Development of Low-cost MEMS Fabrication Technology using Dry-Film Photoresist and Electrodeposition

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Abstract
We present a low-cost approach for electrodeposited materials such as freestanding thin (< 5 μm) films and micropatterned structures, which are useful in variety of applications (e.g., passive electronic devices). We use a customized UV-LED exposure system as a low-cost photolithography tool, dry-film photoresist as an electrodeposition mold material, and alkanethiol-modified sputtered copper as a seed layer. As electrodeposited materials are easily detached from the thiol-modified copper surface, multiple copies of electrodeposited structures can be formed by reusing the same seed layer, minimizing the use of conventional cleanroom facilities.

Introduction & Background
Microlithography, combined with electrodeposition has been an useful method to create metallic microstructures.

Nife microgears (S. Leith, 1999)
Zn pressure sensor (M. Luo, 2014)

Process development toward lower cost
(1) Lithography: UV LED (< 100 $) setup rather than mercury lamp (>1000 $)
(2) Photoresist: Dry film resist for PCB manufacturing
(3) Seed layer: Copper surfaces coated with dodecanethiol are reusable after electrodeposition and structure release

Fabrication Procedure & Results

Fabrication setup

UV LED
Seed
Dry film
Fabrication

Thiol-modified surface (P. L. Schilardi, 2006)

- Economic fabrication processes with minimized use of vacuum tools
- Freestanding films
  (1) Large (> 10 cm²) and thin (< 3 μm) films are reliably released
  (2) Seed layer can be used more than 5 times
- Micropatterned structures
  (1) Structures with critical lengths larger than 50 μm with aspect ratio up to 1:1
  (2) Electrodeposition achievable on the used seed layer

Challenges
- Preventing adhesive residue from photoresist from accumulating on seed layer
- Maintaining thiol uniformity after structure release so that adhesion force between seed and substrate (i.e., Kapton) is larger than that between seed and deposited metal

Conclusions & Future Work
- Economic fabrication of electrodeposited thin films/microstructures is enabled by the combination of low-cost lithography and re-usable seed layer
- This could be a potential manufacturable route to various energy storage devices (e.g., inductors, capacitors, batteries).

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