Indium electrodeposition for finer and denser features flip chip arrays

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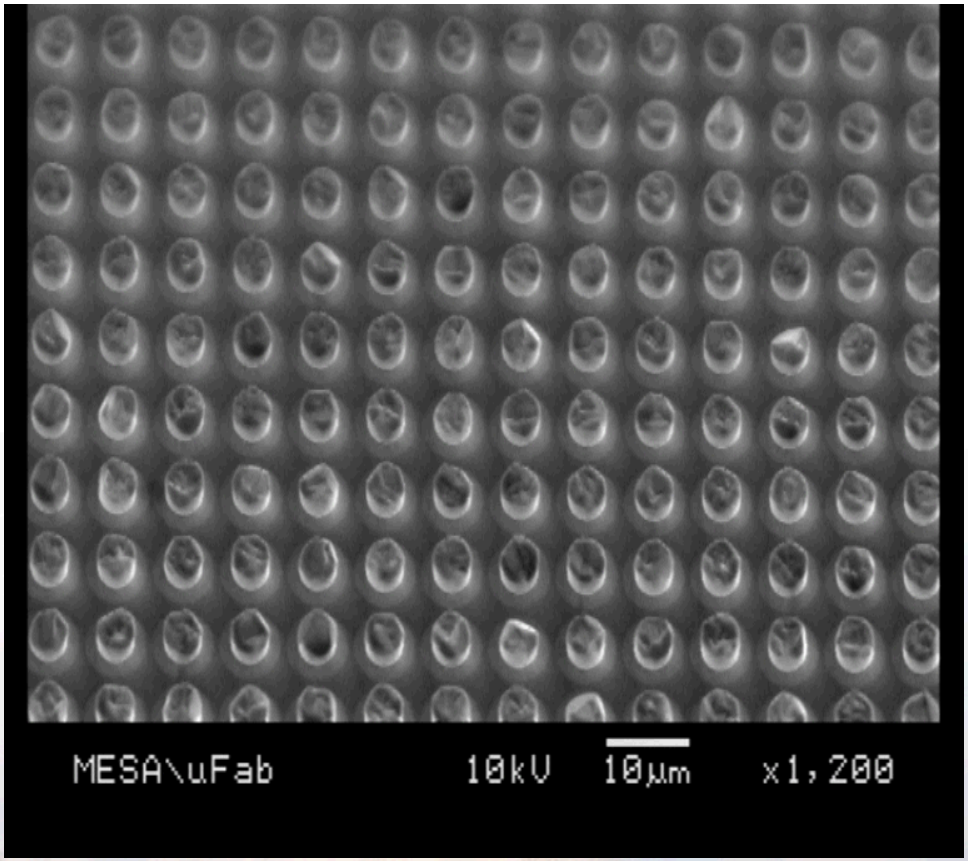
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

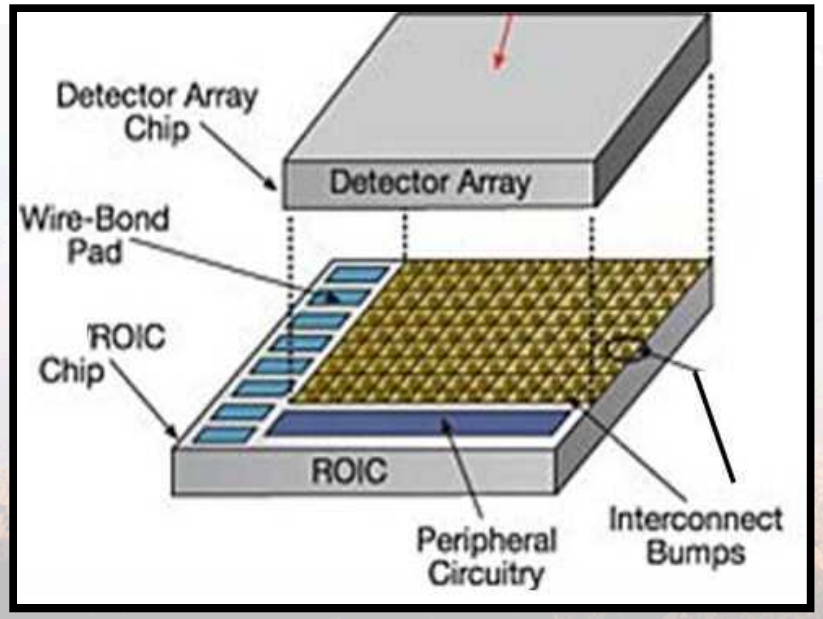
Outline

- Purpose
- Lithography
- Indium Deposition
  - DC, AC, GRDP
- Bonding/Pull Testing
- Future Work

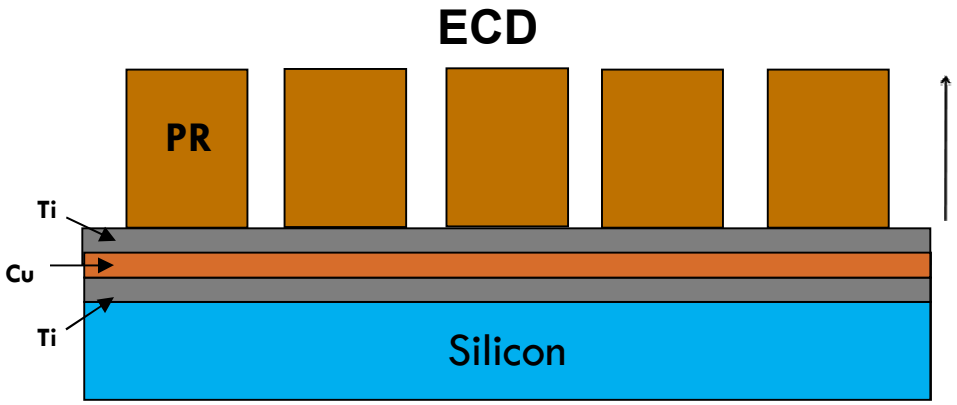


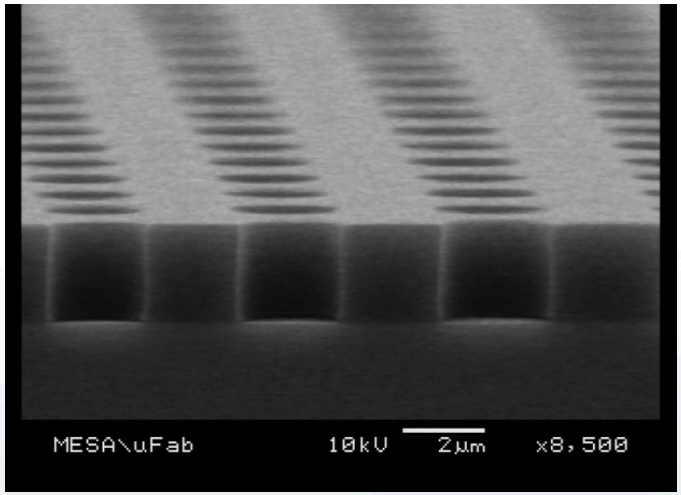
Purpose

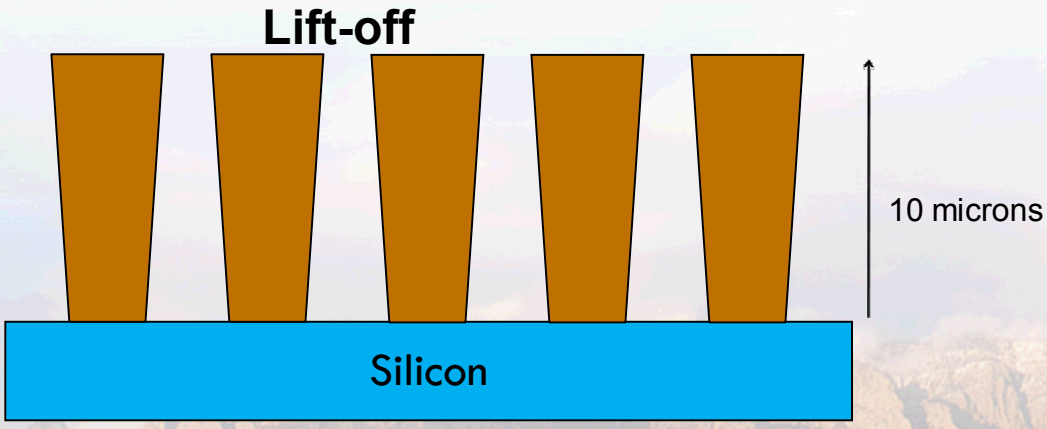
	Industry process	SNL process
Patterned mold	Lift off patterning	Photolithography
Indium deposition	Evaporation	Electroplating
Bump pitch	> 10 μm	<< 10 μm
Feature size	> 10 μm	<< 10 μm



Lithography







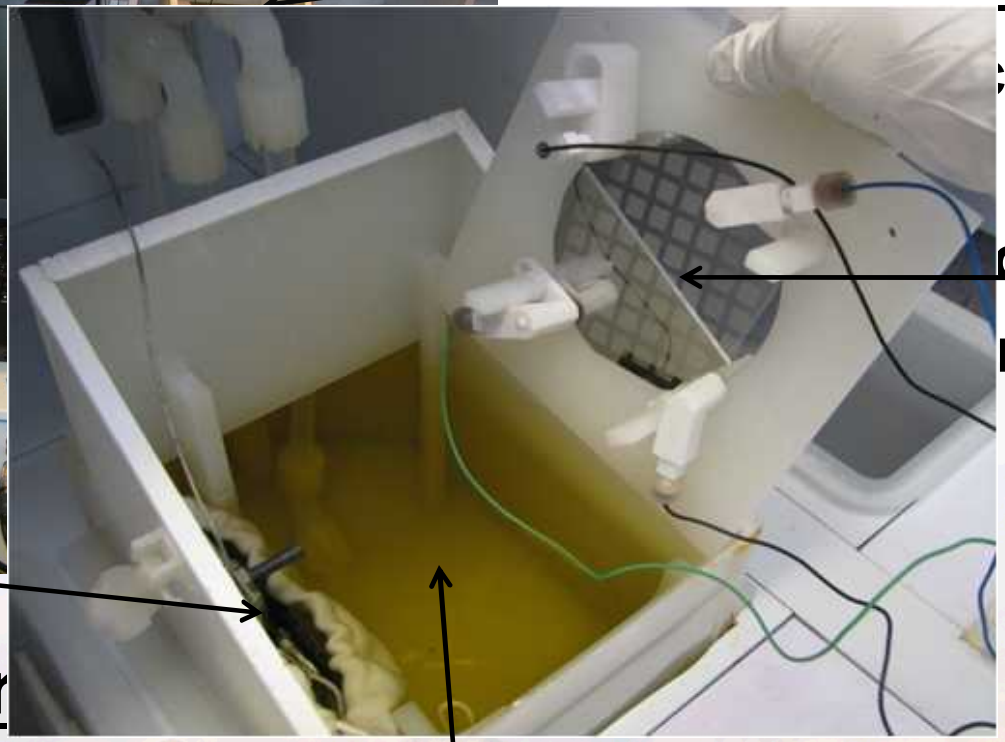
Experimental set up

Custom Bath

Chemistry

on Cathode

rs



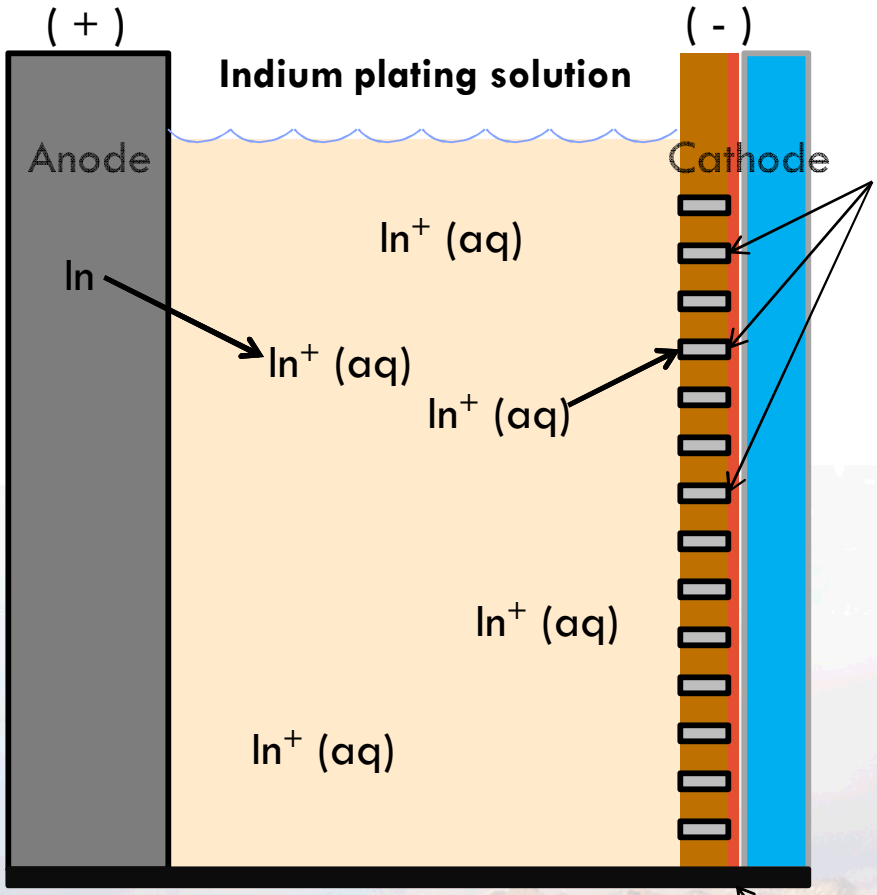
Anode

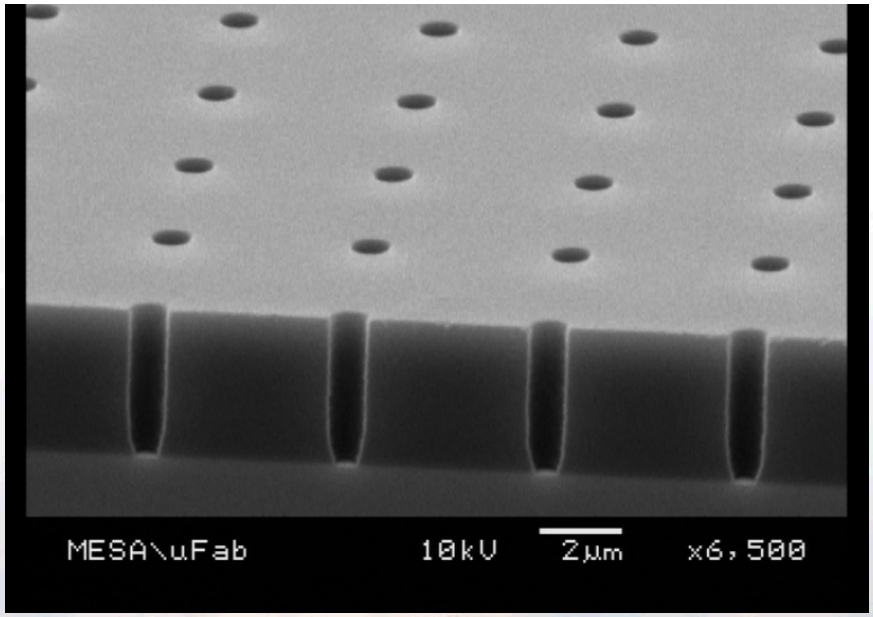
Bath Chemistry

Programm

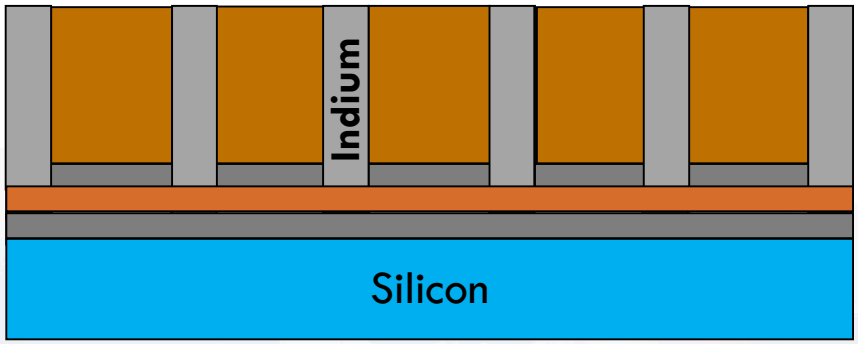
- Allows for full control over applied plating conditions

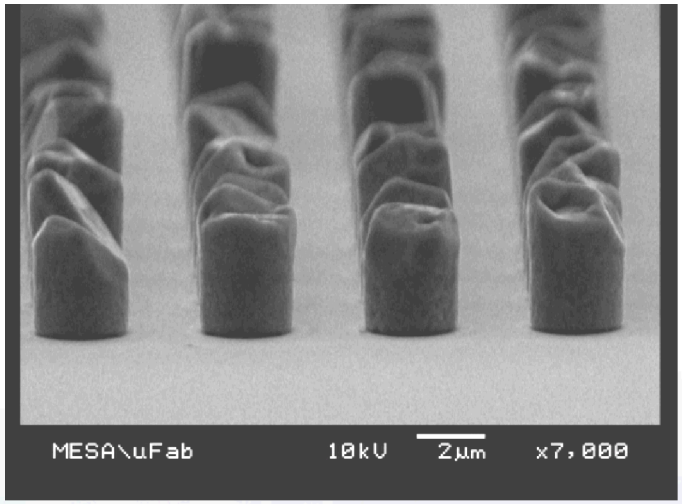
Indium Plating - Electrochemistry



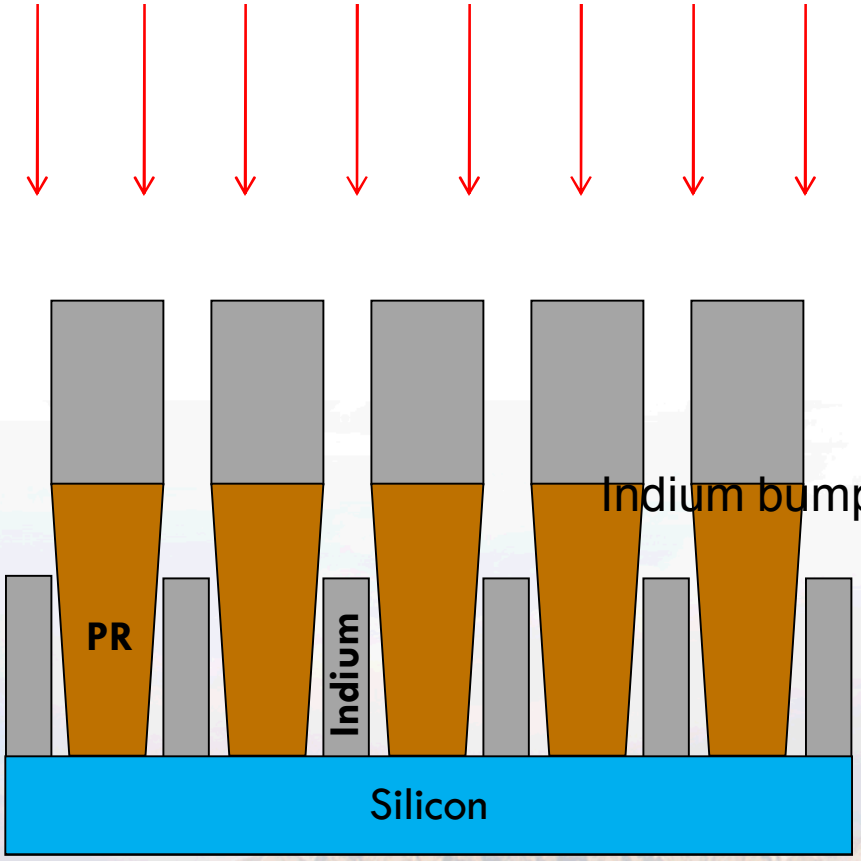


PR Removal ECD Process





Lift-off Process



Metal evaporation

PR Removal and indium lift-off

Indium bumps remain

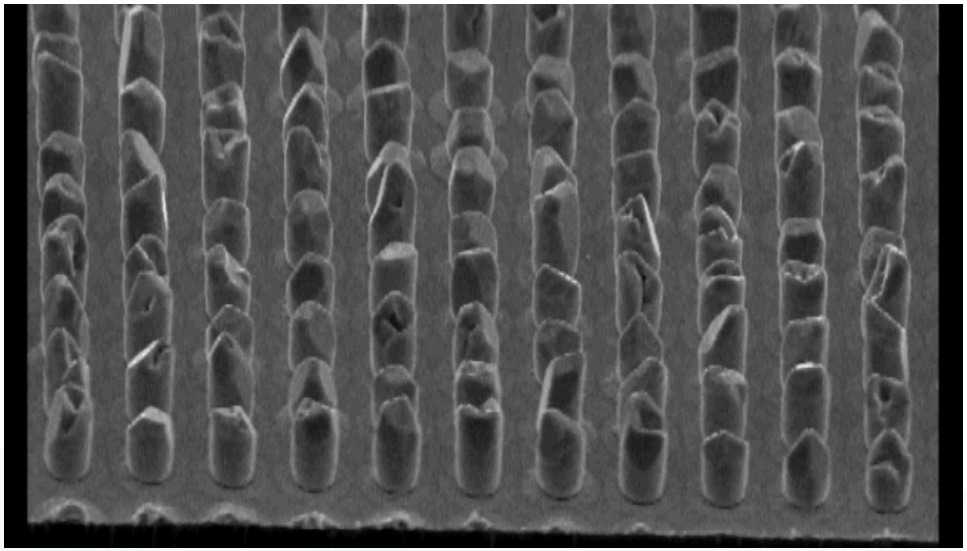
DC electrochemical deposition

Early process development

DC

AC

GRDP



~50% bump height variation

- **Demonstrated indium deposition into a PR mold with Direct Current**
- **Resulted in height variation between bumps**

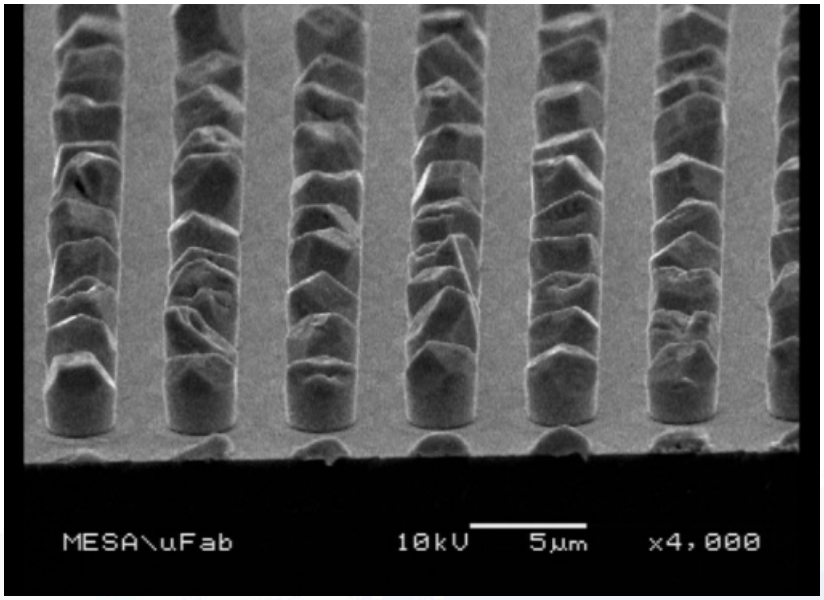
Improved AC ECD

DC

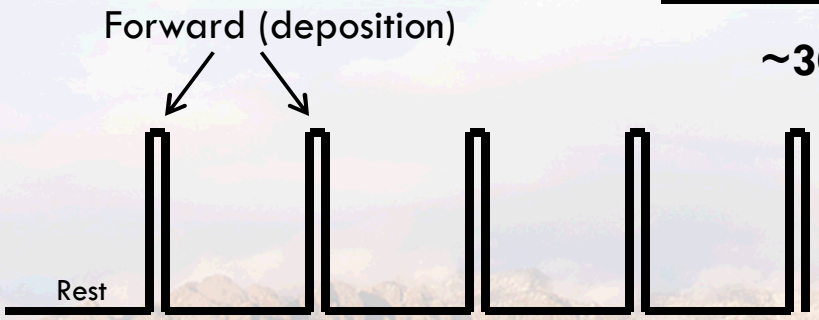
AC

GRDP

- AC plating decreased bump height variability
- Still resulted in non uniform bump profiles



~30% bump height variation



High frequency AC with increased current density

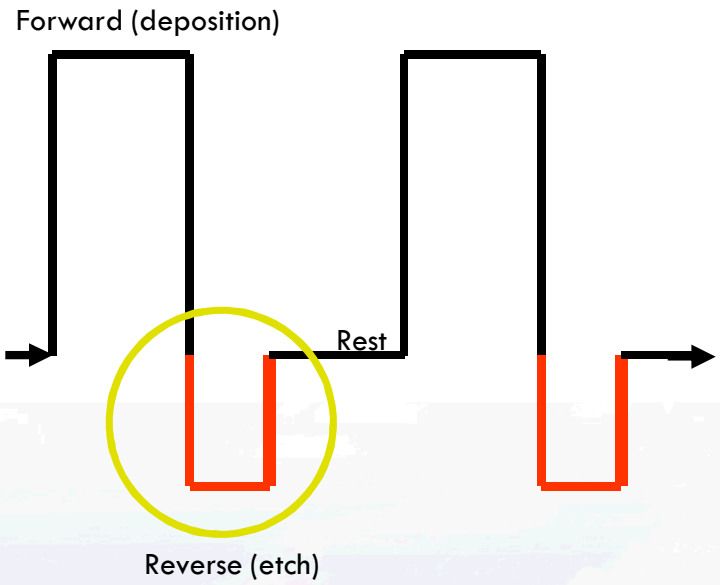
Galvanic recurrent double pulse

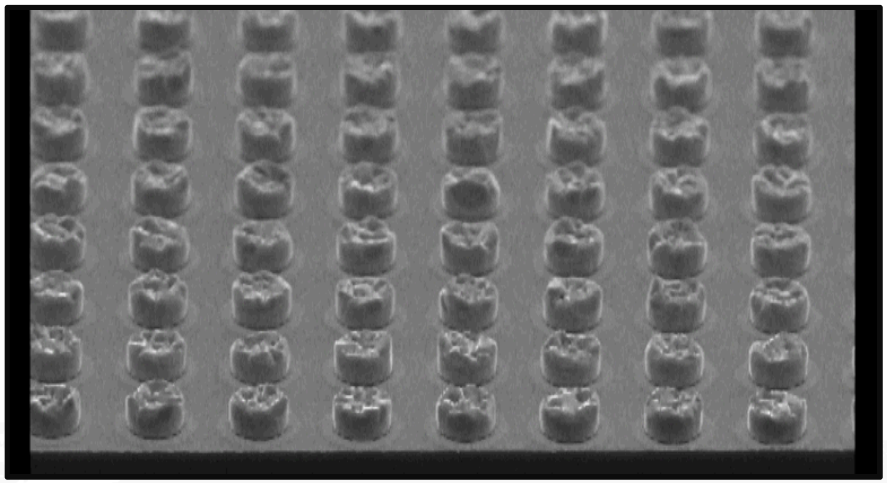
Etch phase reduces bump to bump variation

DC

AC

GRDP

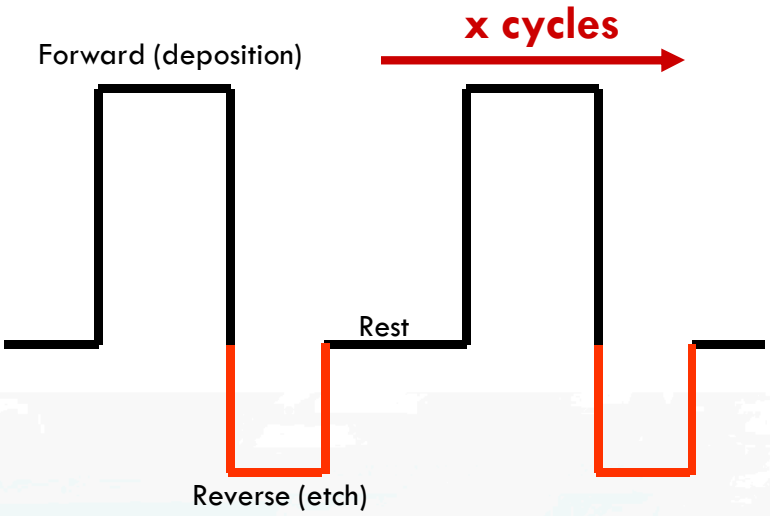


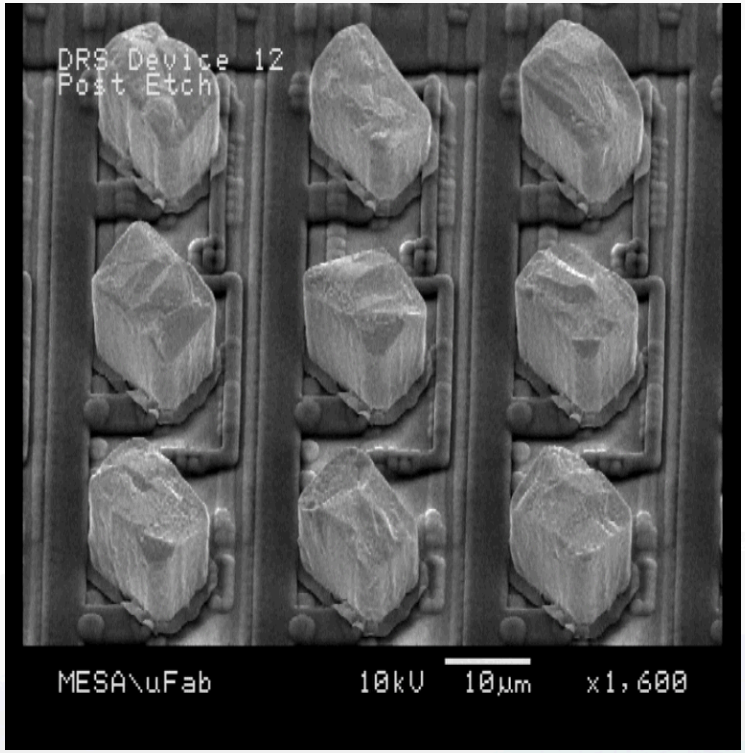


Bumps plated with GRDP

- **GRDP increases patterned plating uniformity**

Optimization of GRDP



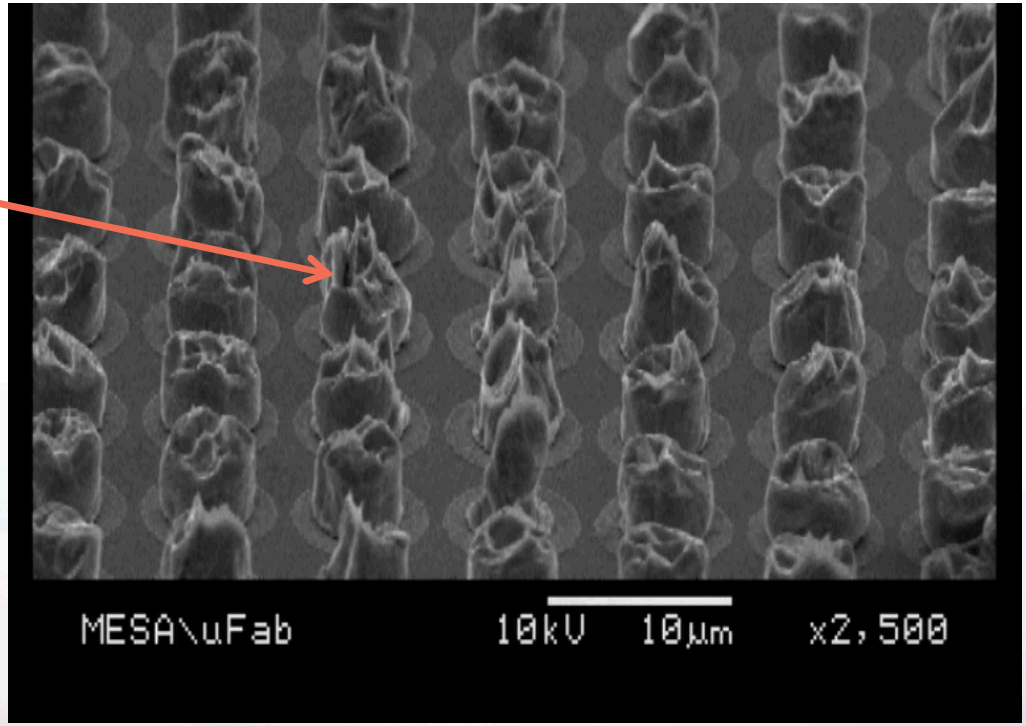


- Balance of forward and reverse phases
- Improved flatness
- Large area bump to bump uniformity

Bonding tests

Indium bump to bulk indium bonding

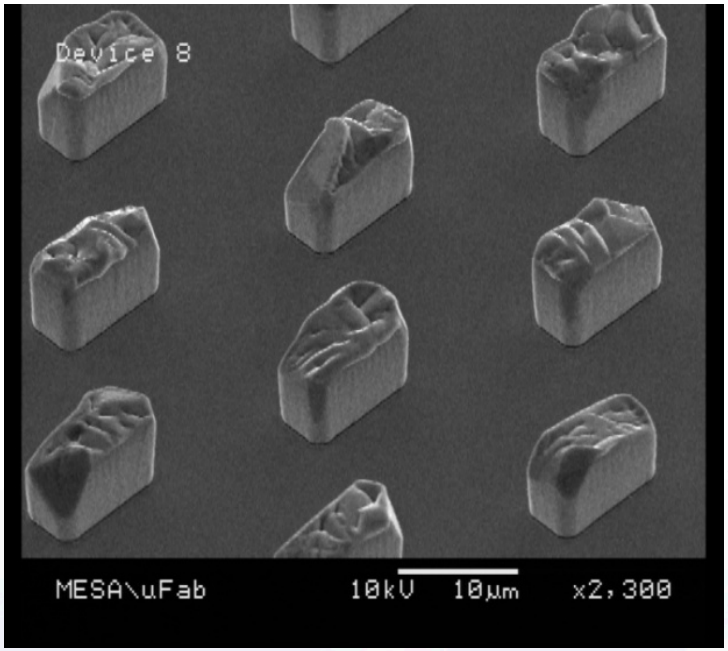
- **Notice the taffy like pull characteristic**
  - Signifies a successful bond



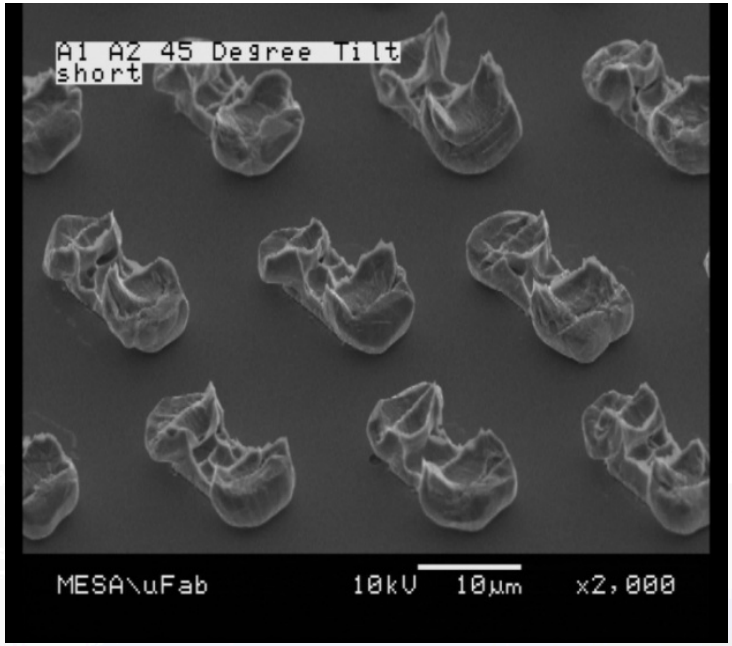
Indium bumps post bonding, post pull

Bonding tests

Indium bump to bump bonding



Indium bumps



Indium bumps, post bonding, post pull

- **Successful alignment and bonding of ECD indium bump arrays**

Future work

- **Electrical connectivity testing**
  - Test electrical connection across indium interconnects
- **Further decrease feature size and bump pitch**

Summary

- **Our process produces high density indium bump arrays**
- **Process**
  - Lithography makes plating molds
  - Molds are electrochemically filled with Indium
    - Galvanic recurrent reverse plating maximizes uniformity
- **Current process results in successful indium diffusion bonding**

Thank you

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