Preparing Arrays of Nanoscale Magnetic Dots to be used for Future **Extremely High Density Recording (EHDR) Hard Drives** using Block Copolymer Thin Films and Spin-on Glass

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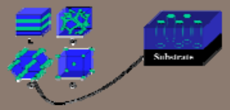
Introduction

As the hard drive industry reaches a limit in storage density using conventional techniques, there becomes a need to create magnetically isolated nanodots that may allow for higher density recording. To do this, block copolymers have been proposed to be used as templates for fabricating large-scale arrays of these magnetic dots. When spin coated into a thin film, polystyrene-polyisoprene-polylactide (PS-PI-PLA) triblock terpolymer self assembles into a hexagonally packed lattice of cylindrical features perpendicular to the surface. After degrading the cylindrical component (PLA), we are left with an array of holes (antidots). The immediate goal of my research has been to use the described polymer film as a template for fabricating magnetic dots. Previous research [1] has used this method to create 40 nm dots.

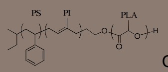
Background

•Weight fractions of polymers in block copolymer are altered to favor formation of cylinders

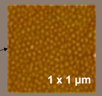


•Triblock polymers favor vertical orientation of cylinders in unannealed polymer films

Triblock

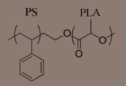


Vertical Orientation Of Cylinders



Phase separation dot patterns of PS-PI-PLA

Diblock



Cylinders Lying Down

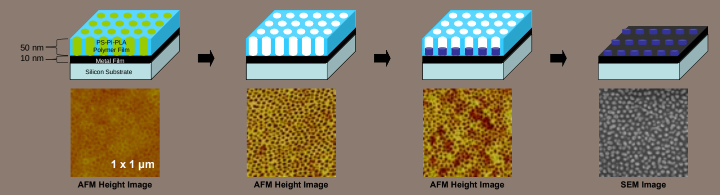
Cylinders lying down in phase separation image of PS-PLA

Creating a Glass Dot Template from a PS-PI-PLA Polymer using Dilute Spin-on Glass

Hypothesis

By using the outlined procedure we will first be able to create an array of nanoscale glass dots. Then, using a process called ion milling, we will be able to create a useful array of nanoscale magnetic dots.

Spin-coat PS-PI-PLA on silicon substrate coated with thin metal film → Degrade PLA in NaOH Solution → Spin-coat dilute spin-on glass over polymer film → Remove polymer with O_2 reactive ion etch



Discussion

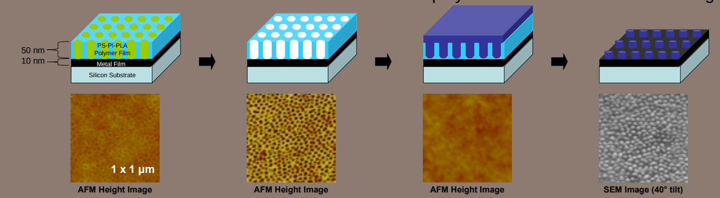
As seen in the diagram, the triblock polymer film spontaneously aligns into a hexagonally packed array of perpendicular PLA cylinders in a matrix of PS. After degrading, an array of holes (antidots) remains. Filling the resulting holes with a dilute concentration of spin-on glass and removing the polymer film with a reactive ion O_2 etch produces an array of glass dots. The diameter of the features (antidots or dots) remains constant throughout the process at approximately 35 nm. The height of the glass dots is approximately 5-10 nm. This height, however, does not provide enough material to mask the underlying metal film during the patterning process.

Creating a Glass Dot Template from a PS-PI-PLA Polymer using Concentrated Spin-on Glass

Hypothesis

By instead using a concentrated solution of spin-on glass, we will be able to create a more uniform array of taller glass dots. These dots will then provide enough material to act as a mill stop when patterning the underlying magnetic film.

Spin-coat PS-PI-PLA on silicon substrate coated with thin metal film → Degrade PLA in NaOH Solution → Spin-coat concentrated spin-on glass over polymer film → Remove excess spin-on glass and polymer with ion milling



Discussion

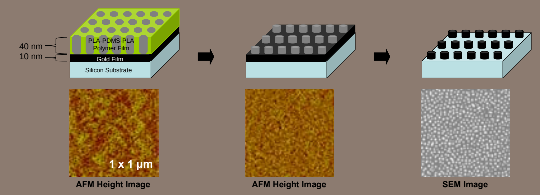
Different from the first method, using a concentrated solution of spin-on glass creates an excess layer on top of the polymer membrane. Ion milling is subsequently used to remove this excess spin-on glass and the polymer matrix. The result is a more uniform array of glass dots. This method produces glass dots with a height of approximately 30-40 nm. Consequently, there exists more material to act as a mill stop when patterning the underlying metal film. However, presumably due to the lack of adhesion between the glass dots and the metal film, it has proven difficult to proceed with this patterning.

Creating Gold Dots from a PLA-PDMS-PLA Polymer Template

Hypothesis

Since PDMS is more resistant to O_2 reactive ion etching than PLA, we may create SiO_2 dots with one etching step, and create metal dots with one additional milling step thus simplifying the pattern transfer process. This process may then be used to pattern a magnetic material thus creating a useful array of nanoscale magnetic dots.

Spin-coat PLA-PDMS-PLA on silicon substrate coated with thin gold film → Selectively etch PLA with O_2 reactive ion etch → Pattern metal layer with ion milling



Discussion

Similar to PS-PI-PLA, PLA-PDMS-PLA forms vertically oriented cylinders upon spin-coating. However, PDMS is the minority component (cylinder) rather than PLA. As seen in the diagram, after an O_2 reactive ion etch, we are left with SiO_2 dots. After subsequent ion milling through the underlying gold layer, gold dots remain. This process has proven to be simple and the most promising for creating magnetic dots among those presented. The diameter of the dot features produced is approximately 17nm. This correlates to a hard drive density of approximately 1 Tbit/in^2.

Acknowledgements

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References

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Future Work

•Use the PLA-PDMS-PLA template to fabricate a useful nanoscale array of magnetic dots.
•Explore chemical polymer staining (e.g. ruthenium tetroxide) to make polymer films more robust and facilitate the magnetic material patterning process.
•Pursue chemical vapor deposition (CVD) as an intermediate patterning step.