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

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Publication date: 2013

Citation (APA):
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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

Symmetric Diblock Copolymer

Asymmetric Diblock Copolymer

Symmetric Diblock Copolymer

Entangled Polymer Chains

Annealing above Tg

Phase separation after annealing

Substrate

Substrate
Two BCP systems:

- PS-$b$-PMMA, PS (polystyrene) - PMMA (polymethylmethacrylate)
- PS-$b$-PDMS, PS (polystyrene) - PDMS (polydimethylsiloxane)
Preparation and orientation of diblock copolymer thin film

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

Parallel orientation

Silicon

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

Perpendicular orientation

Silicon

PS-b-PMMA(18k-18k)
Nanowire fabrication using PS block as a soft mask

Surface Neutralization

PS-r-PMMA

Silicon

Selective etching of PMMA block

Silicon

Silicon Nanowires
High resolution TEM images

PS-r-PMMA brush layer

Brush layer (5 nm thick)

Bulk Si

8 nm Silicon nanowires

Si nanowires developed in SOI substrate
Fabrication of Germanium nanowires

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.

Fabrication of 3-D Copper nanowires

(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.
Future Work

Graphene

PS-b-PDMS on Graphene
Conclusions:

- BCP is the potential candidate for low feature size device fabrications.
- BCP can act 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