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Block Copolymer Self-Assembly based nanopattern creation for sub-16 nm device fabrication

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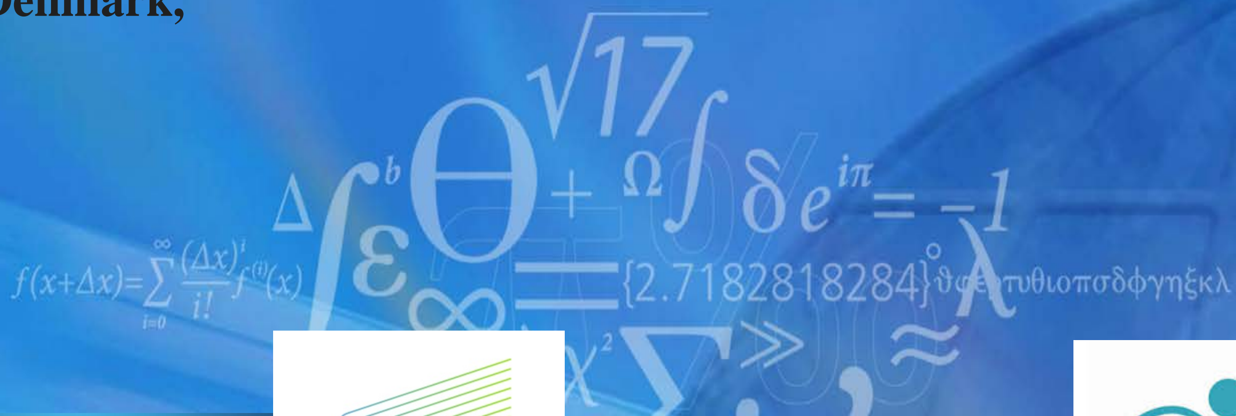

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Why and How ?

- To continue Moores' law/ statement …
- Betterment and strong demand for ICT
- Top-Down approach(Advanced Lithographic techniques)
- Bottom-Up approach(Block copolymer self-assembly)

Diblock copolymer self-assembly

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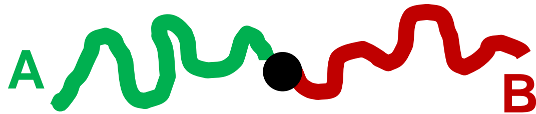
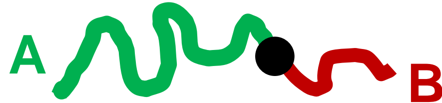
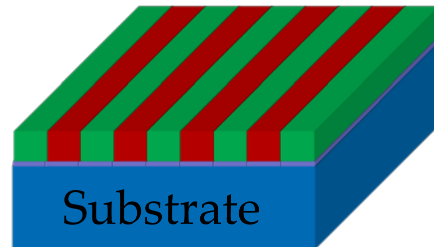
Symmetric Diblock Copolymer



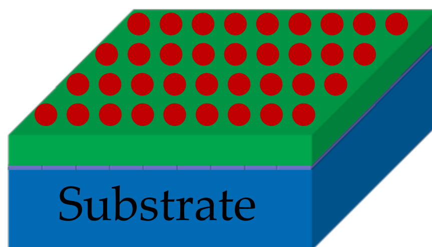
Asymmetric Diblock Copolymer



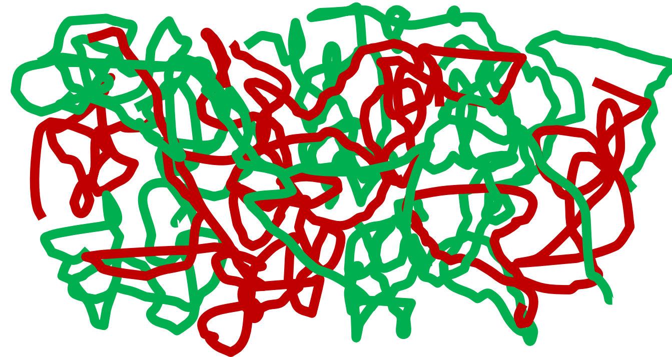
Symmetric Diblock Copolymer



Asymmetric Diblock Copolymer

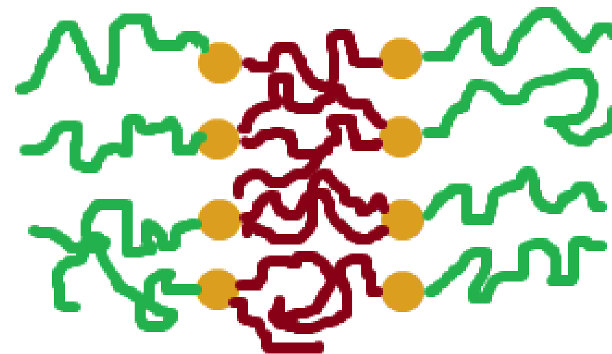


Entangled Polymer Chains



Annealing above Tg

Phase separation after annealing

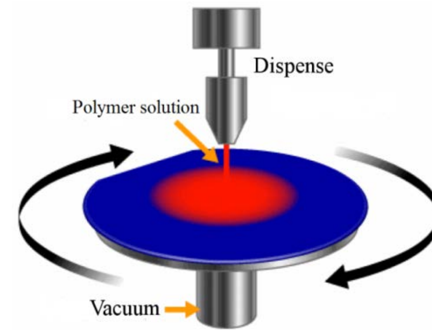


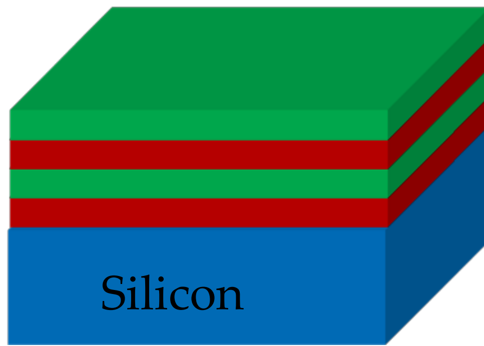
Two BCP systems:

- PS-*b*-PMMA, PS (polystyrene) - PMMA (polymethylmethacrylate)
- PS-*b*-PDMS, PS (polystyrene)- PDMS (polydimethylsilixane)

Preparation and orientation of diblock copolymer thin film

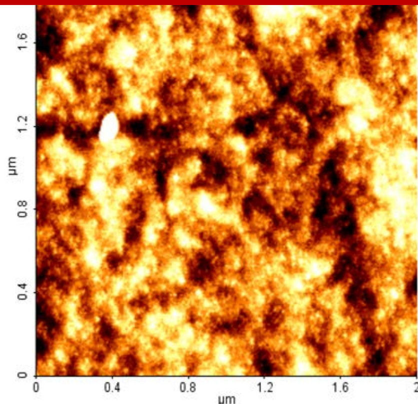
- Spin coating for 30sec with ramp of time 5sec
- Uniform film thickness
- Low surface roughness

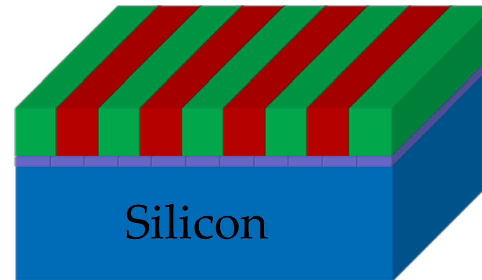




Parallel orientation

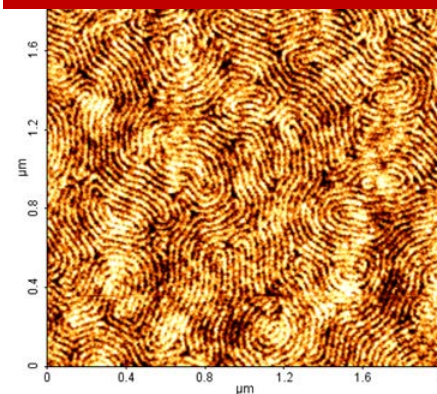
PS-b-PMMA(18k-18k)





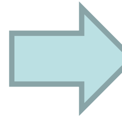
Perpendicular orientation

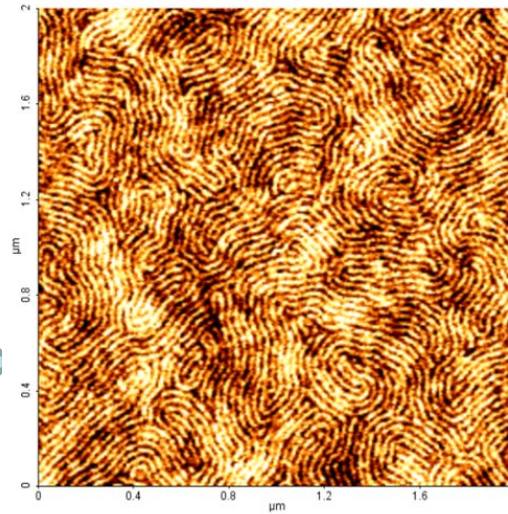
PS-b-PMMA(18k-18k)

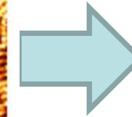


Nanowire fabrication using PS block as a soft mask

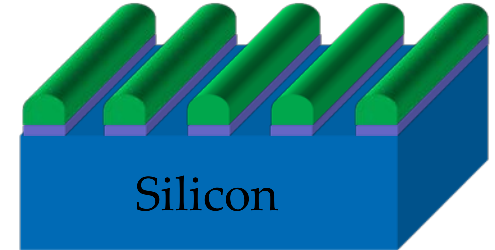
Surface
Neutralization

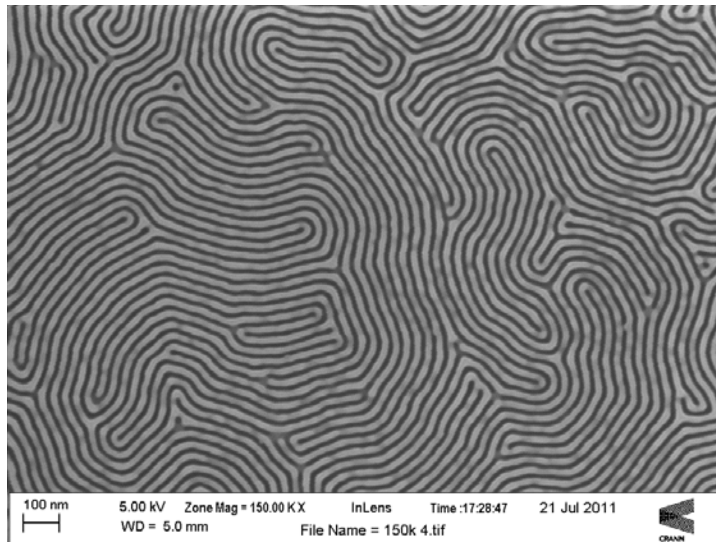


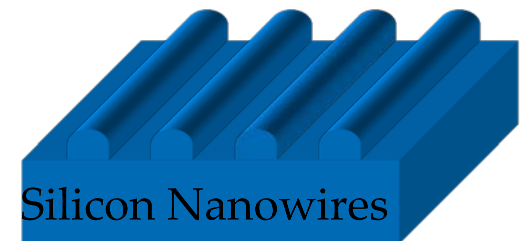




Selective etching of
PMMA block







High resolution TEM images

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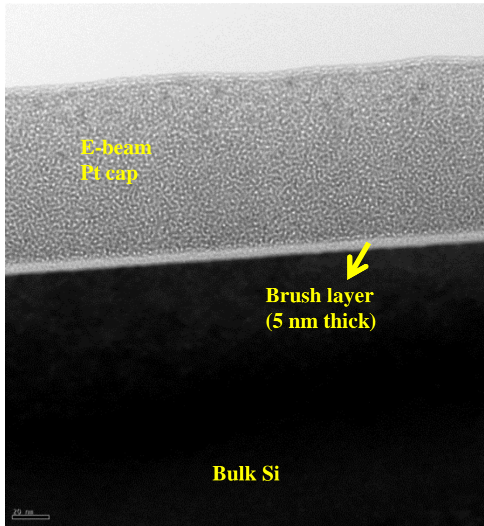
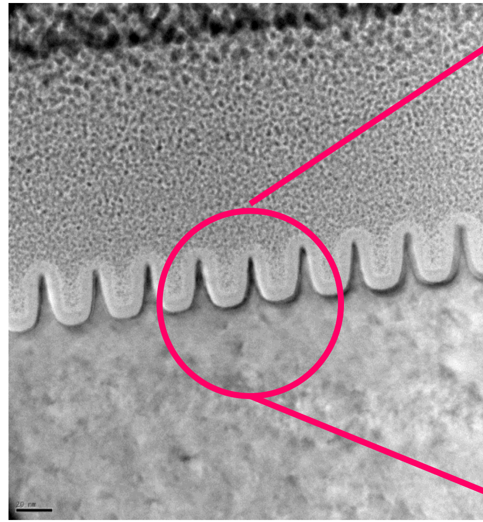
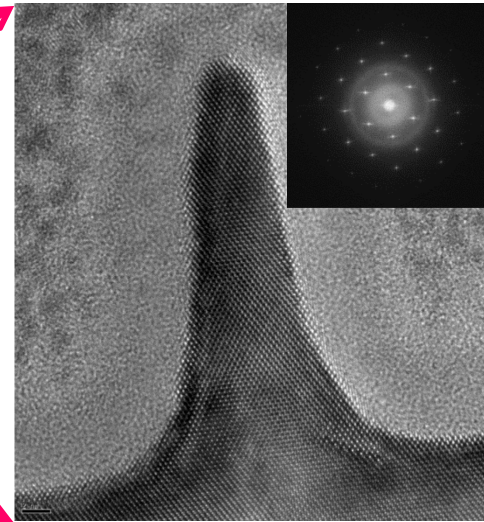
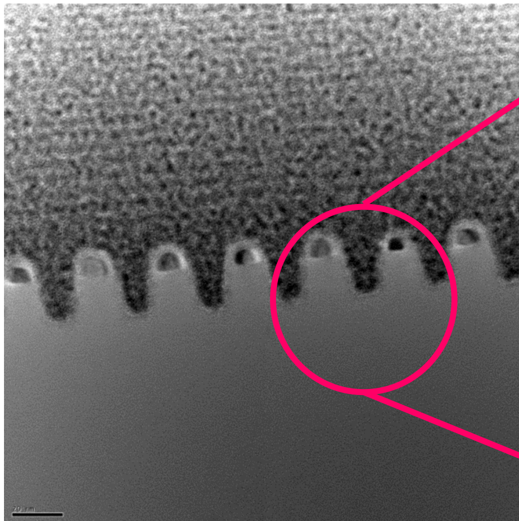


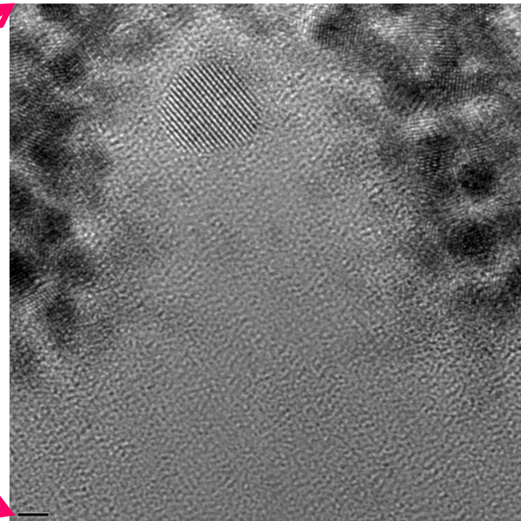
PS-r-PMMA brush layer





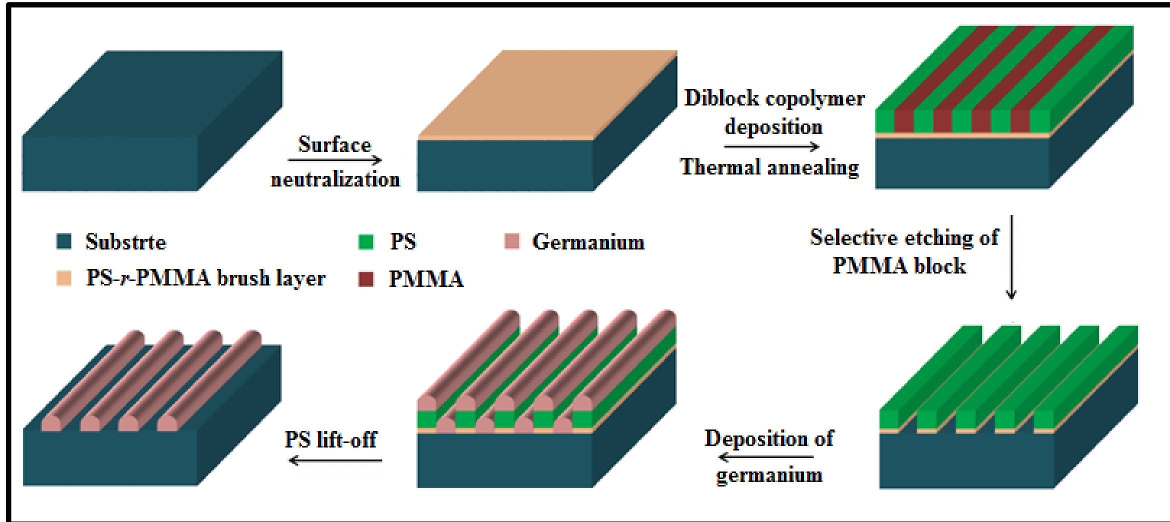
8 nm Silicon nanowires





Si nanowires developed in SOI substrate

Fabrication of Germanium nnaowires



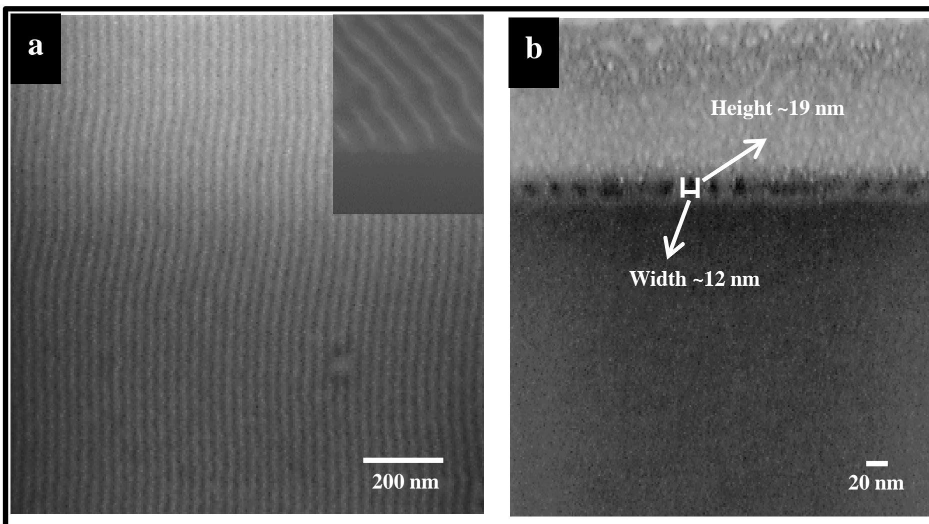


Figure 1. (a) Top-down SEM image of the PS template created by a selective
etch of the PMMA block. Inset (b) is the cross-section SEM image.
(b) FIB cross-section image of PS template.

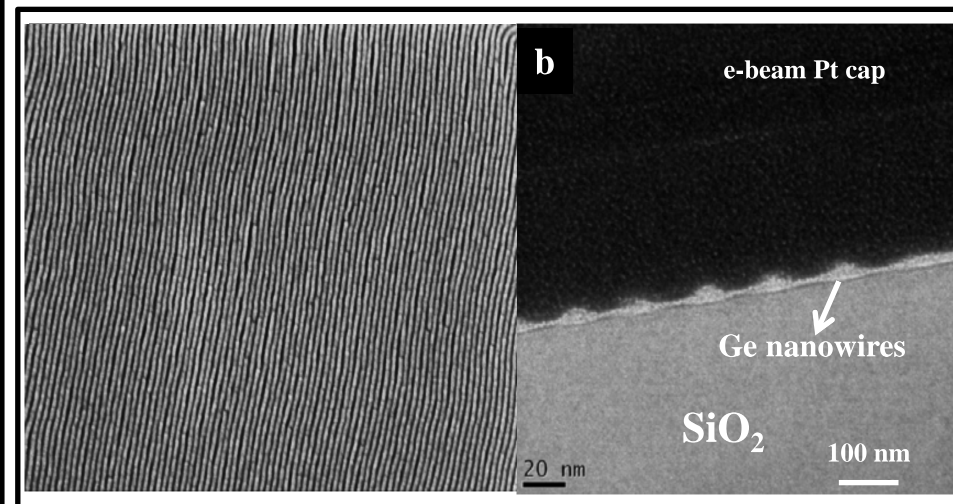


Figure 2. (a) Top-down SEM image of GeNWs obtained after PS lift-off (b) Bright-field TEM cross-section image of GeNWs obtained after PS lift-off.

Rasappa, S., D. Borah, et al. (2013). "Fabrication of Germanium Nanowire Arrays by Block Copolymer Lithography." *Science of Advanced Materials* 5: 1-6.

Fabrication of *3-D* Copper nanowires

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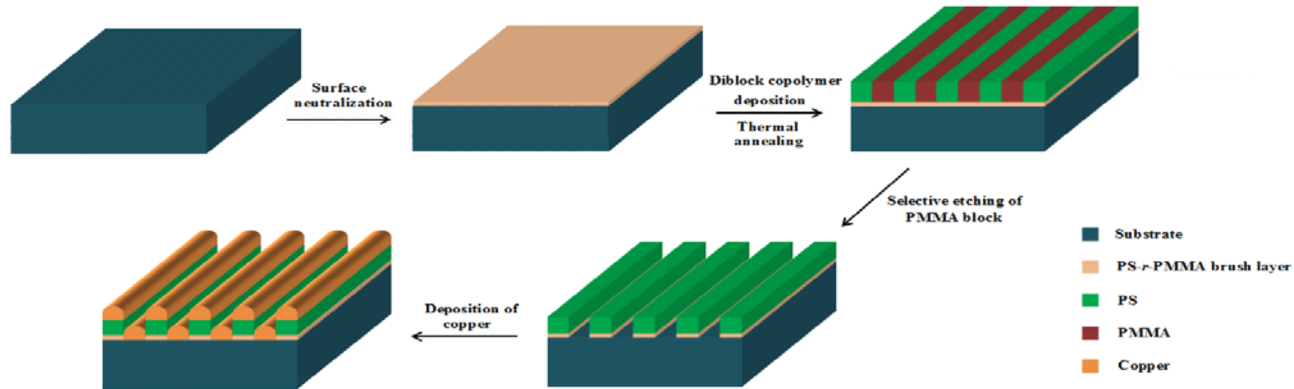
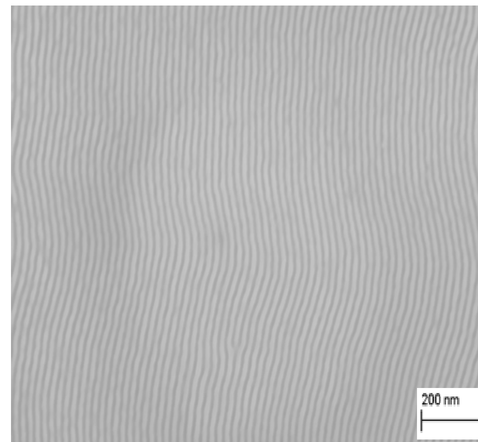
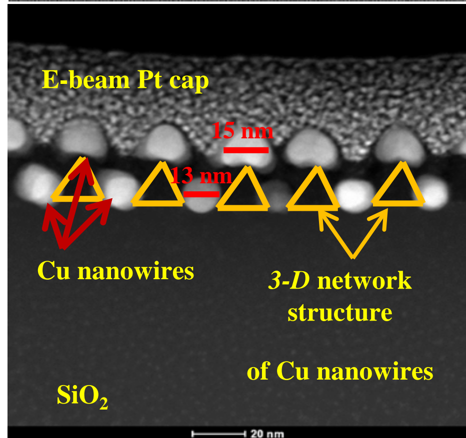


a

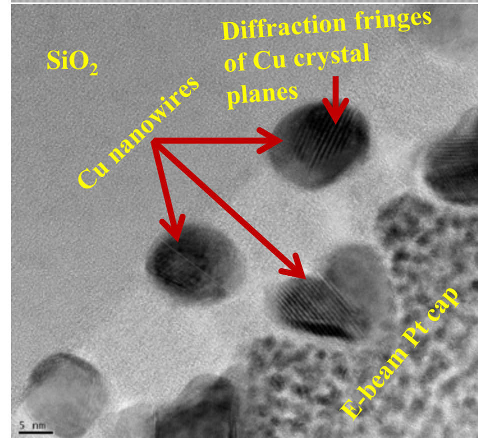
b



c

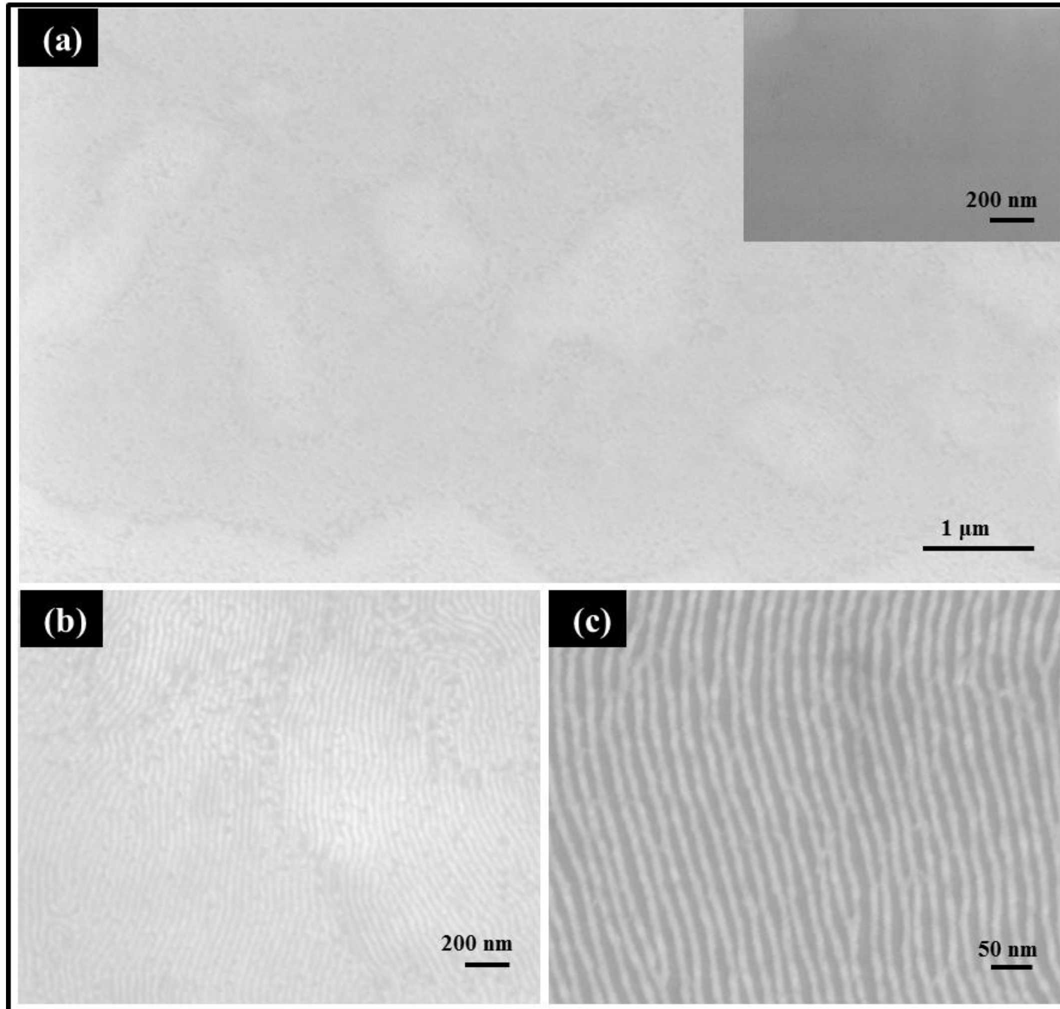


d



(A) Top-down SEM image of PS template
(b) Top down SEM images after copper deposition
(c) Dark-field and
(d) bright-field TEM cross-section images of Cu nanowires with *3-D* geometry.

PS-*b*-PDMS based sub-16 nm device structures



Top-down SEM images of PS-*b*-PDMS in 4 Inch wafer. (a) Top-down SEM image of PS-*b*-PDMS after PDMS removal and inset shows PS-*b*-PDMS before upper PDMS removal which shows no patterns. (b and c) Low resolution and high resolution of oxidised PDMS cylinders.

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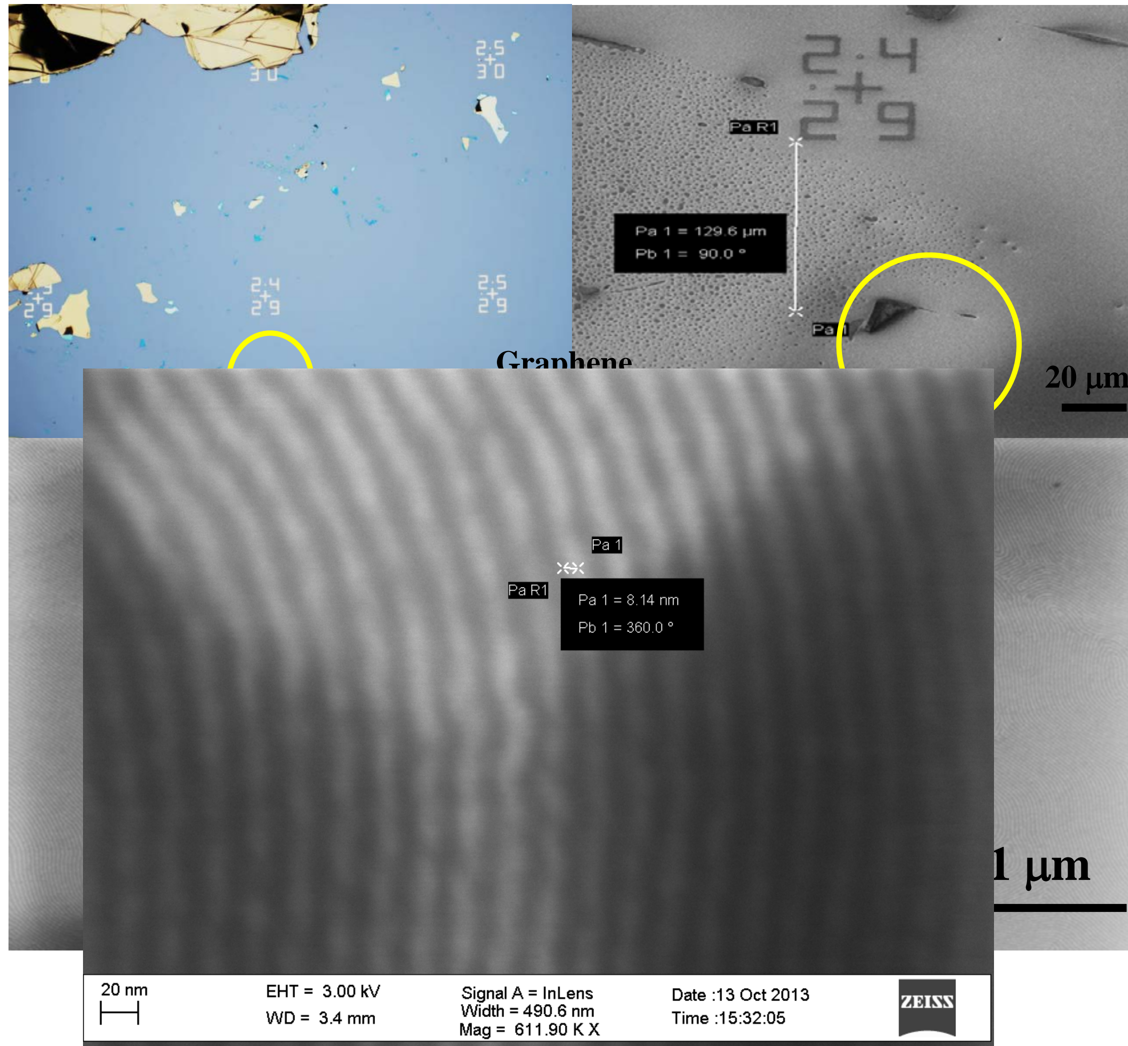
Future Work Graphene

PS-b-PDMS on Graphene



Conclusions:

- BCP is the potential candidate for low feature size device fabrications.
- BCP can acts as a template to fabricate cost effective metal and metal-Oxide structures for real device applications.
- BCP is a breakthrough for Graphene nanopatterning

Thanks You so much.,…… Looking forward for Expo 2020