

# “The color of a flower field changes with a butterfly’s flight vector” is a metaphor for homochirality colorimetry via chiral nanostructure arrays

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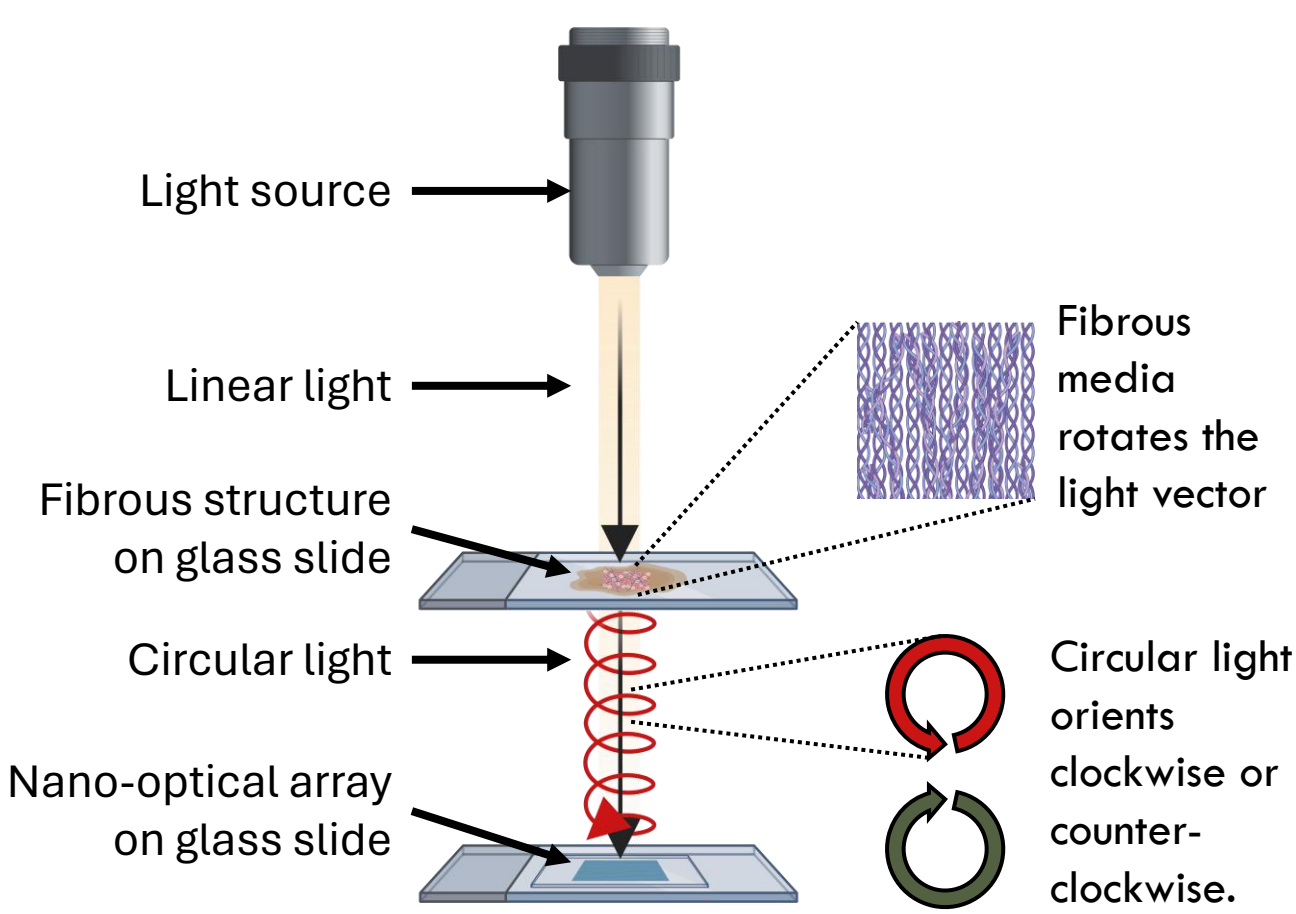
## Introduction

Fibrous or filamentous biological structures, like microbial mats, can rotate a light wave's travel vector [1,2]. However, this rotation is too minimal to measure without meter-scale tools [3]. **This work explores miniaturizing these tools to the nanometer level for *in-situ* applications.**

One possibility is rotating a light vector into a circular path, either clockwise or counter-clockwise [3]. Homochirality is when an orientation of circular light is favored over the other [3,4,5]. **Detecting homochiral light is an agnostic biosignature of life [5].**

We investigate how this biosignature could be detected using arrays of nanoscale particles. By using visible light, our optical arrays also act as colorimetric sensors of homochirality [3,6,7].

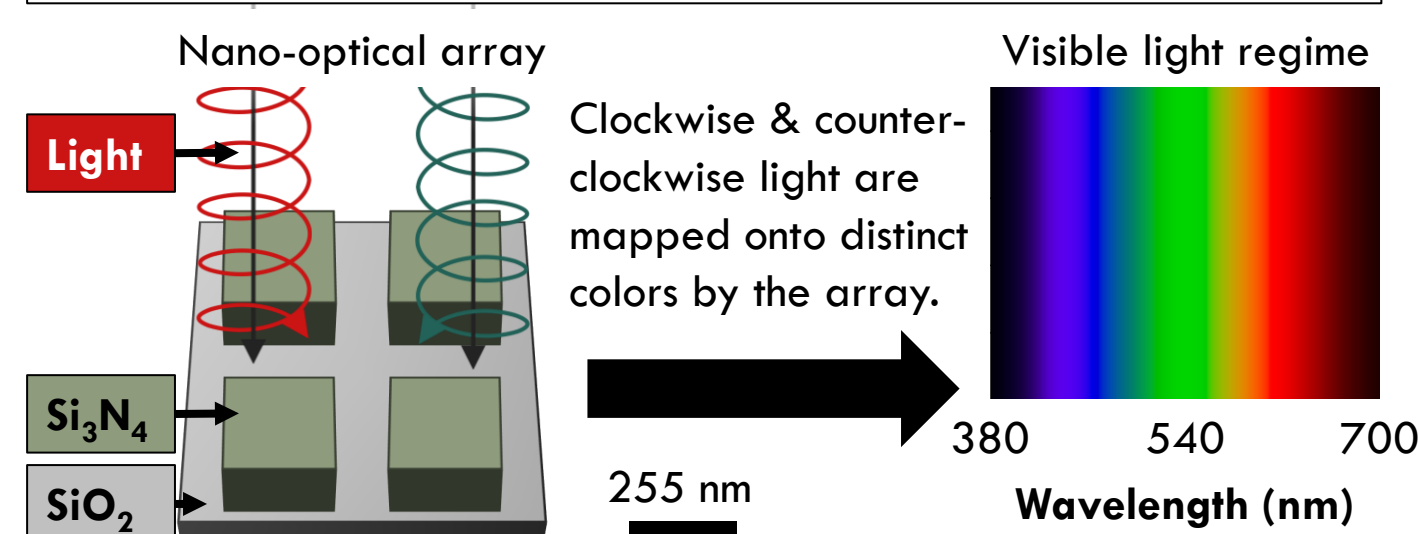
Figure 1: Schematic of sensing system.



## Materials and methods

We investigate how a cut to one corner of square- and rectangle-shaped nanostructures affects their sensitivities to differentiating between incident clockwise or counter-clockwise oriented circular light.

Figure 2: Summary of methods.



## Results

- Differentiation of clockwise and counter-clockwise polarization states of circular light was achieved.
- Squares:** Figure 3 shows cuts to the square structure affect the reflectance response but result in non-differentiable outputs. Table 1 displays the non-differentiable colorimetry results. Figure 4 examines the near-field response: cuts simplify the problem from a quadrupole to a dipole, which dampens the reflectance response due to a decreased energy output.
- Rectangles:** Simplifying the problem in rectangles from four nodes to two nodes extinguishes the longer-wavelength reflectance peaks, as shown in Figure 5's “Medium Cut” group. This unequally dampens the shorter-wavelength peaks of the two polarization states. Both these observations contribute to the differentiable colorimetry results in Table 2.

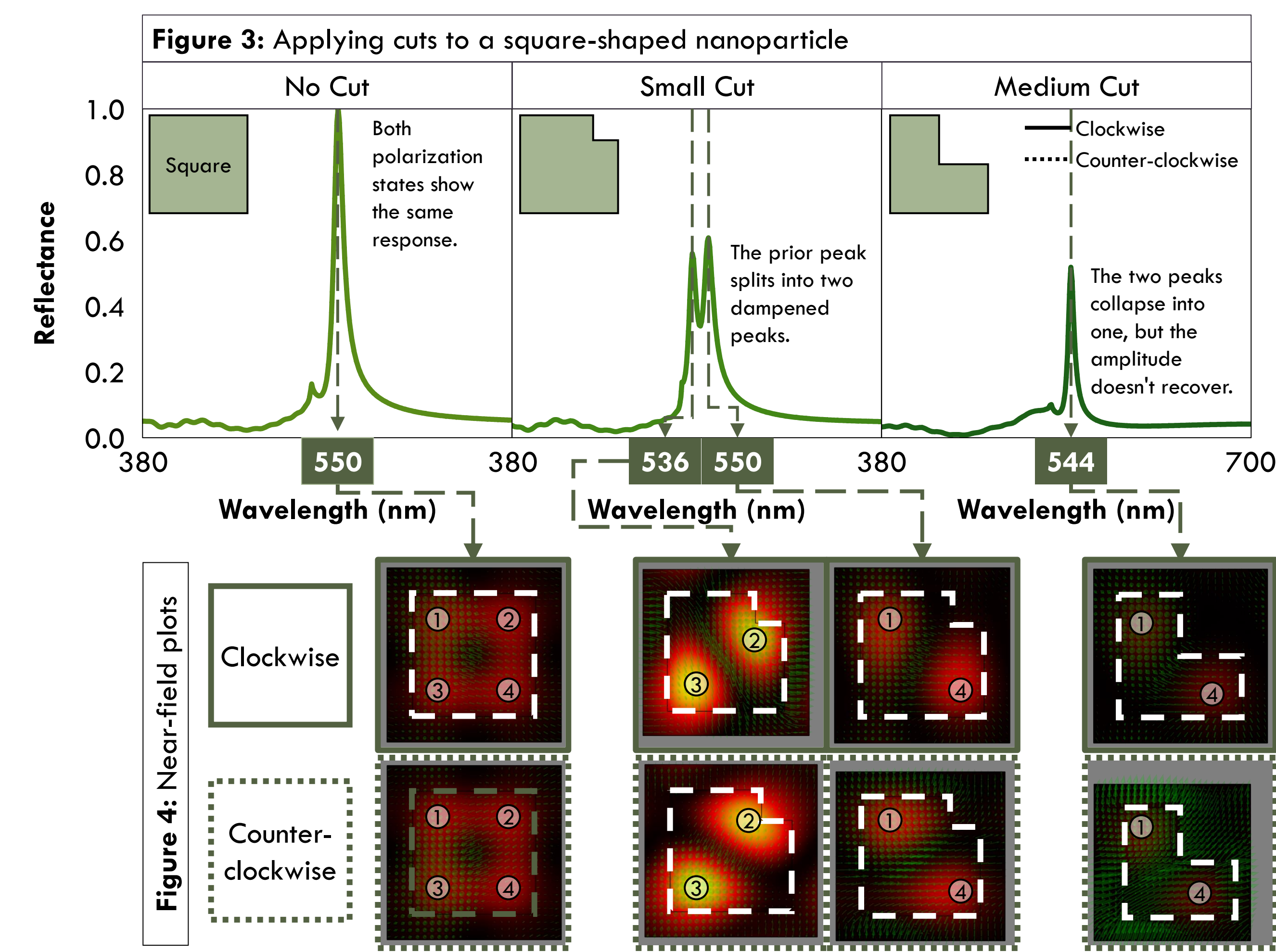


Table 1: Colorimetry results from Figure I reflectances.

	Clockwise	Counter-clockwise
No Cut	#598C18	
Small Cut	#428716	
Medium Cut	#1C6117	

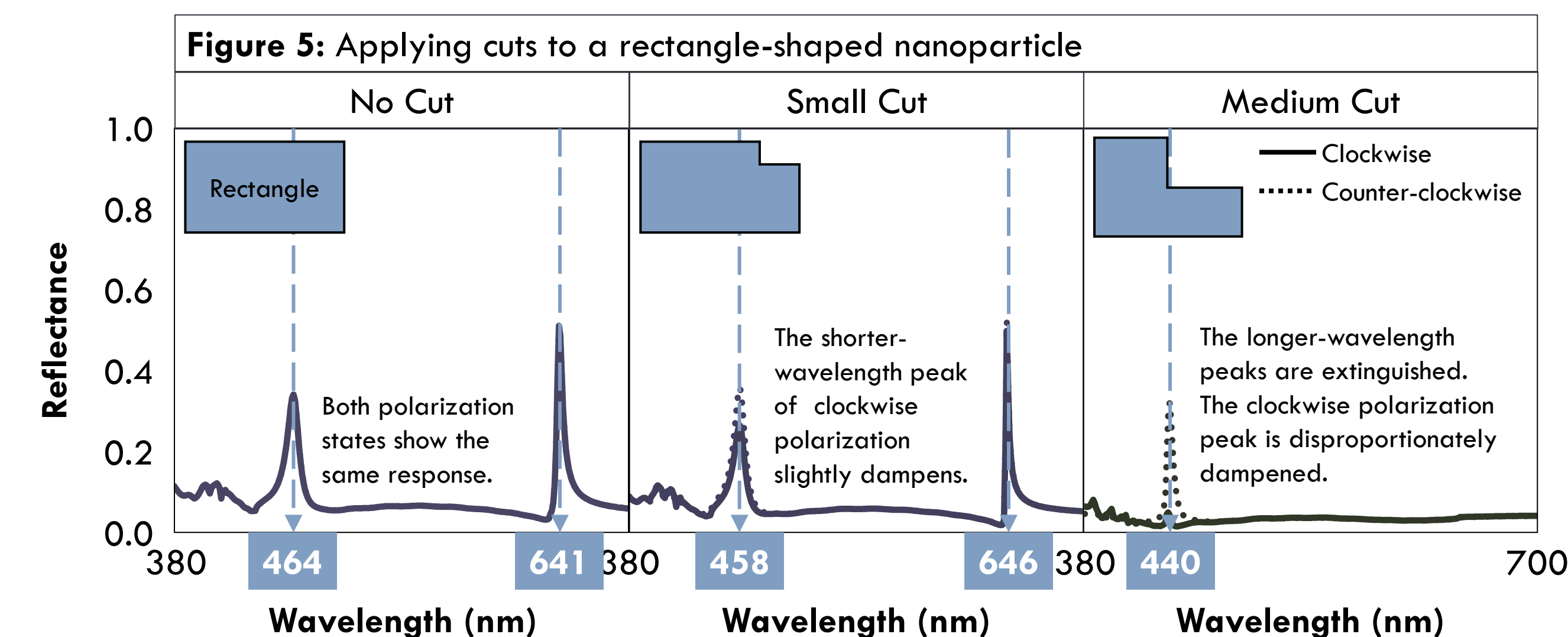


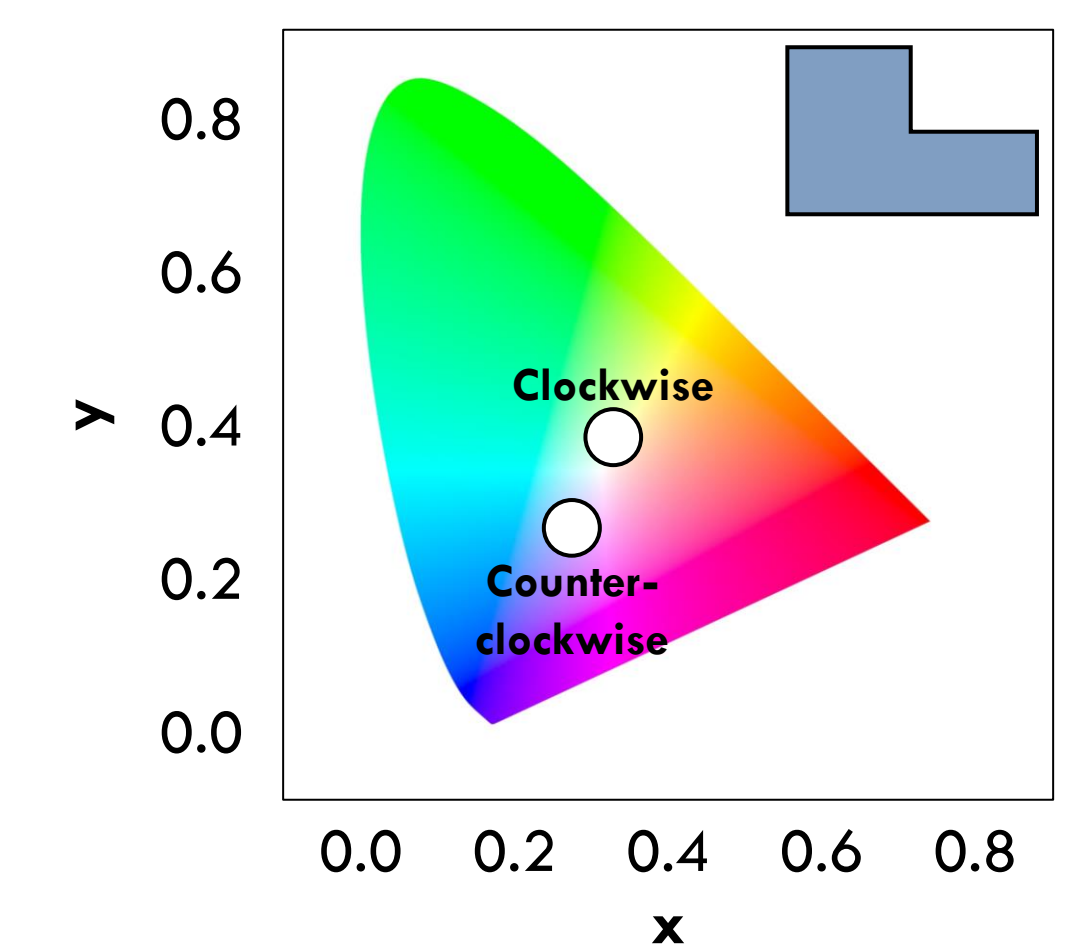
Table 2: Colorimetry results from Figure III reflectances.

	Clockwise	Counter-clockwise
No Cut	#484564	
Small Cut	#424059	#433F62
Medium Cut	#31352A	#343146

## Conclusions

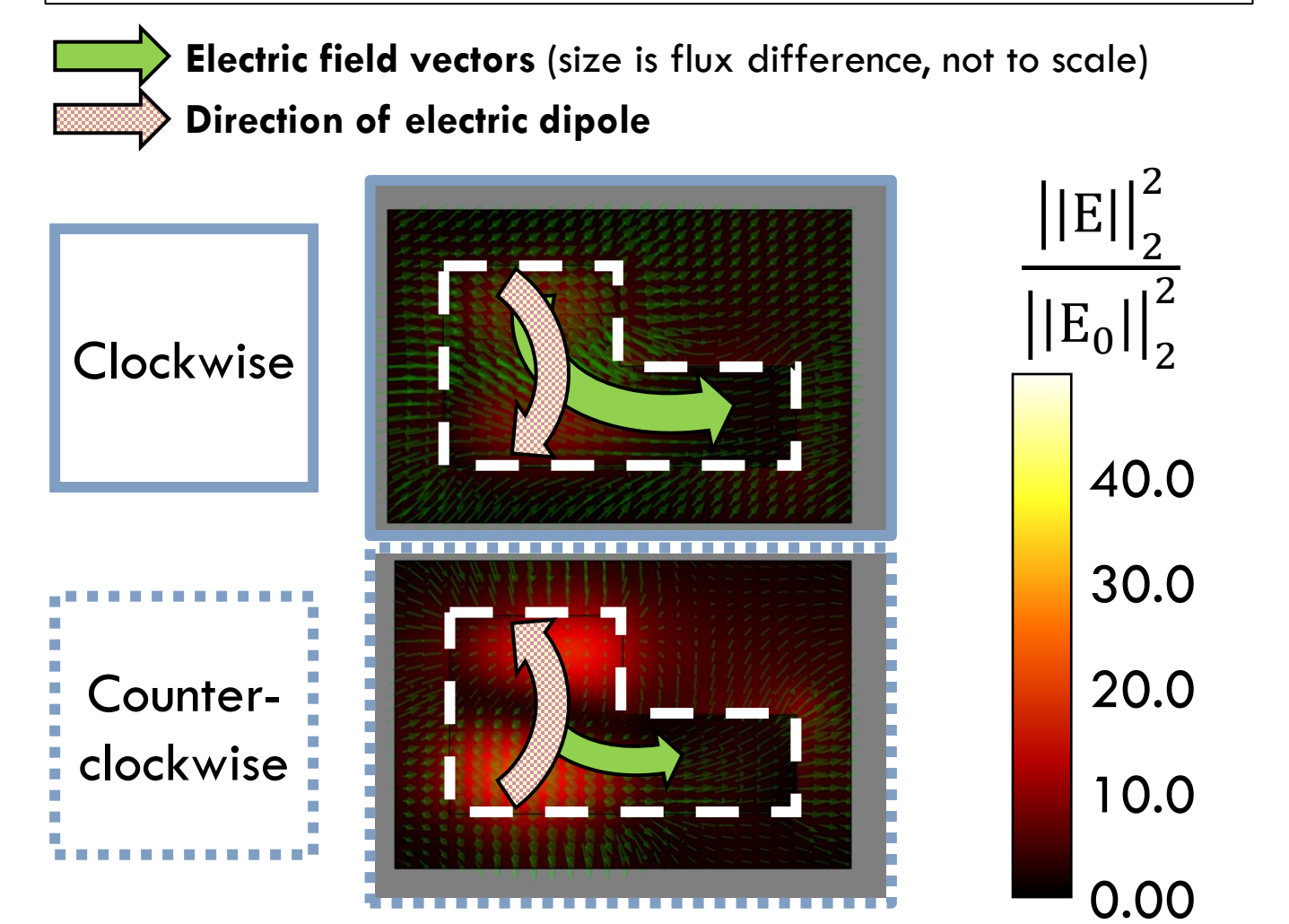
Biological media with fibrous structures can alter light polarization, an agnostic indicator of life [1,2]. **Designing nano-optical arrays enables miniaturized optical sensors for polarized light, which may be useful for *in-situ* investigations.** Our study showed that nano-optical arrays can differentiate clockwise and counter-clockwise circularly polarized light, **allowing colorimetry homochirality detection (see Figure 6).**

Figure 6: Colorimetry using medium-cut rectangles.



However, the reason for this remains unclear. Figure 7 suggests that under clockwise light, the dipole charge aligns with the sideways flux, reducing light reflected towards the imaging apparatus. Under counter-clockwise light, the dipole charge opposes this flux. This could explain the disproportionate dampening in reflectance and the distinct colorimetry results.

Figure 7: Near-field of medium cut rectangle.



## Literature cited

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## Further information

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