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Nano structuring of silicone elastomers for optical applications

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Abstract

Color pixels composed of plasmonic nanostructures provide a highly promising approach for new display technologies, capable of vivid, robust coloration and incorporating the use of low-cost plasmonic materials.[1] Silicone elastomers, usually in the shape of polydimethylsiloxane (PDMS) elastomers, are commonly used to replicate structures mainly on the micro scale but recently also on the nano scale. PDMS dielectric elastomers are promising materials and have the potential to be used in novel applications, especially due to the ability to be formed into complex shapes and still provide actuation.[2] This work deals with the development of *PDMS based silicone elastomers* with the ability to easily *replicate structures on the nano scale of the silicon (Si) stamps* in order to achieve the *color tuning* for potential optical applications.

Keywords: silicone, PDMS elastomer, plasmonic color, replicate nanostructure, optical applications

1. Introduction

Silicone elastomers with nano structures have been used for waveguides (Fig.1).

Nano structures covered with metal (e.g. silver) cause plasmonic colors. A plasmonic array device changing color by mechanical deformation has been fabricated (Fig.2).[1]

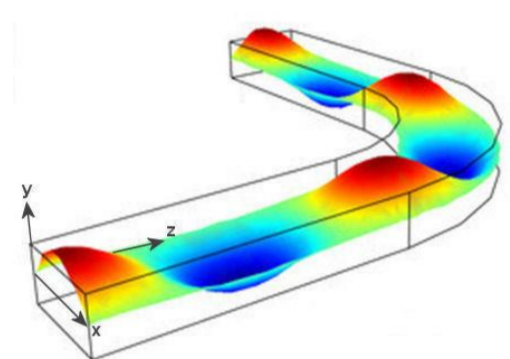


Figure 1. An illustration of a waveguide.

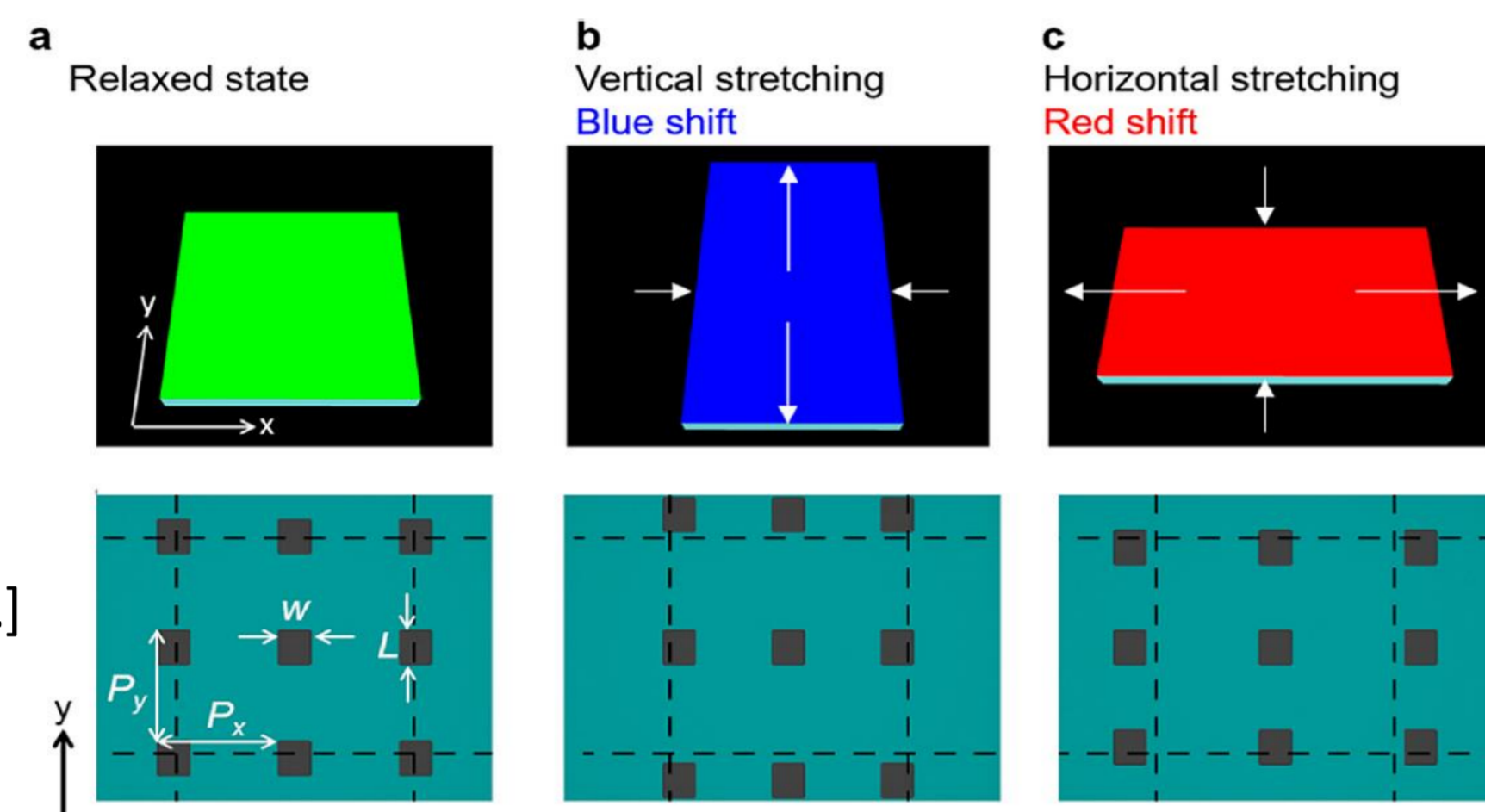


Figure 2. Working principle of the stretchable plasmonic device. Top: (a, b, c) color change of the device under different stretching conditions. Bottom: corresponding schematic of the nanostructure array.

2. Experimental

Materials

Mold: Si stamp

PDMS elastomer: Sylgard 184 from Dow Corning

Preparation

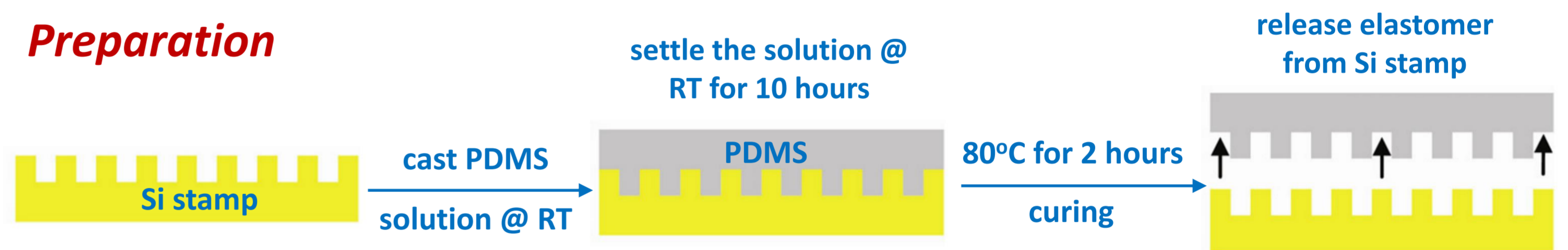


Figure 3. Fabrication process of PDMS reproduction with replicate nanostructures on the Si stamp.

3. Results

Appearance

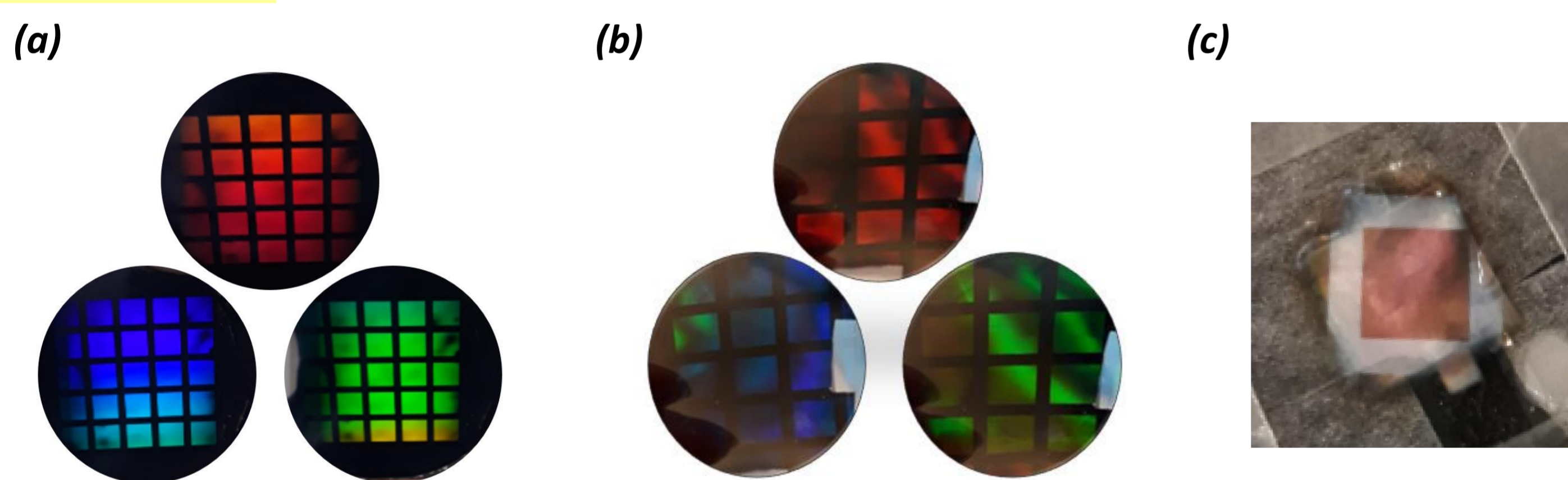


Figure 4. The Si stamp shows reflection colors from different angles (a), PDMS reproduction shows reflection colors from different angles (b), PDMS reproduction shows plasmonic color observed perpendicularly (c).

Structure

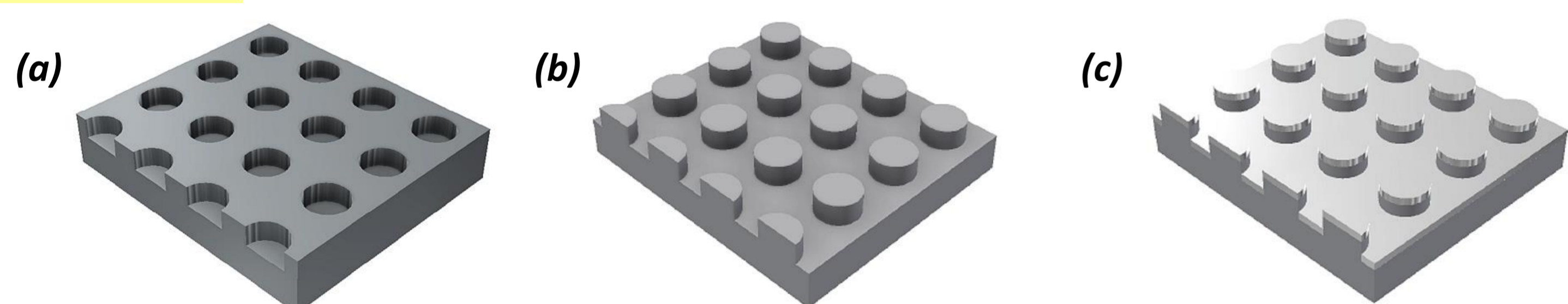


Figure 5. The Si stamp with nanopillar array (a), PDMS reproduction (b), PDMS reproduction after silver deposition (c).

Morphology

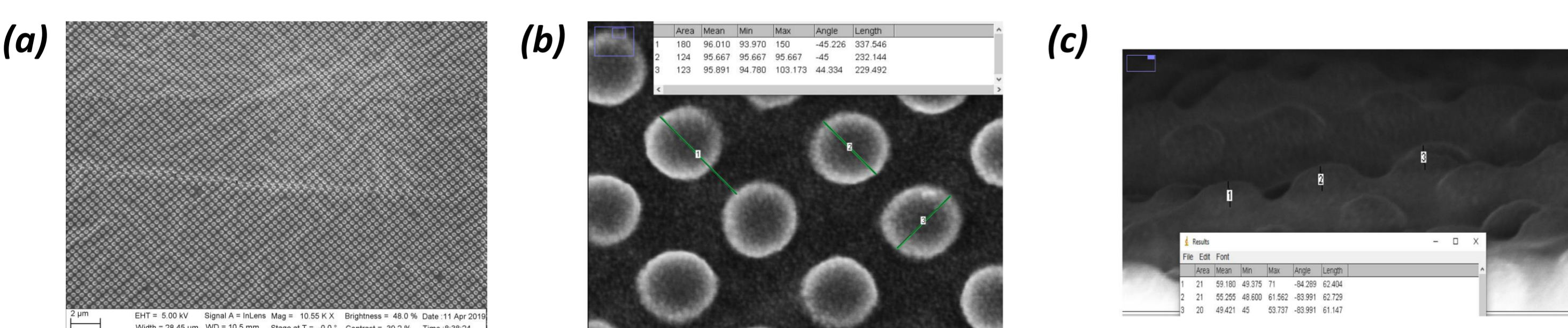


Figure 6. SEM images of the top surface (a, b) and cross-section (c) of the PDMS reproduction.

Table 1. Dimension parameters of the Si stamp and PDMS reproduction.

	Pillar diameter (nm)	Pillar spacing (nm)	Pillar height (nm)
Si stamp	200	400	200
PDMS reproduction	230	340	60

Color tuning

Mechanical deformation

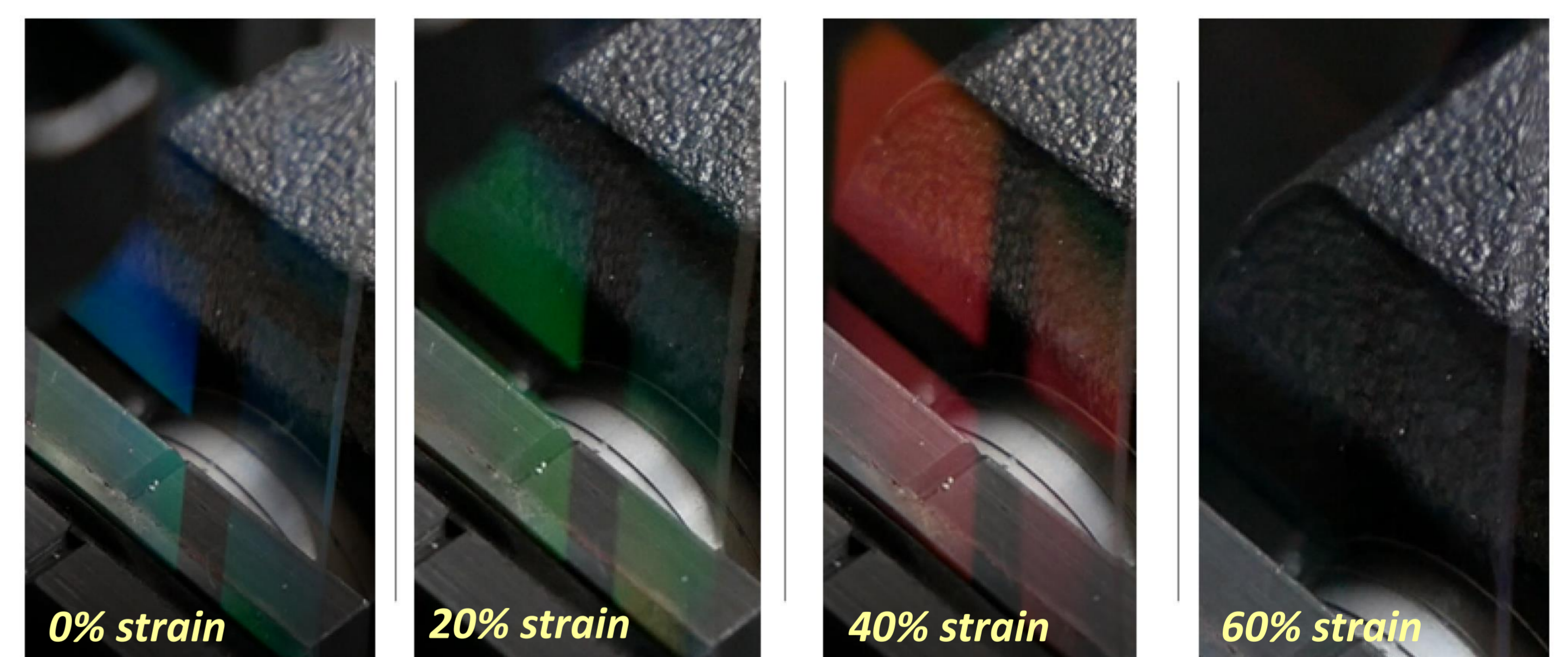


Figure 7. Color tuning via vertical stretching.

Electrical deformation

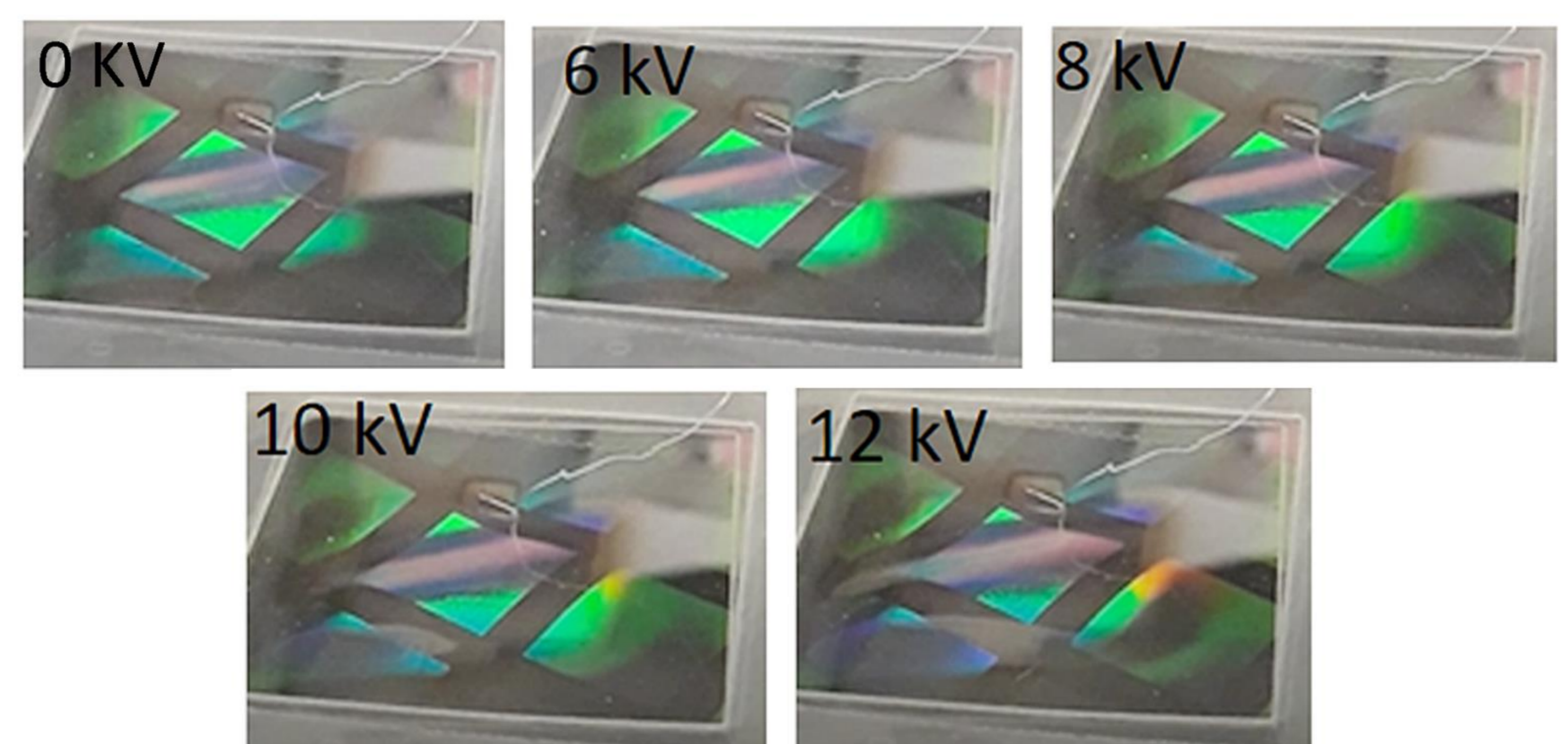


Figure 8. Color change via electrical actuation.

4. Conclusions

This work investigated the fabrication methods to create a dielectric PDMS elastomer embedded with nanostructures. After obtaining the PDMS reproduction, the surface with *reflection* and *plasmonic colors* can achieve color tunable if the array structure of the nanopillars is altered through the *mechanical* or *electrical deformation*. The color change response depends on the mechanical and dielectric properties of the PDMS elastomers. This design strategy has the potential to open the door for next-generation flexible photonic devices for a wide variety of visible-light applications.

Acknowledgments

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