Fabrication of Self Rolling Bi-morph Thin Films

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Abstract

- Thin film technology is well established in industry and academia. We attempt to create three dimensional self rolling structures. Through growing multilayers by e-beam deposition and/or sputtering deposition on a silicon substrate we can selectively deposit and etch elements in order to have free hanging portions of thin films that will roll in order to minimize its potential elastic energy. The alloys used were chosen for very specific magnetostrictive and thermal properties and our aim is to use these thermal and magnetic behaviors to control the radius of curvature of a self rolling structure. We chose galfenol and permalloy for their specific magnetic and thermal properties and we hope to use these properties to control the radius of curvature. The composition of the alloys were verified using EDS. These rolling structures can be used in actuators and sensors in industry.

Introduction

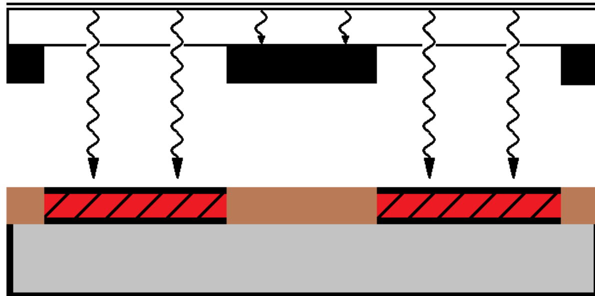
- We are trying to find methods to control the radius of self rolling thin films.
- Self rolling thin films have a wide range of uses in industry as micro actuators.
- It is expected to be able to make self rolling thin films and to be able to through magnetic field change the length of a sample therefore the radius of curvature.

Fabrication - Photolithography

A - Silicon Wafer

B - Add positive Photoresist

- Spin Coat and Bake



C - Expose to UV

D - Develop with MF-319

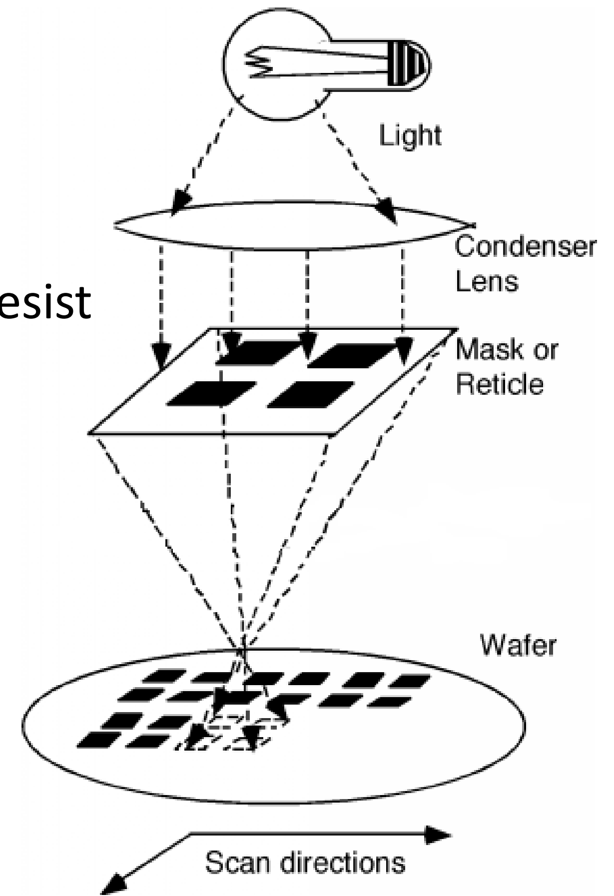
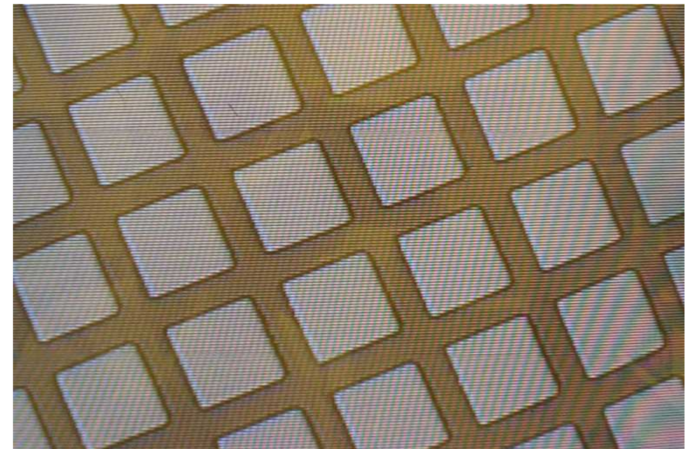


Figure 1 [6]

Creating Patterns

- Clean Silicon Wafer
  - Acetone 5 mins – H_2O 5 mins – Isopropyl Alcohol 5 mins
  - Contained in an ultra sonic cleaner
- Spin Coating
  - Cover with photoresist and spin at 4000 RPM
- Baking
  - Bake wafer at 125C for 75 seconds
- Exposure
  - Expose under a photomask of square pattern 50 um X 50 um with UV light
- Develop
  - Develop wafer with MF-319 for 45 seconds

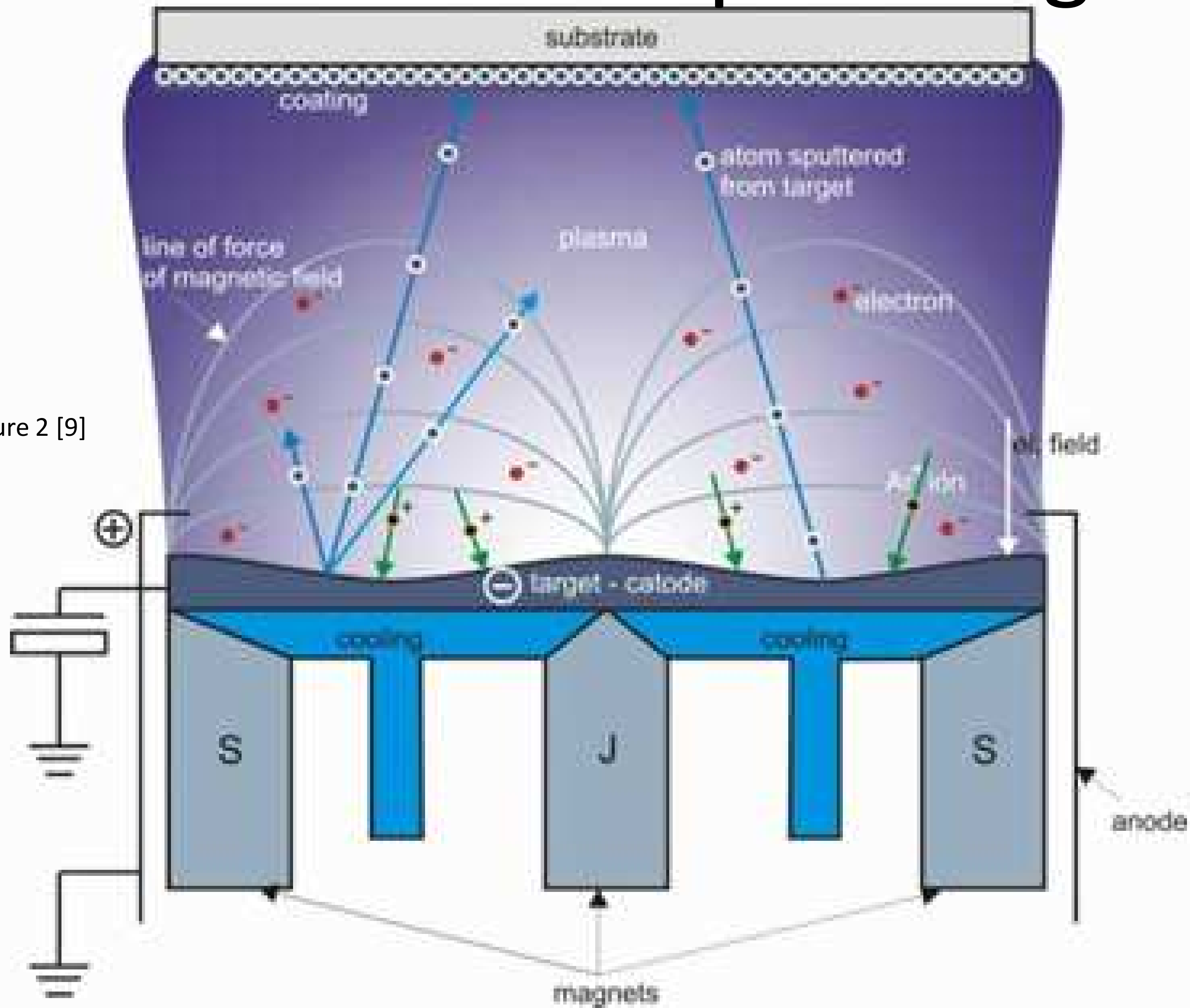


Theory of UV Light to Expose Photoresist

- **Photolithography** (or "optical lithography") is a process used in microfabrication to selectively remove parts of a thin film or the bulk of a substrate **[2]**.
- A **photoresist** is a light-sensitive material used in several industrial processes, such as photolithography and photoengraving to form a patterned coating on a surface **[3]**.
- A **photomask** is an opaque plate with patterns of chromium or transparencies that allow light to shine through in a defined pattern. They are commonly used in photolithography **[5]**.
- Photoresists are classified into two groups: positive resists and negative resists **[3]**.
  - A *positive resist* is a type of photoresist in which the portion of the photoresist that is exposed to light becomes soluble to the photoresist developer. The portion of the photoresist that is unexposed remains insoluble to the photoresist developer.
  - A *negative resist* is a type of photoresist in which the portion of the photoresist that is exposed to light becomes insoluble to the photoresist developer. The unexposed portion of the photoresist is dissolved by the photoresist developer.

Fabrication - Sputtering

Figure 2 [9]



Theory of Sputtering Deposition

- **Sputtering** is a process whereby atoms are ejected from a solid target material due to bombardment of the target by energetic particles. It is commonly used for thin-film deposition, etching and analytical techniques **[1]**.

- When an energetic particle strikes a surface (the target), a plume of material is released, like the shower of sand when a golf ball lands in the bunker. This effect is known as 'sputtering' and is used to produce films of materials as thin as just a few millionths of a millimetre. **[10]**. The Argon positive ions are undergone to an acceleration process on a metal target and due to that they expel the atoms from the metallic plate. Colisional excitation will transfer energy to the surface of the target allowing the particles of the target to break off. The substrates rotate in front of the source. Then these atoms condensate on the substrates **[9]**.

- It is necessary to obtain the correct alloy composition of 64%/36% Iron/Nickel.

Verify Sputtering Technique

- Based on time in sputtering chamber and rate of deposition we can determine how thick the layer of element is.
- Microposit remover will remove the low lying photoresist covered by element from sputtering. This uncovers the silicon substrate.
- To verify the deposition thickness an Atomic Force Microscope (AFM) measures with nano precision, from the substrate to the top surface of element deposited.

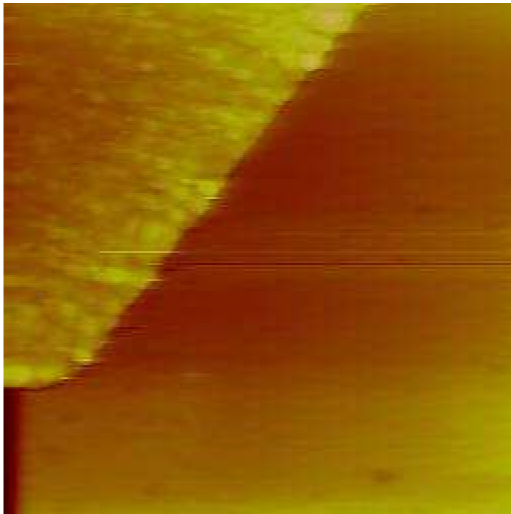


Figure 3

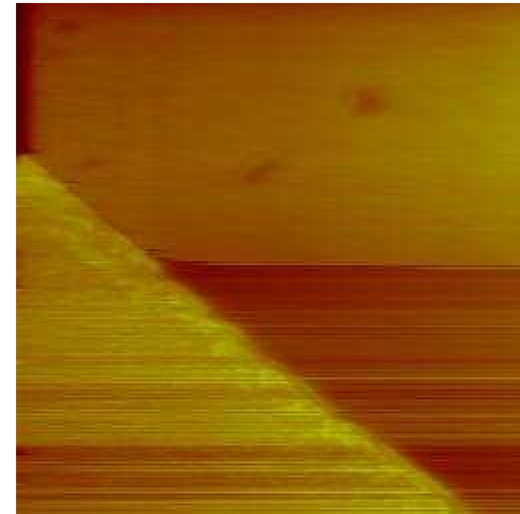


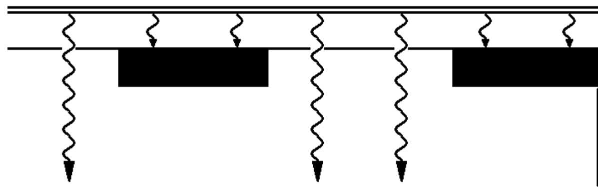
Figure 4

Fabrication - Sacrificial Layer

E – Deposit Copper layer

F – Develop with microposit remover

G – Add Photoresist



– Spin Coat and Bake

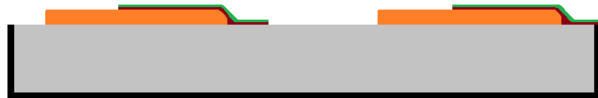
H – Expose to UV

I – Develop photoresist

Frabrication - Etching

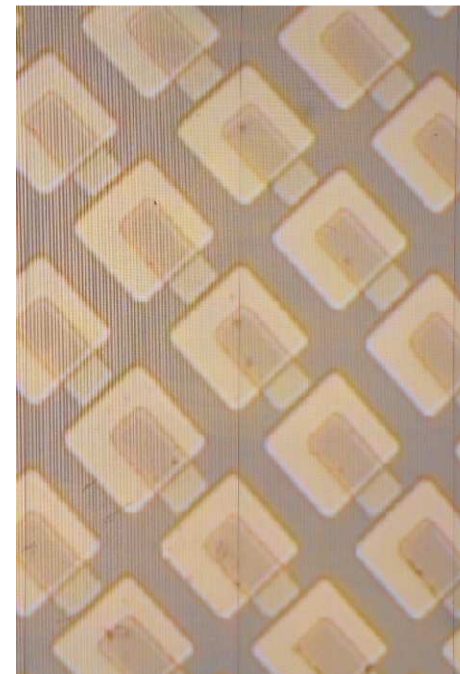
- The elements of Nickel and Galfenol are sputtered onto the silicon substrate to make the thin film layer. When the process is complete the remaining photoresist is etched away and free hanging self rolling structures are left.
- These thin films roll based on a lattice constant.

J – Deposit Thin film layer



K – Etch photoresist away

L – Etch copper away



Results and Discussion

- Through these methods it has been proven that self rolling thin films can be created.
- Our research will continue in order to produce results.
- Three complications to create thin films.
  - The process involved countless hours testing the correct composition of the alloy thin film.
  - Deposition rate (thickness) was difficult due to time.
  - Photoresist at high temperature cause a problem in the process.

Summary/Conclusions

References

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5. http://en.wikipedia.org/wiki/Photo_mask
6. http://cnx.org/content/m1037/latest/ - (UV light exposure picture)
7. http://www.oxford-vacuum.com/background/thin_film/sputtering.htm
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