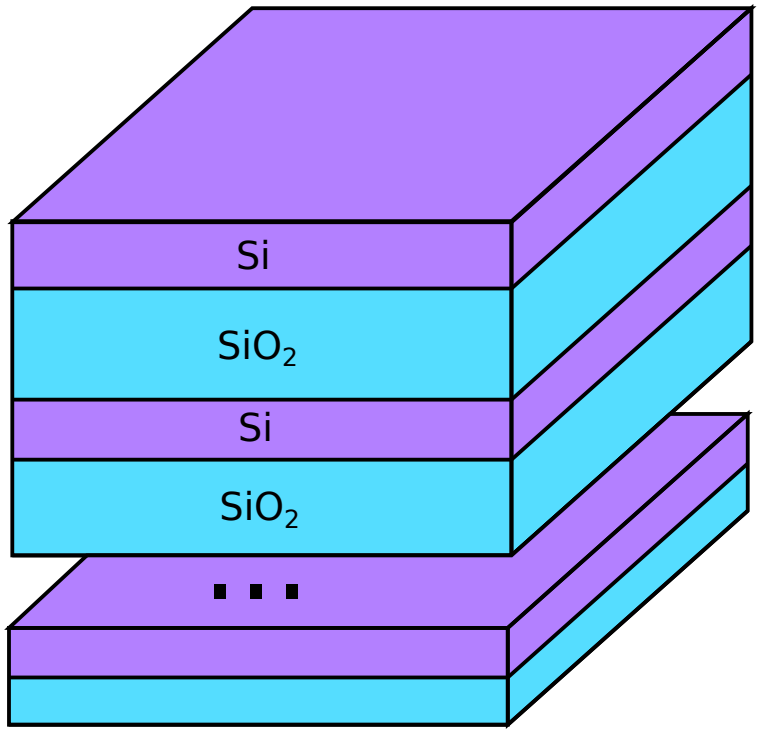


Choosing Materials

Example: reflectionless at λ=532nm (green laser).

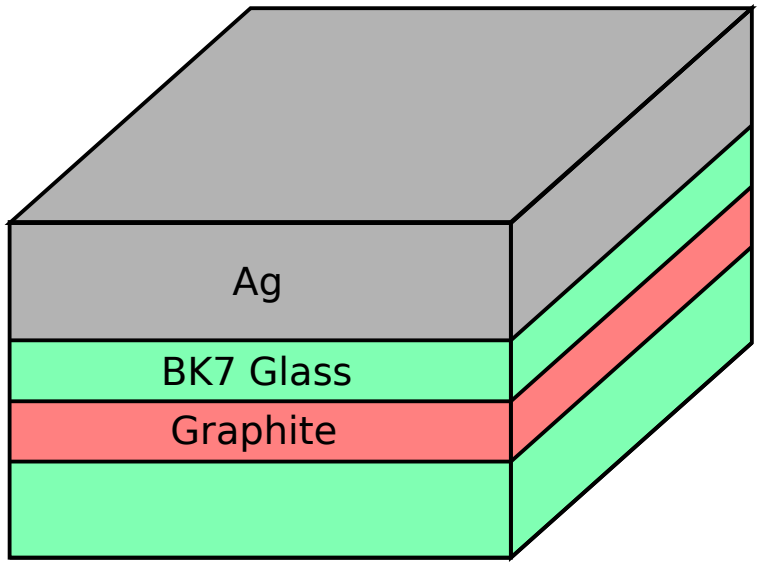
Typical Solution[2]

Reflectance: 1.9×10^{-3}



New Solution

Reflectance: 1.0×10^{-6}



[2] L. Feng et al., "Demonstration of a large-scale optical exceptional point structure," Opt. Express 22, 1760–1767 (2014).

Discussion & Future Work

Discussion:

A general-purpose method was developed that:

- Appears effective on sample problems
- Scales performance linearly with additional CPU cores
- Can choose materials for multilayers

Future Work:

- Test the method on more classes of problems.
- Test other methods for choosing materials.
- Improve speedup during genetic algorithm.

Questions?

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