EUV mask cleaning: challenges and solutions

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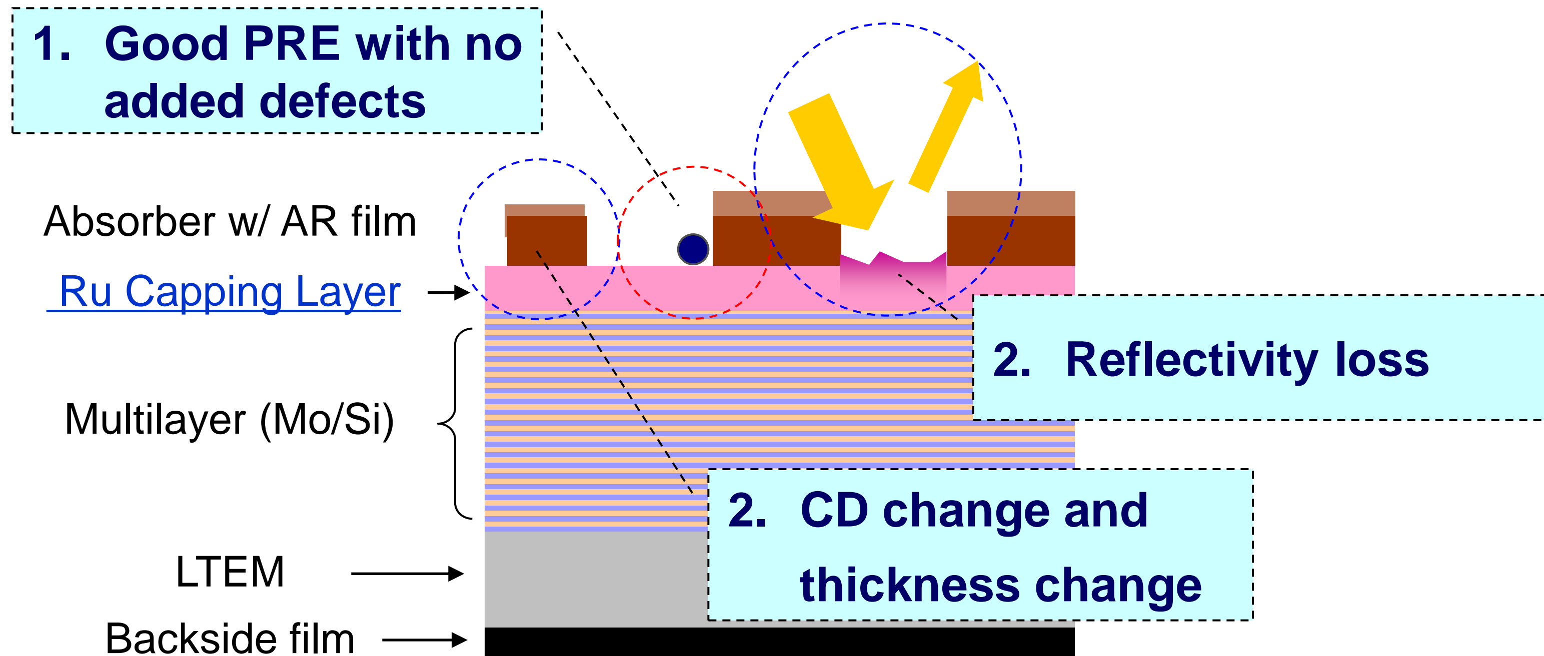
EUV mask cleaning challenges



1. EUV mask cleaning required to remove all printable particles
   - ITRS: 25nm defect for 23nm NAND Flash Device
2. Minimum damage to absorber pattern, Ru surface and multilayer
3. Need more frequent cleaning due to lack of pellicle

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EUV mask cleaning : SPM-SC1 recipe

- Cleaning performance
  - Particle removal efficiency
  - Added defects
- Damage
  - ARC layer
  - CD change
  - Ru capping layer

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EUV mask cleaning : SPM-SC1 recipe

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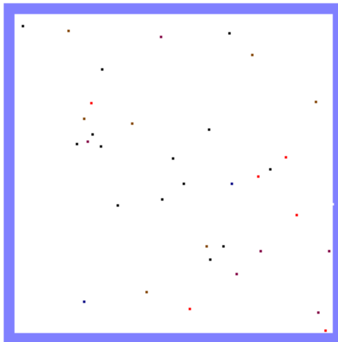
Particle removal

M1350

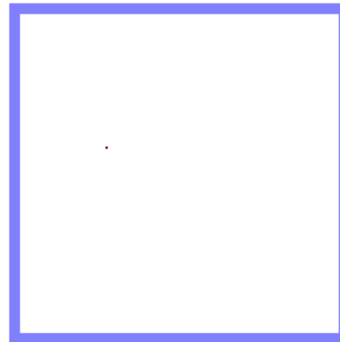
Added handling particles

(Before clean)

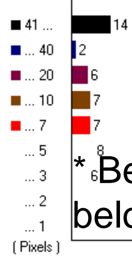


Remained handling particles

(After clean)



Pixel Histogram



Pixel Histogram

* Below pixel 6 are removed out due to below 100% capture rate

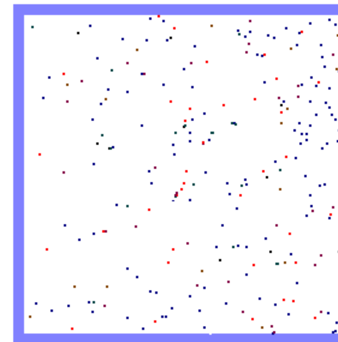
Almost all particles removed (>80 nm)

PRE = 97%

M7360

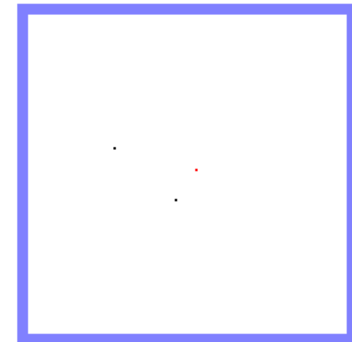
Added handling particles

(Before clean)

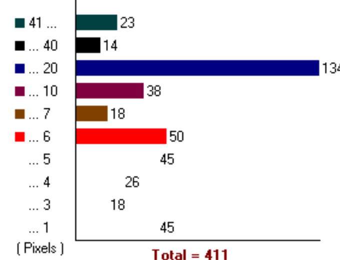


Remained handling particles

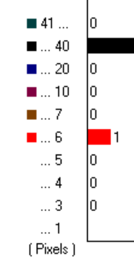
(After clean)



Pixel Histogram



Pixel Histogram



Almost all particles removed (> 50nm)

PRE = 99%

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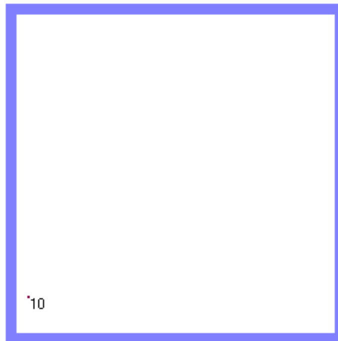
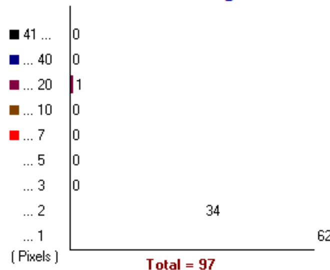
Added defects from cleaning

M1350

Adder map

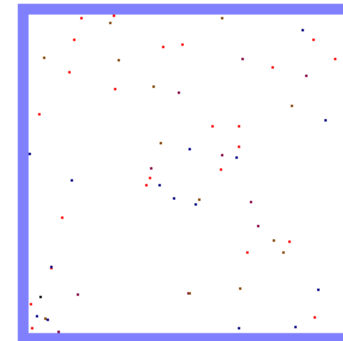


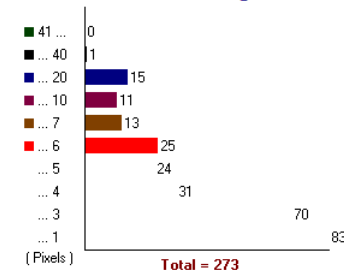


1 adder (> 80nm)

M7360

Adder map





65 adders (> 50nm)

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2 types of added defects

- Added defects
  - Particles type defects
    - Filtration of chemicals
    - Clean chemical
  - Pit type defects
    - Megasonic optimization

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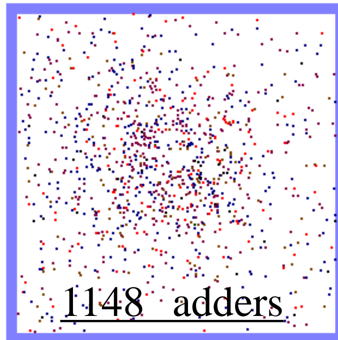
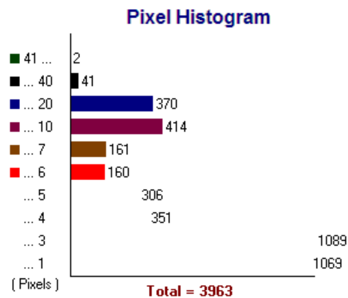
Particle type adders

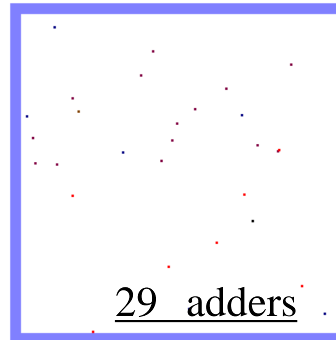
Adder maps from each chemical steps

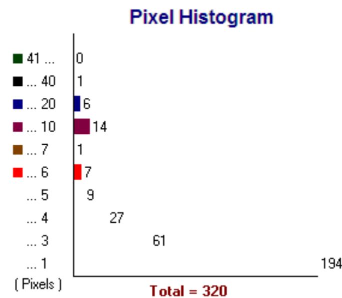
SPM step



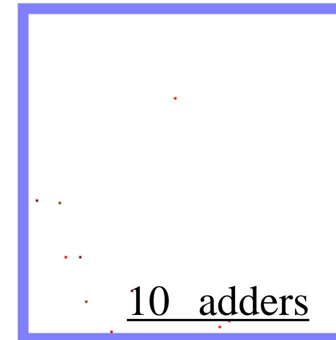


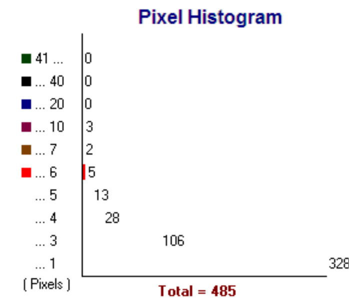
Hot water step





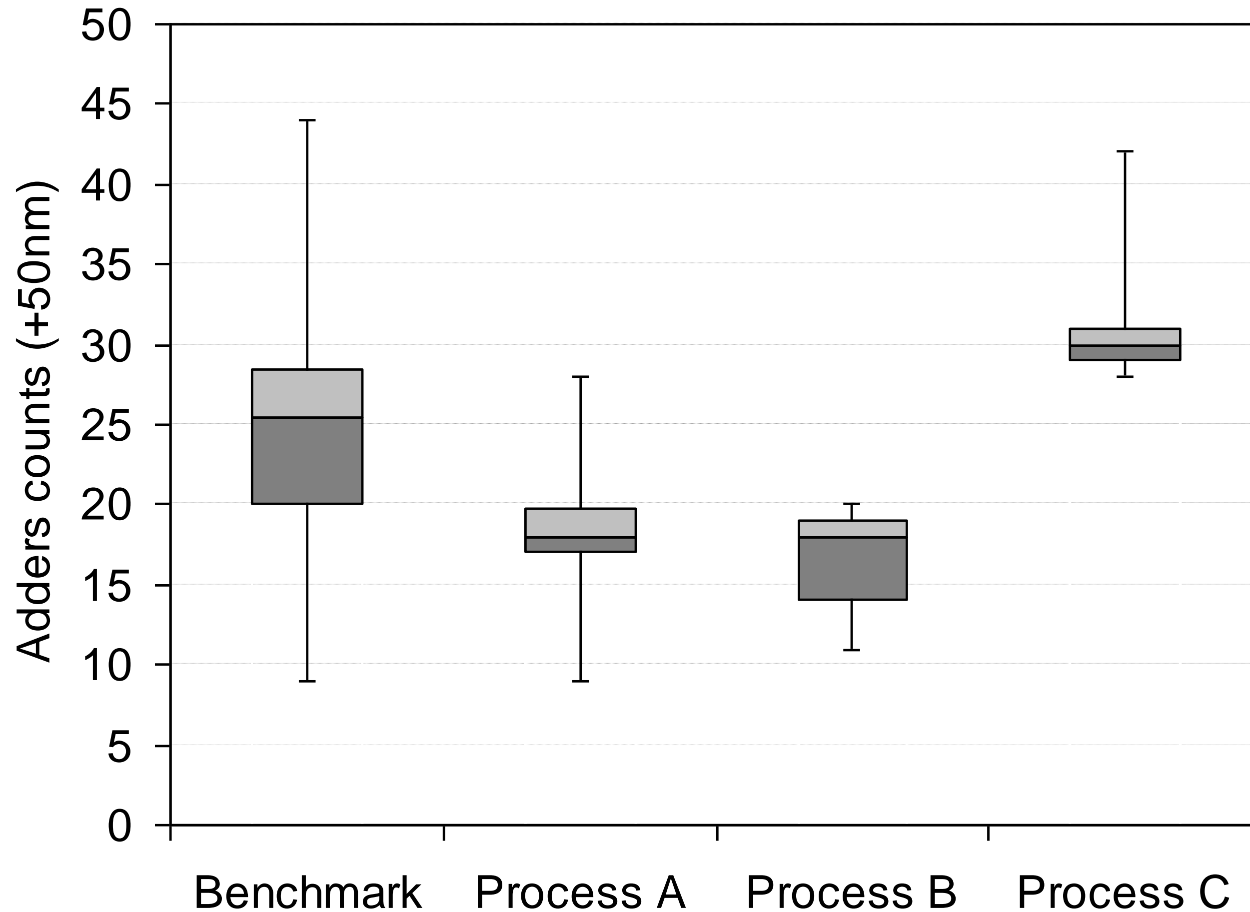
SC1 step





SPM chemical is likely main source of particle type adders

Pits type adders



Lower megasonic power and higher frequency

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To be presented at poster session of EUVL symposium 2011

SEMATECH

EUV mask cleaning : SPM-SC1 recipe

- Cleaning performance
  - Particle removal efficiency
  - Added defects
- Damage
  - ARC layer
  - CD change
  - Ru capping layer

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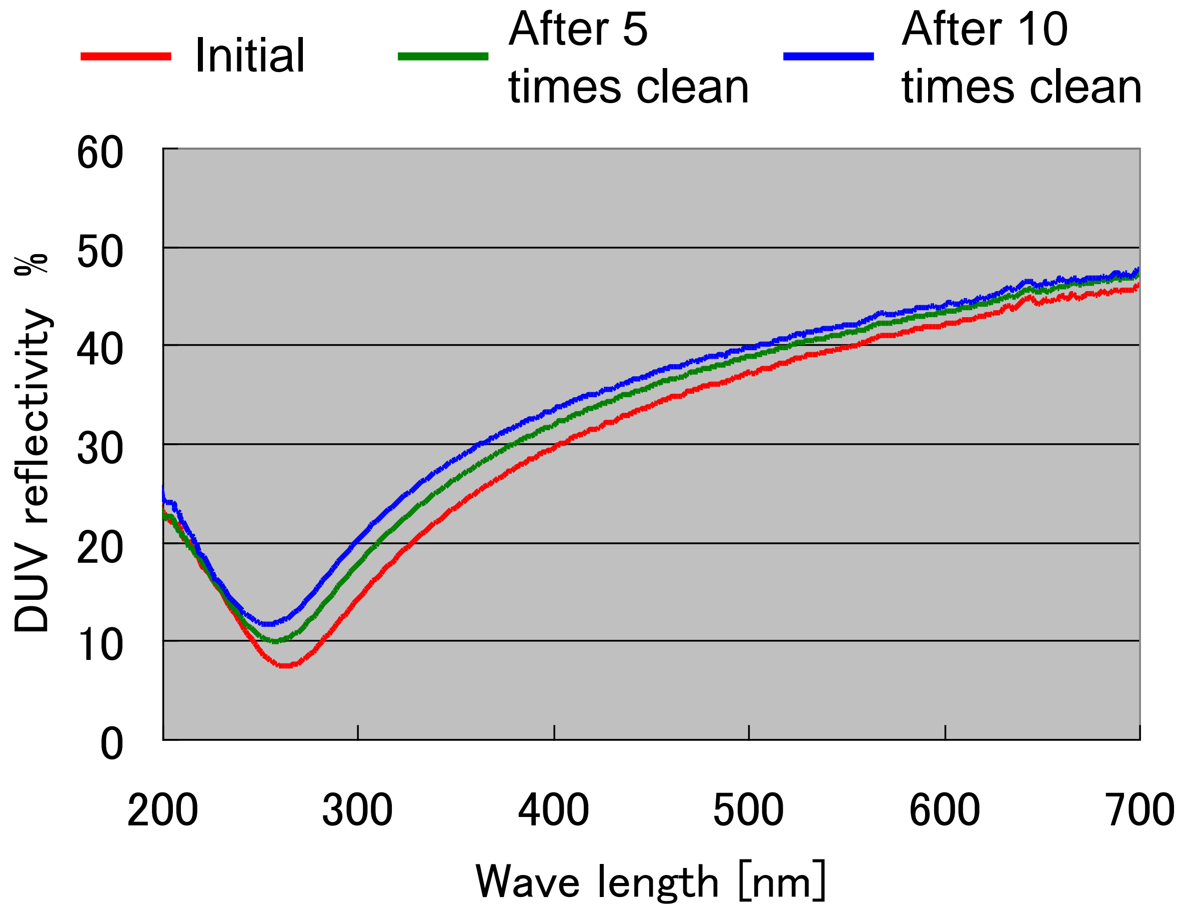
ARC damage (Thickness change)



Estimated TaBO damage is 0.25nm /clean

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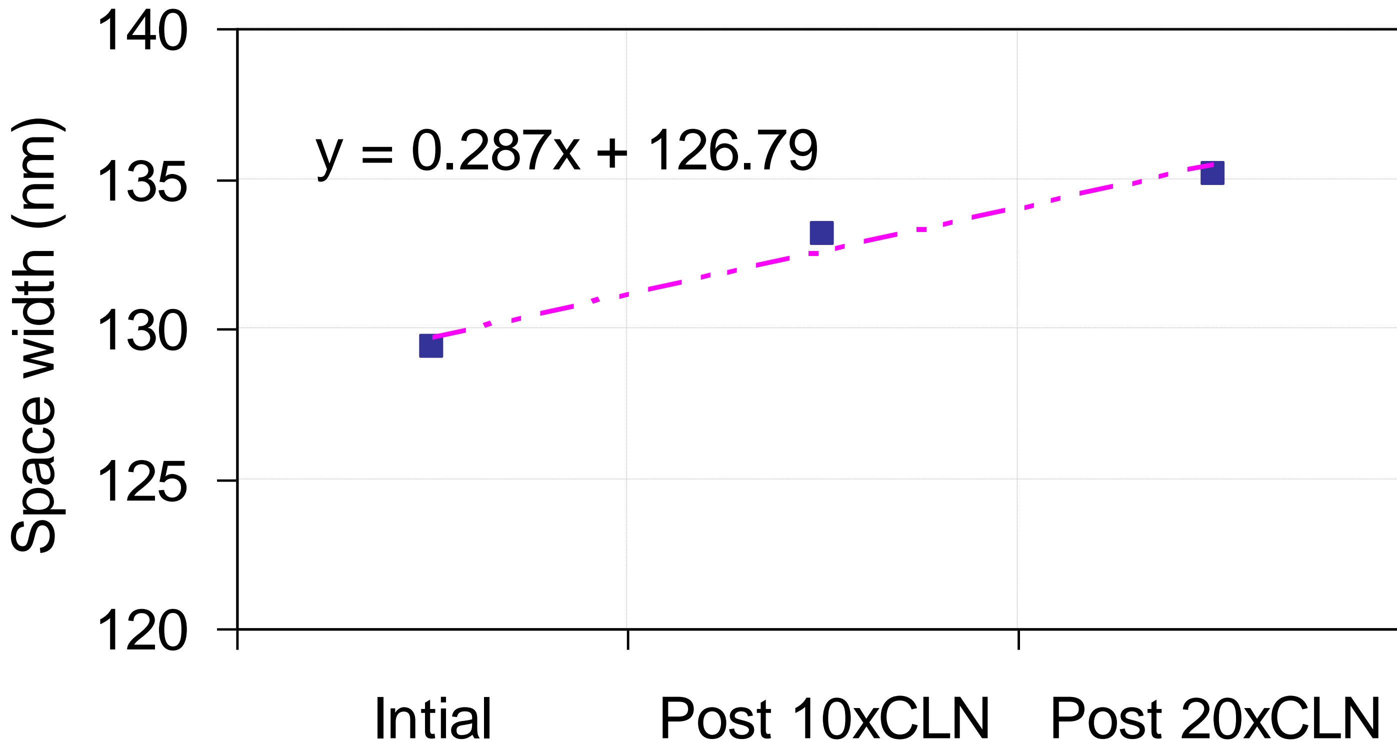
Absorber damage (CD change)



CD change	0.29nm/clean

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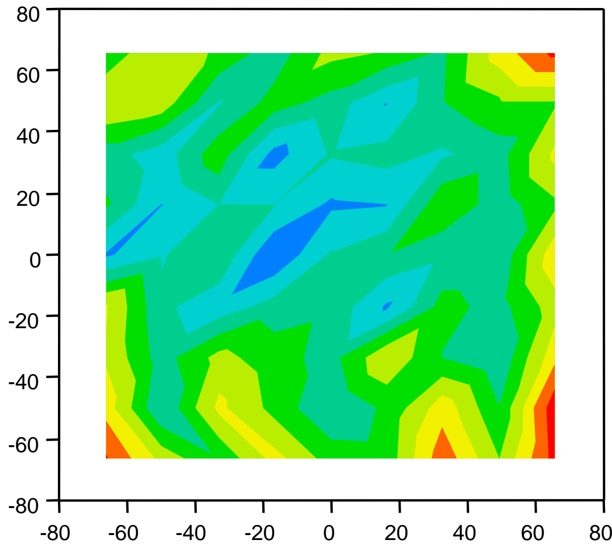
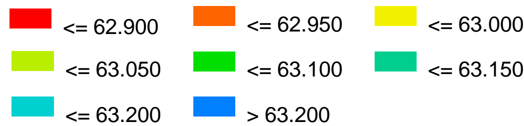
Ru damage (EUVR change)

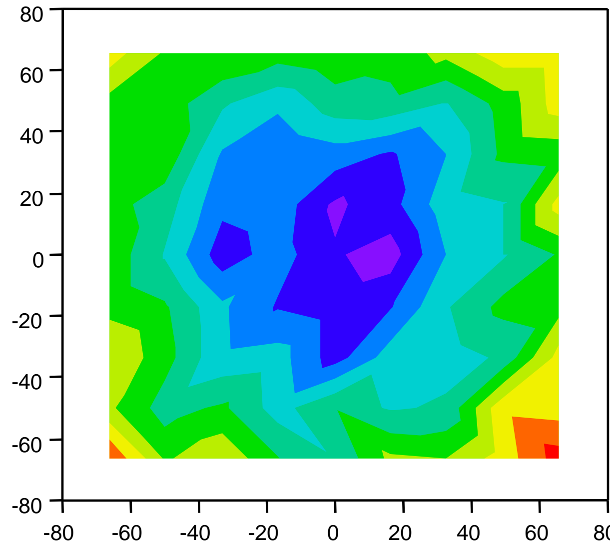
Initial

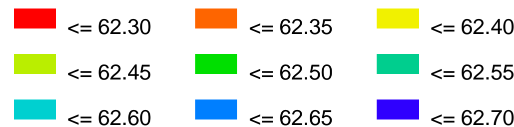




Average 63.08%
Range 0.39%
3sigma 0.25%

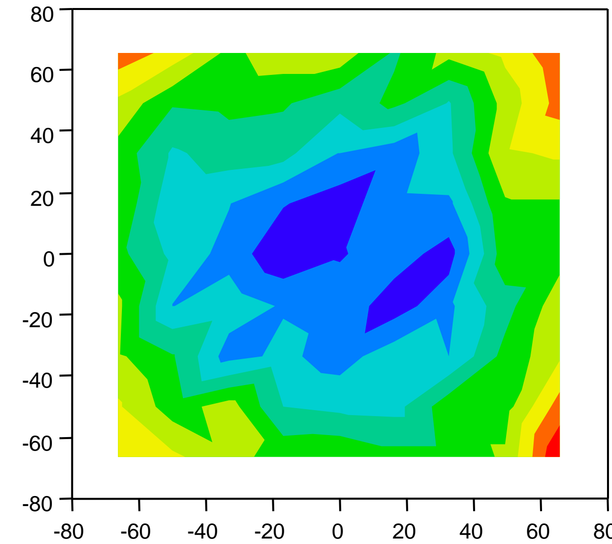
After 10 times clean

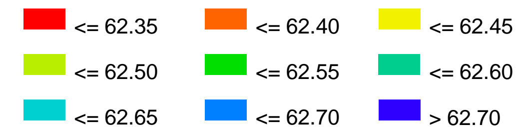




Average 62.52%
Range 0.45%
3sigma 0.30%

After 20 times clean





Average 62.55%
Range 0.44%
3sigma 0.29%

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Summary

	SPM-SC1	DIO3-SC1	New cleaning
PRE (50nm)	99%	NA	Under evaluation
Adders (50nm)	<20	NA	Under evaluation
CD change	0.29nm/clean	NA	<0.1nm/clean
ARC Thickness change	0.25nm/clean	NA	<0.1nm/clean
EUVR change	No change	1.0%/clean*	Under evaluation

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*Takeya Shimomura and Ted Liang Proc. SPIE 7122, 712226 (2008)

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Acknowledgements

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