# Optimization of Block Copolymer Patterning for Complex Oxide Thin Films


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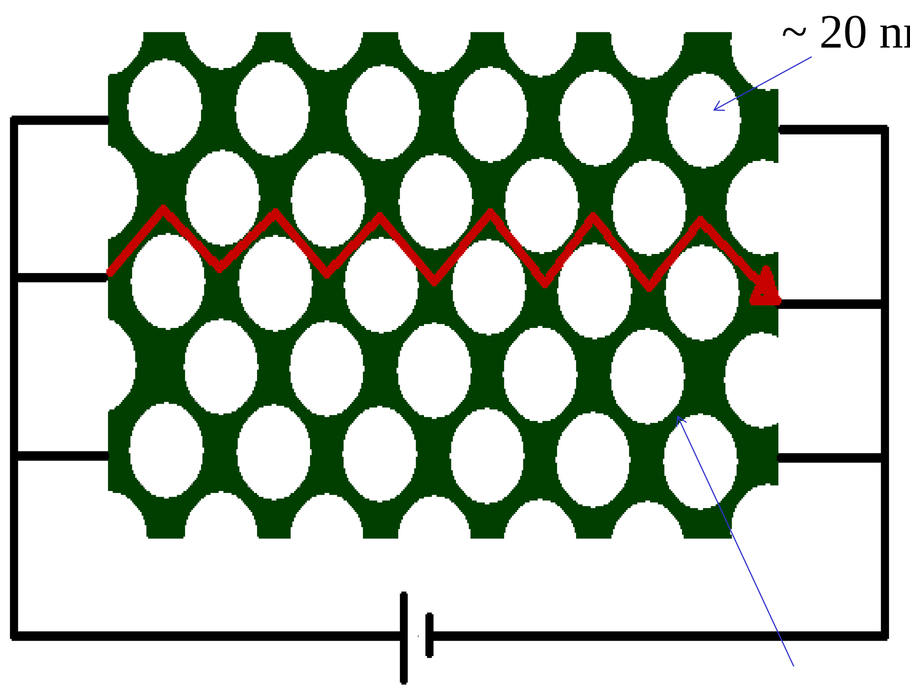
## Introduction

The basic purpose of this study is to optimize the block copolymer (BCP) template patterning method to a magnetic complex oxide- $La_{0.5}Sr_{0.5}CoO_{3-\delta}$ (LSCO). Utilizing this optimized BCP mask, anti-dots (holes) are created in LSCO to create nanopaths for electronic conduction. Further studies of magneto-transport properties of LSCO films are possible with size tuning of the nano constrictions.

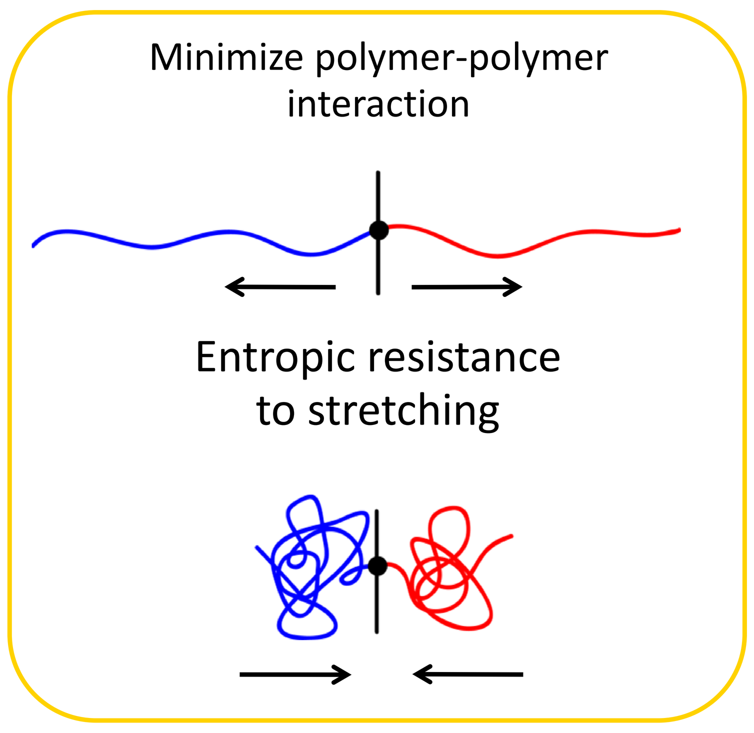
## Motivation

BCP lithography is the current way to make an ideal nano wire by constructing a “grid” arrangement. The scale of nano constrictions is related to the size of anti-dots so that one can study the relationship between magneto-transport properties and width of nanopaths.

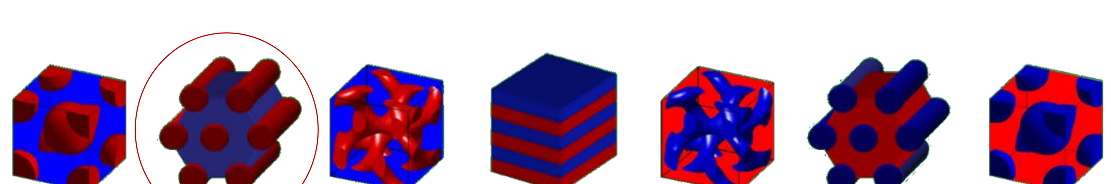



## Methodology: BCP Template Preparation

BCPs are microphase separated chains of two different polymers




Controlling of the molecular weight of each block can tune feature size, pitch (center-to-center distance) and morphology.




The hexagonal cylindrical patterning is desired to produce anti-dots structure.

Polystyrene-polylactide (PS-PLA) was used here to form the cylindrical structure as a mask for anti-dot formation. The composition of block copolymer and dimensions of the cylinders were chosen as:

PS-PLA (64 kg/mol):
PLA phase fraction = **28%**
Pore diameter = **30 nm**
Pore height = **55nm**
Center-to-Center distance = **42nm**

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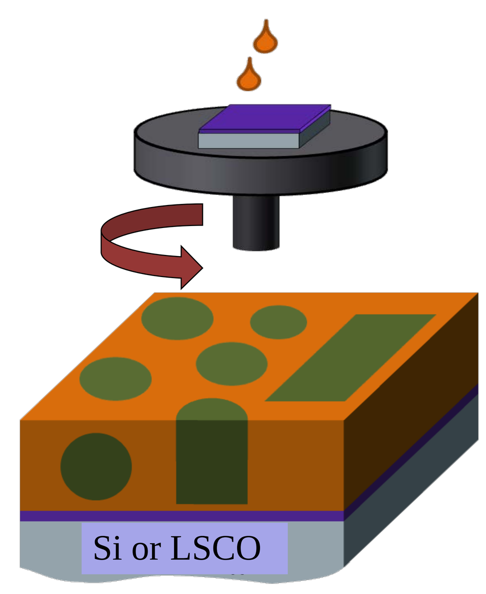
Orange-PS
Green-PLA




The first step was to spin coat PS-PLA on a Si wafer or LSCO thin film.

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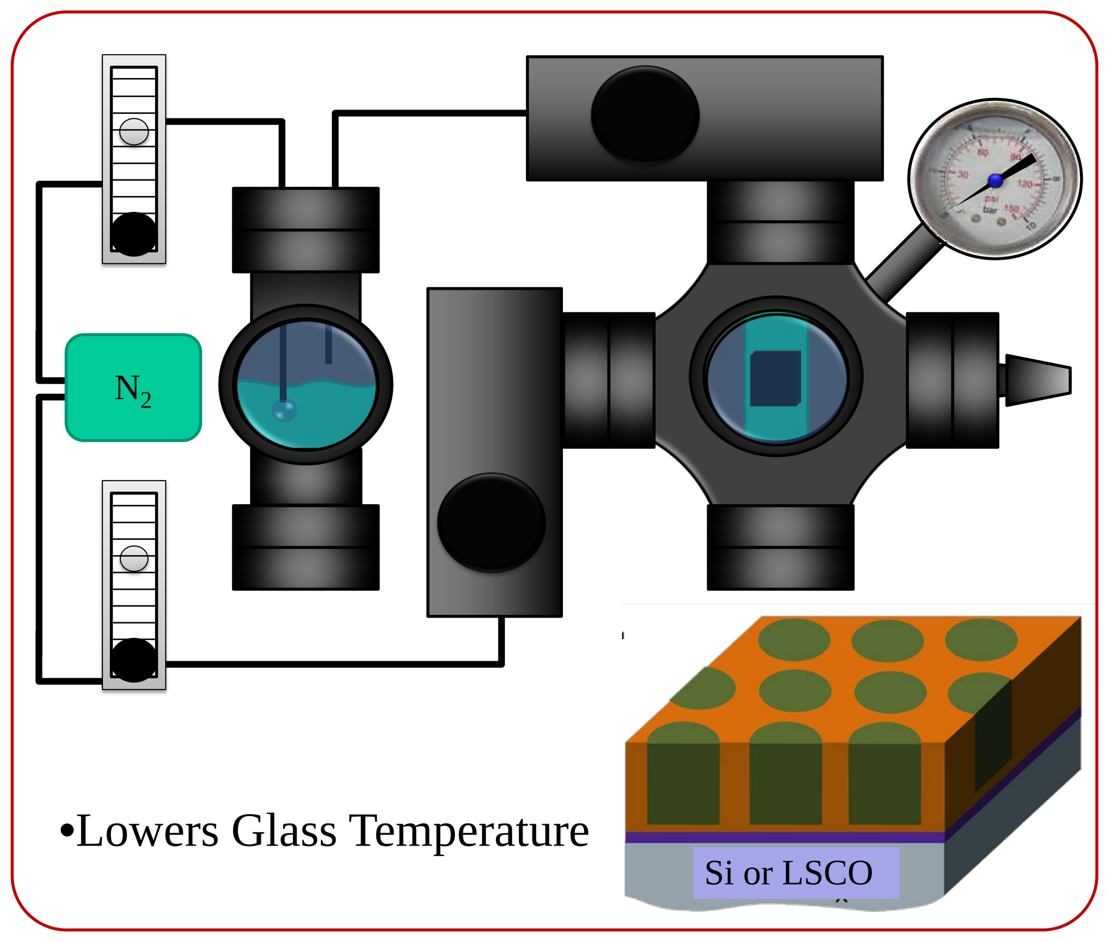


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Then solvent-annealing process was applied to swell the PS-PLA so that the PLA blocks can order vertically.

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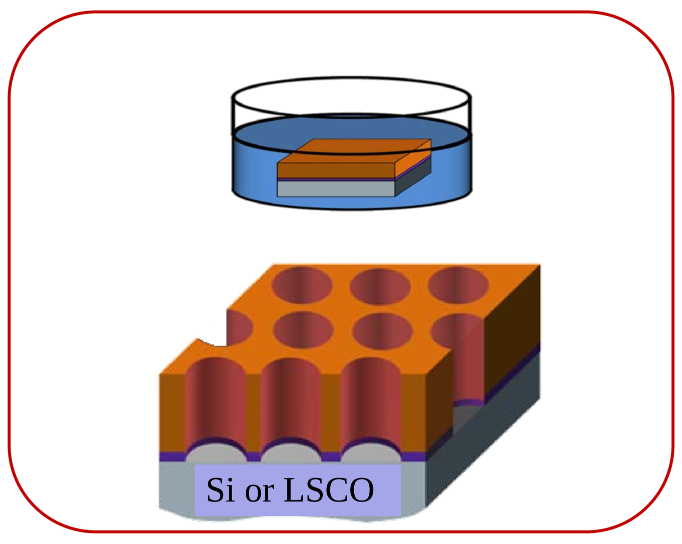


Finally the PS template was produced by degrading the PLA by basic treatment.

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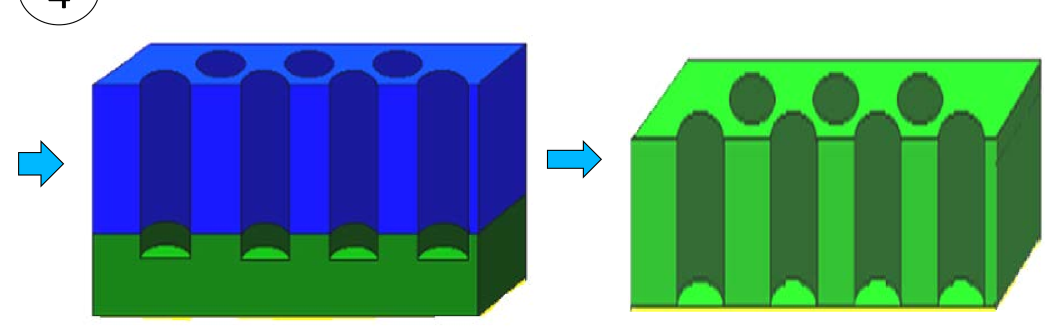
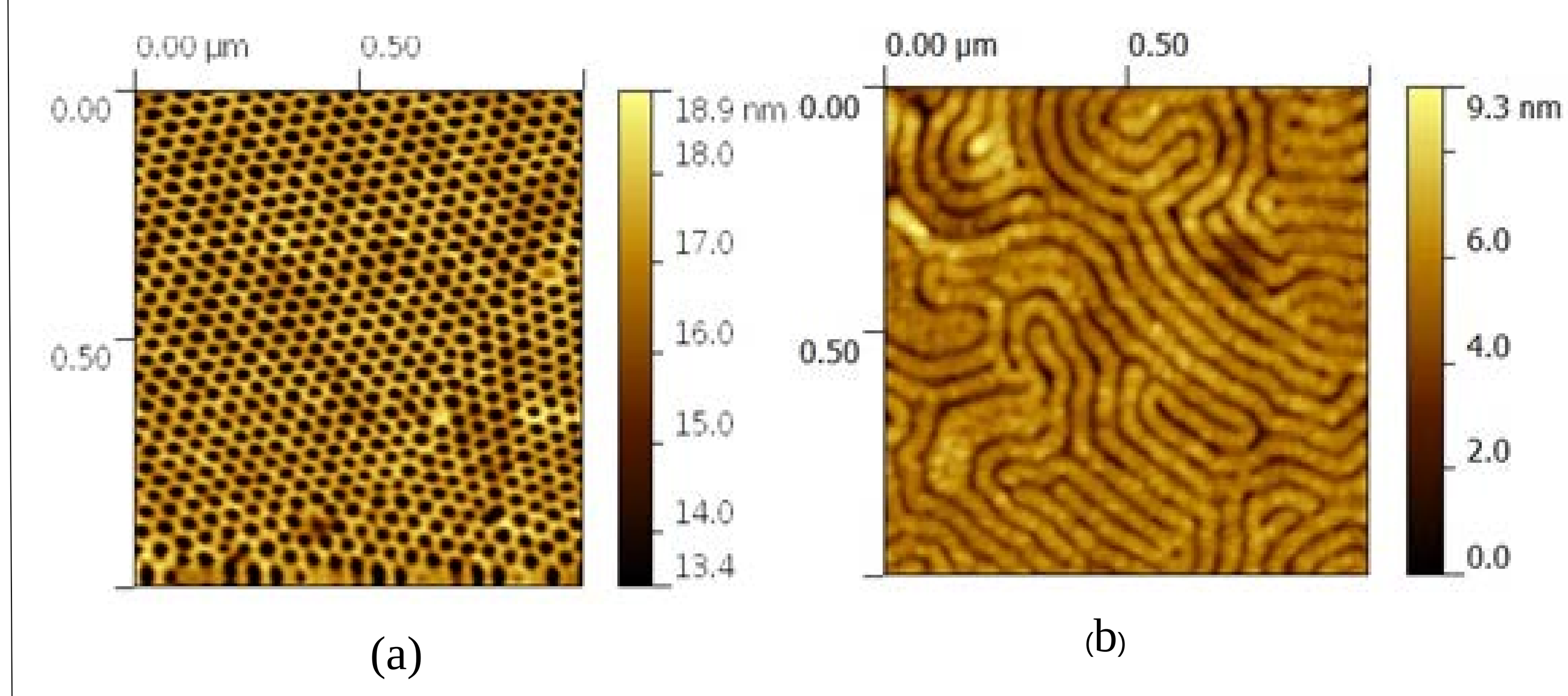


Blue-PS; Green-Si or LSCO

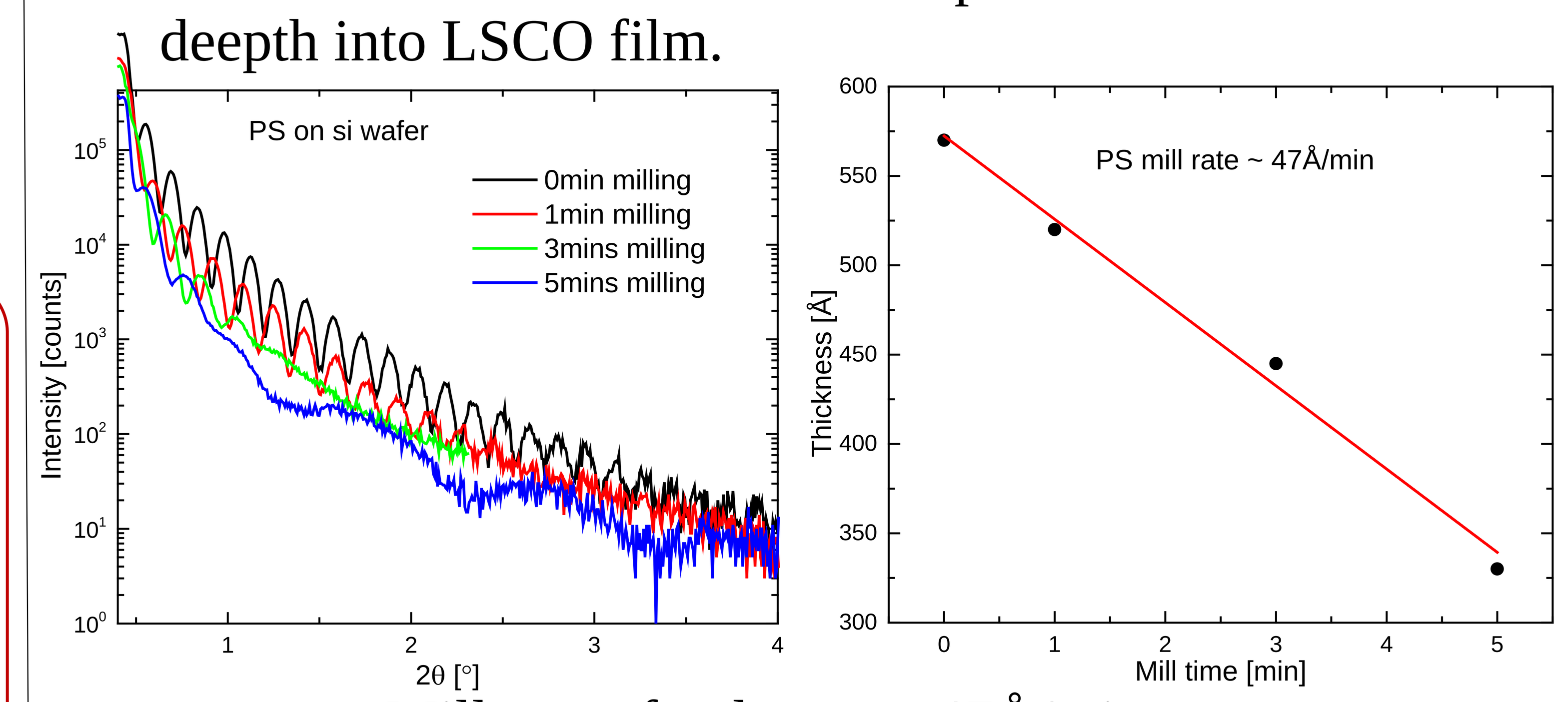
Normal incident ion-milling subsequently mills away both PS and materials from template and Si or LSCO from the top, leaving holes on top of the wafer. The remaining PS template can be removed by heating.

## Results

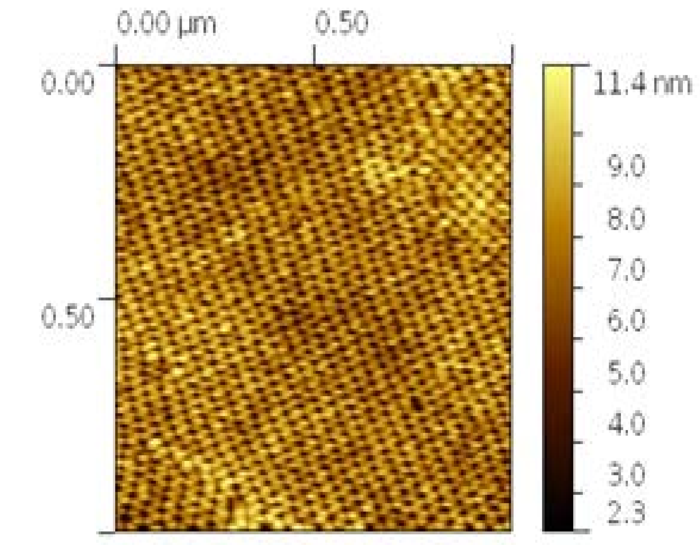



Atomic force microscope (AFM) image of PS template on (a) Si and (b) LSCO films before milling.

- Vertical cylindrical template was achieved on a Si wafer but horizontal alignment was generated on LSCO film.
- The milling rates of polymer and LSCO films were measured in order to explore the hole deepth into LSCO film.




Mill rate of polymer ~ 47Å/min
Mill rate of LSCO film 18Å/min




AFM images of Si wafer after milling for 3 minutes

## Conclusion

- Polymer template is achieved on both LSCO thin film and Si wafer.
- Mill rate of PS is 2.6 times to that of LSCO.
- Preliminary ion-mill experiments of PS template on Si wafer were successful.

## Future Goals

- Further research will be done to achieve optimized PS template formation of on top of LSCO and study why horizontal cylindrical patterning were created instead.
- More study will be focused on size tuning of nanopaths
- Studies of magnetotransport mechanism on patterned LSCO will be performed.

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