Plasma etch resistivity of high molecular weight microphase separated PS-b-PVP block copolymers

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Motivation

- Pattern transfer in block copolymer lithography relies on good etch selectivity between block copolymer components
- Common examples with high etch selectivity suffer from either low γ-values (PS-PMMA, PS-PB, PS-PEO) or from extra steps in pattern fabrication (PS-PDMS)
- Introduction of inorganic constituents offers the potential for materials with useful physical or chemical properties to be directly fabricated from the block copolymer film, giving functional, as opposed to sacrificial, resist materials
- Inorganic-organic block copolymers have high γ-values and sufficient etch selectivity, however metal-containing structures are undesirable in semiconductor fabrication
- Universal approaches to tune etch resistivity of polymer materials are sought for

Bottom-to-top approach towards polymer-inorganic composites

- Blending homopolymers with PEOS silica precursor polymer – hyperbranched polyethoxysiloxane
- Advantages:
  - Metal free inorganic-organic composite
    - homogeneous distribution of liquid precursor in the polymer matrix
- Challenge 1: mechanism of PEOS/TEOS conversion to SiO, upon plasma etching
- Challenge 2: effect of the film processing on the distribution of the precursor in the polymer

Processing under controlled solvent vapor atmosphere

Set up for in-situ ellipsometrie measurements

Swelling of polymer films under controlled solvent vapor annealing

Swelling steps of PS-b-P2VP film at varied temperatures of the substrate and of the chloroform vapor

Selectivity of swelling of homopolymer and PS-b-P2VP block copolymer film under controlled partial vapor pressure of chloroform

Tuning etch resistivity of common polymers

AFM images of homopolymers as a function of PEOS concentration before annealing

PMMA:
- Distribution of PEOS in each homopolymers is different:
  - PMMA: PEOS is assembled in bubbles
  - PS-PVP: PEOS cluster on surface of polymer
  - PS: PEOS partially cluster on surface, but are also distributed beneath the surface

Summary & Outlook

- Set-up realized for accurate process control during vapor annealing of BCP films
- BCP film sensitivity to process parameter changes demonstrated:
  - BCP film morphology guided by substrate and vapor temperature
  - BCP film swelling, i.e. unit cell structure, is guided by vapor temperature
- PEOS loading with different wt.% of homopolymers PMMA, PS and PVP demonstrated
- Etch rates of homopolymers with and without PEOS determined
- PEOS incorporation seems to alter the PVP etching behavior – further experiments for confirmation are needed
- Continuation of experiments with higher PEOS loading in homopolymers
- Etching of ordered BCP film with (partially) incorporated PEOS

Nanopatterns from high molecular weight block copolymers

Applications of high molecular weight BCPs: optical gratings, guiding patterns for DSA
- Challenge: low mobility for processing

AFM height images of surface structures of PS-b-P2VP films

Morphology is sensitive to vapor/substrate temperature

Half-layer standing lamella and perforated lamella

Degree of swelling guides the parameters of the unit cell of the structure

Height: 5nm

Etching of PS-b-P2VP with CHF₃/SF₆/O₂ Plasma in RIE set-up

Before PS-b-P2VP template with stripe morphology before and after etching

Profile of striped template before and after etching

PS-b-P2VP template with perforated morphology before and after etching and etched Si without BCP remains

Profile of perforated template before and after etching and etched Si

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