EE412
Deep Trench Spray Coating
Final Presentation

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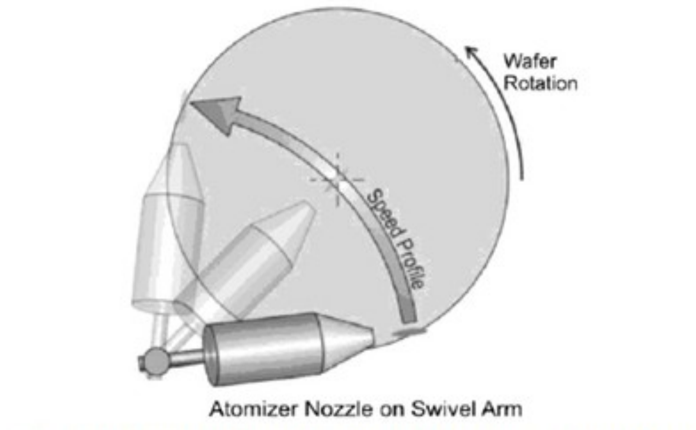
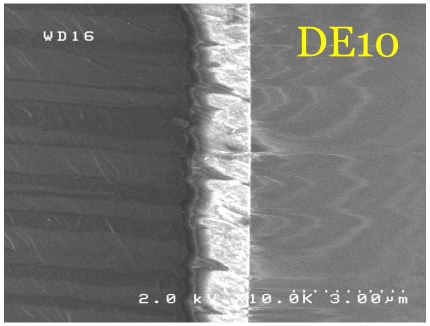
12/08/2010

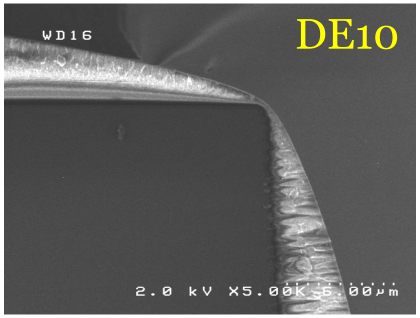
Introduction – EV101 Spraycoater



Sidewall
(250um deep)

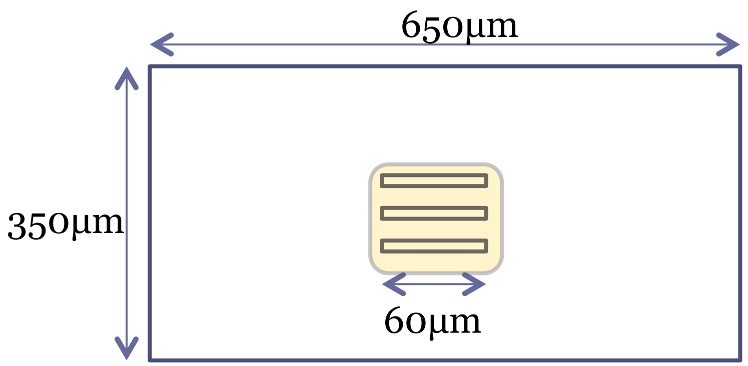


Corner

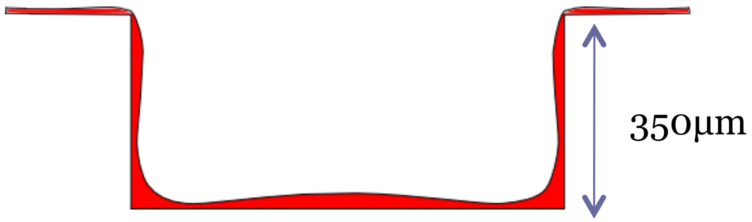


- Sprays a resist mixture using an ultrasonic nozzle. Typical droplet diameter ~ 20um
- Low spin speeds (30rpm – 60rpm)
- Resist thickness is typically 10um+. Lower thickness possible if
  - Shallow features, or
  - Deep features but large areas to fill resist
- Can be used to protect sidewalls and corners with resist
- Uses relatively little resist material
- Both, planar and conformal coatings possible using different nozzles (‘vortex’ and ‘accumist’)

Objectives



Top View



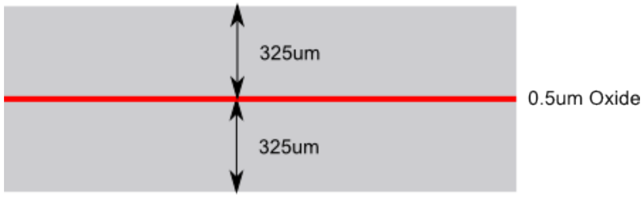
X-Section View

- Obtain a uniform coat of photoresist with thickness < 3μm in the region of interest at the bottom of a 350μm deep 350μm x 650μm DRIE trench coated with silicon nitride
- Thickness variation < 0.5μm
- Expose test pattern in ASML using the MSI patch to test resolution limits

- Starting recipe was Pierres Ponce's P44

Wafer Preparation

1



Fusion bond two R-prime wafers using the teflon jig with 0.5um oxide on handle. Exact procedure in wiki

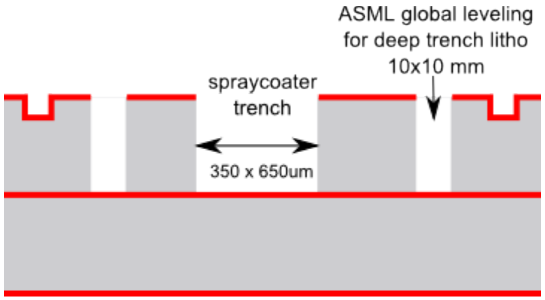
2

ASML alignment marks

3

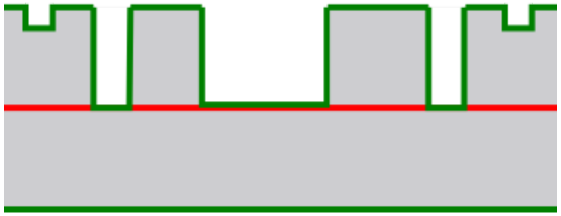
Deposit 3um LTO and pattern trenches

4



Sts2 DRIE etch through top wafer

5



Strip masking oxide and BOX in 6:1 BOE. Deposit nitride

6

Before coating 20min in 9:1 piranha
Followed by HMDS prime in YES oven

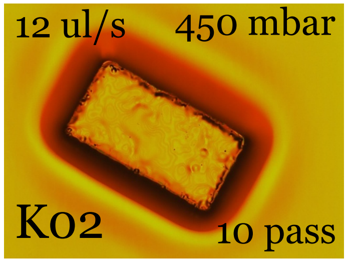
Parameters Explored

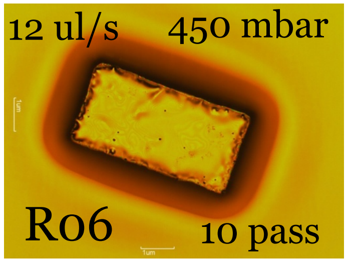
- Resist mixture consists of:
    - Photoresist SPR 220-7 (4.8% - 11.4%)
    - Low vapor pressure solvent Ethyl Lactate (25% - 45%)
    - High vapor pressure solvent MEK (remaining)
- Resist mixture dispense rate (3ul/s – 15ul/s)
- Nozzle pressure (300mbar – 900mbar)
- Number of passes (5 – 15)
- Velocity profile
- Heated chuck was used and set at 75C
- Total of 91 experiments exploring different combination of parameters. All results available on wiki

Repeatability

- Experimental results are repeatable

7.7% Resist
25% LVP





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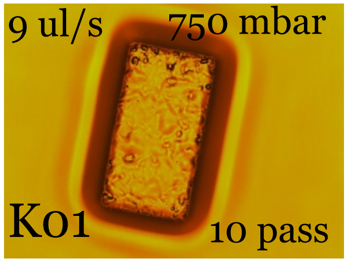
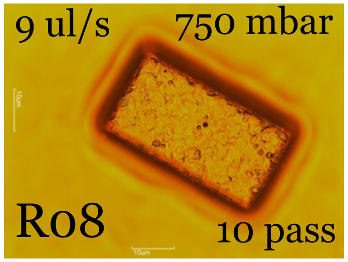
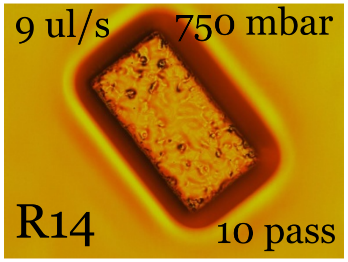
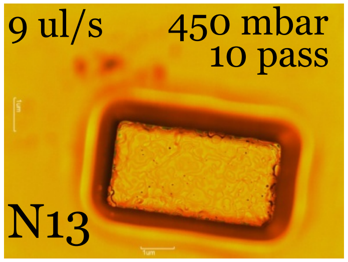
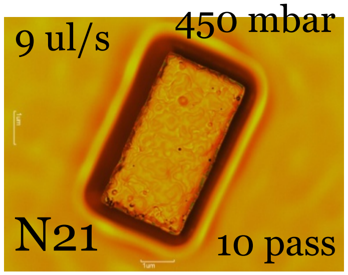






5% Resist
45% LVP

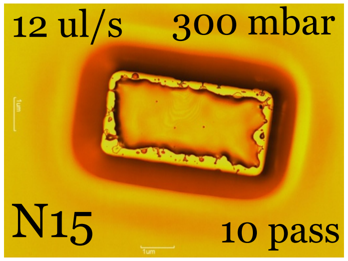


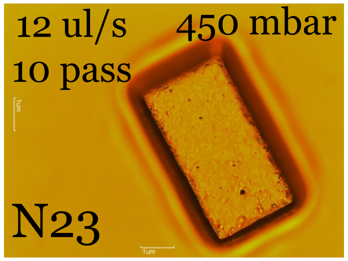


Effect of Pressure

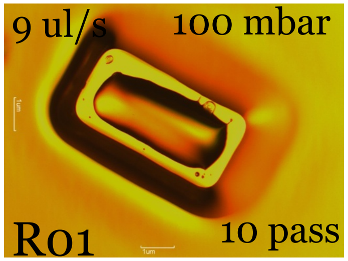
- Higher pressure improves uniformity and causes less pooling of resist at the bottom of trench

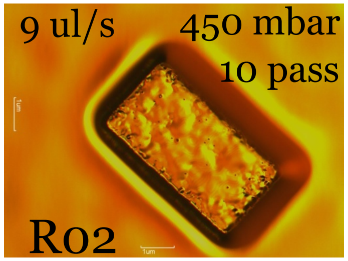
5% Resist
45% LVP

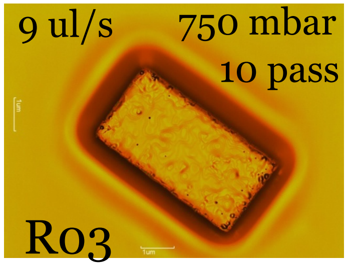




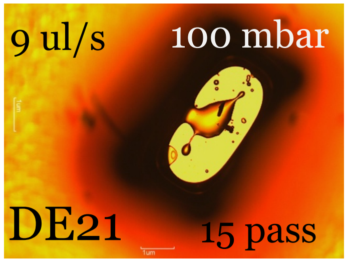
5% Resist
25% LVP

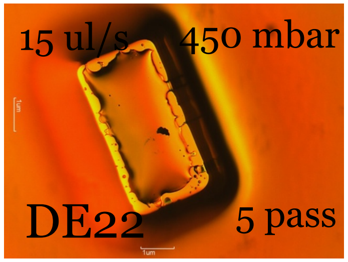


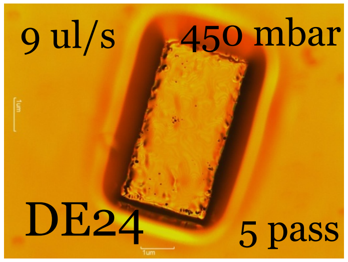




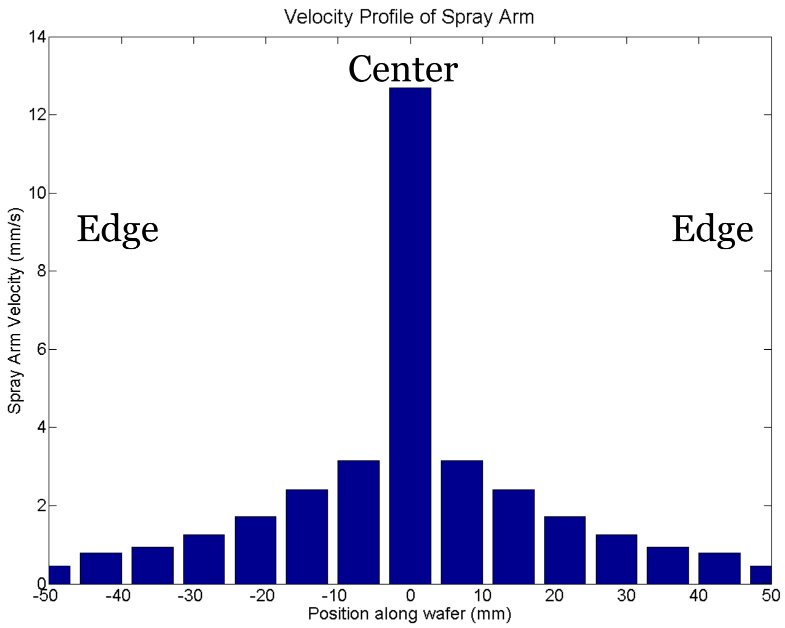
11.5% Resist
44.6% LVP







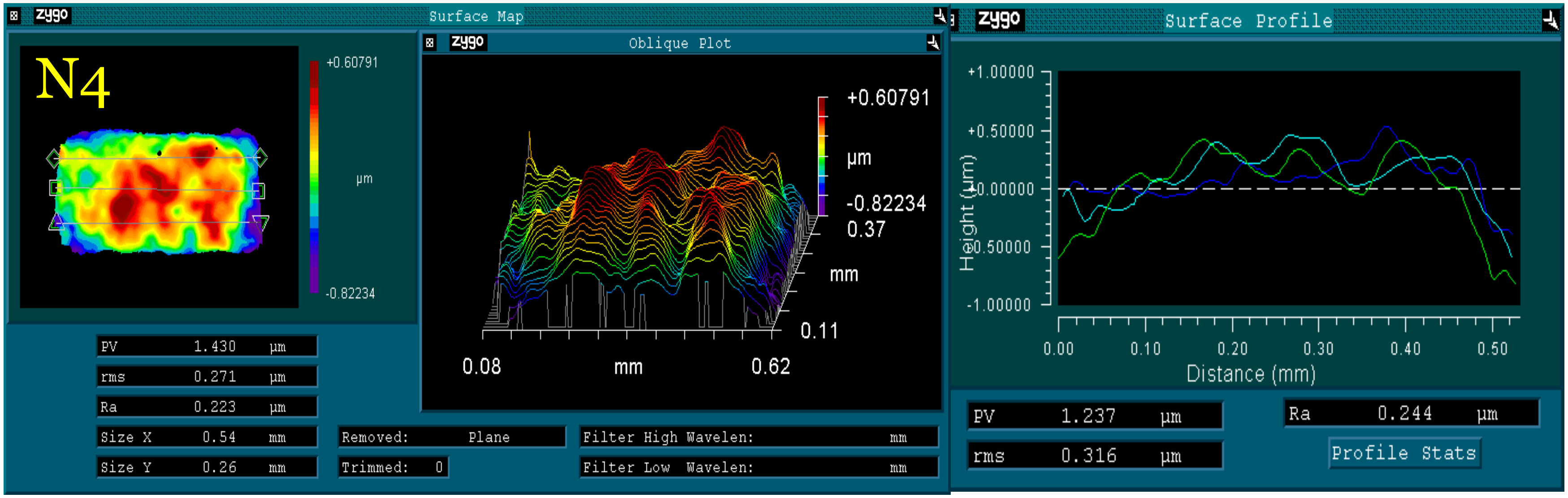
Velocity Profile



- Area to be coated is higher at edge as compared to center. Hence, velocity needs to be adjusted to obtain uniform coating thickness
- Velocity profile can be scaled to increase or decrease overall time per pass
- Scaling also changes dispense rate if thickness is to be kept constant
- Slow passes lead to less rough films. But can cause resist pooling due to large quantity of resist being dispensed

Nga N Pham *et al* 2005 “Spray coating of photoresist for pattern transfer on high topography surfaces”, *J. Micromech. Microeng.* **15** pp691-97

Zygo Results (Jason)



PV 1.430 µm
rms 0.271 µm
Ra 0.223 µm
Size X 0.54 mm
Size Y 0.26 mm
Removed: Plane
Trimmed: 0
Filter High Wavelen: mm
Filter Low Wavelen: mm

PV 1.237 µm
rms 0.316 µm
Ra 0.244 µm

- Zygo measurements on select samples. Full results on wiki
- Samples coated with 300A of Aluminum
- Surface roughness for above sample:
  - Ra = 0.223um
  - RMS = 0.271um

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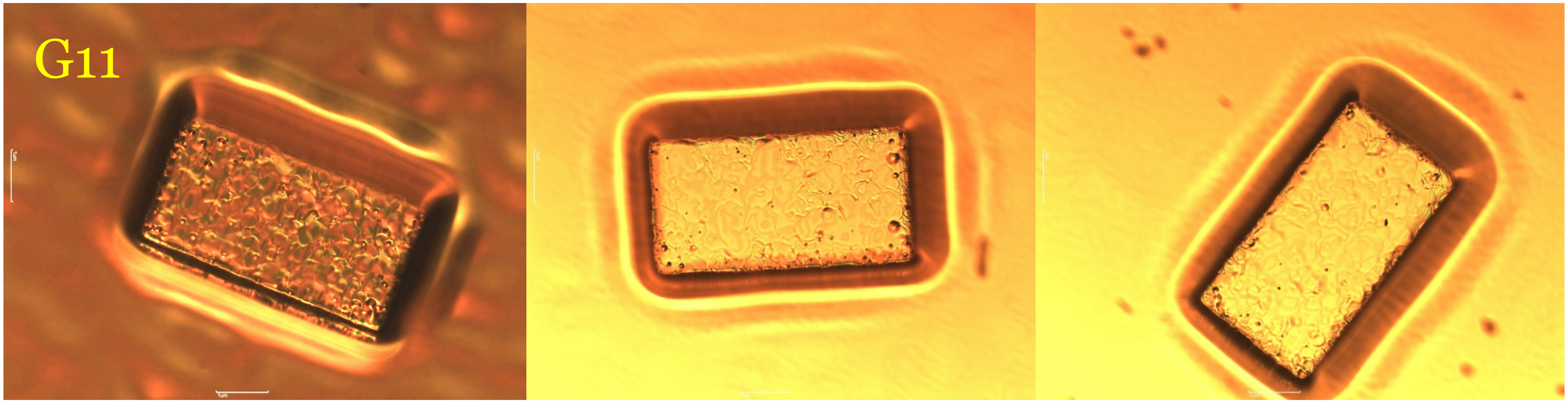
Recipe Used For ASML Exposure Testing

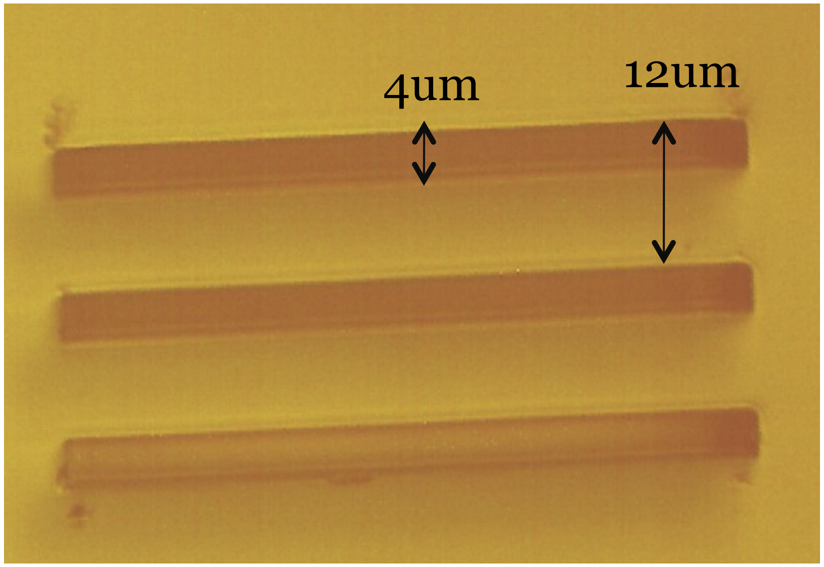

Center
Mid
Edge

- Resist Mix : 5% SPR 220-7, 35% Ethyl Lactate, 60% MEK
- Dispense rate: 9ul/s, Pressure: 600mbar, Passes: 12

Deep Trench Lithography With ASML

- ASML in ‘normal’ mode
  - Cannot apply focus offsets of more than 30um
  - Global leveling is done at three points which are not user controllable. If deep features are present the wafer can get rejected
- ASML in special ‘MSI’ patch mode
  - Gives user control of level sensor locations. However need large area (10 x 10mm)
- Deep trench lithography possible if 3 large 10 x 10mm squares (GL openings) are etched to the same level as features to be exposed
- GL openings need to have low roughness

Exposure Testing with ASML



- 4um features could be resolved in the large 10mm x 10mm trenches up to 1mm from the trench walls
- Dose of 150mJ and 2min development cleared some of the features and not others. Over exposed wafer second time with 250mJ to clear resist from all areas
- Resist couldn’t be cleared from smaller 350um x 650um trenches even after high energy dose (700mJ)
- Manual development in Headway for 2min – 5min

Conclusions

- Developed a spraycoat recipe for coating resist in 350x650 wide and 350um deep cavities
- Final recipe
  - Resist mix: 5% SPR 220-7, 35% Ethyl Lactate and 60% MEK
  - Dispense rate: 9ul/s
  - Pressure: 600 mbar
  - Passes: 12
- Resist thickness in the central 100um x 100um area at the bottom of trench 2.7um ± 0.3um
- Tested recipe for deep trench lithography applications with ASML and was able to resolve 4um features in large areas

Acknowledgements

- Jason Parker, Pierre Ponce, J Provine
- Makoto Nakamura, Linda Ohara, Ping Ding, Vinny Pici
- Mahnaz Mansourpour, Mary Tang