**Docket #:** S17-427

# A Photonic Crystal Slab Laplace Differentiator

Stanford researchers have developed a high throughput, low energy consumption, optical method for real-time, image differentiation (image sharpening) using a photonic crystal slab. Spatial differentiation can be carried out via digital computation, but it can be slow and challenging. Optical methods are either one-dimensional, rely upon bulky optical components, or operate in reflection modes, which is less compatible with image processing. The Shanhui Fan group has addressed these drawbacks with an isotropic imaging filter comprising a photonic crystal slab (Figure 1). This all optical method for edge enhancement (Figure 2) is fast, compact, and low-energy, and can be used in a range of image processing applications from surveillance to industrial inspection and microscopy.

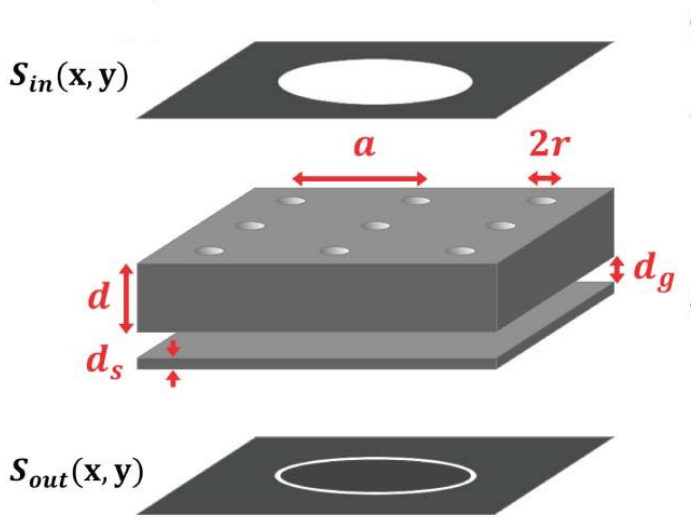



Figure 1 Photonic crystal slab differentiator - a photonic crystal slab separated from a uniform dielectric slab by an air gap.

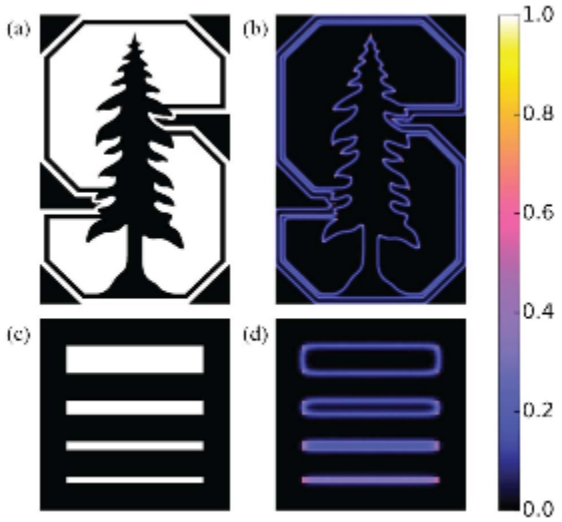



Figure 2 Theoretical Results (a) Stanford emblem with a size of 2610a × 1729a. (b) Calculated transmitted image with unpolarized light. (c) Incident slot patterns with length 500a and widths 100, 50, 30, and 20a. (d) Calculated transmitted images with unpolarized light, which show the spatial resolution of the design is around 30a.

**Stage of Research** – Proof of Concept

## Applications

- Real time image/video sharpening and edge-based segmentation for: satellite, surveillance, remote sensing, telescope, medical imaging, microscopy, industrial inspection, object detection, etc.

## Advantages

- Real-time
- High throughput
- Ultra-low energy consumption
- Compact
- Versatile - transmission (and reflection) mode compatible for image processing applications

## Publications

- Guo, Cheng, Meng Xiao, Momchil Minkov, Yu Shi, and Shanhui Fan. "Photonic crystal slab Laplace operator for image differentiation." *Optica* 5, no. 3 (2018): 251-256. https://doi.org/10.1364/OPTICA.5.000251

## Patents

- Published Application: 20190146120
- Published Application: 20210278566
- Issued: 10,928,551 (USA)
- Issued: 12,032,118 (USA)

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