MCP Process Flow, Facilities, and Needs

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Incom

LAPPD2 Microchannel Plate Godparent Review
Argonne National Laboratory
April 4, 2013

Questions

1) **What is the flow of 8'' plates?**
   - what it is now and what changes should be made?

2) **What is the facilities status?**
   - electroding at SSL and Fermilab
   - what's available for ALD process?
   - do we share them with others? if yes, how does it affect us?
   - quality control
   - resistance measurements
   - annealing ovens
   - storage and handling
   - clean room

3) **What's needed?**
   - clean handling and minimized exposure to air (or dust)
   - storage
   - annealing
   - electroding
   - any additional diagnostics required at any step of the process

What is the Flow of 8” Plates?

manufacture

Incom

Inspect

Argonne NATIONAL LABORATORY

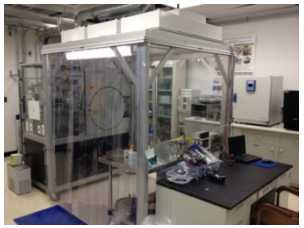
(360)

electroding

Fermilab

SSL

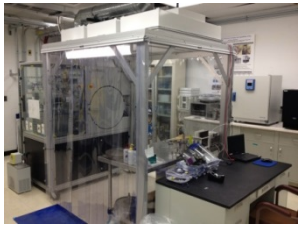
storage



(362 C332)

...

Coat



(362 C332)

Measure R

(362 C340)

Anneal

(382)

Measure R

(362 C340)

Test

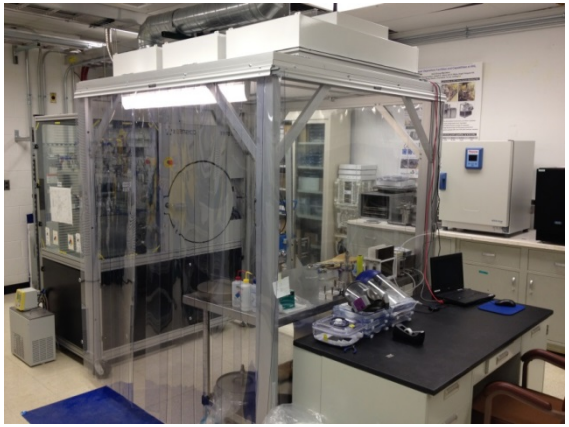
SSL

Matt and Andrey

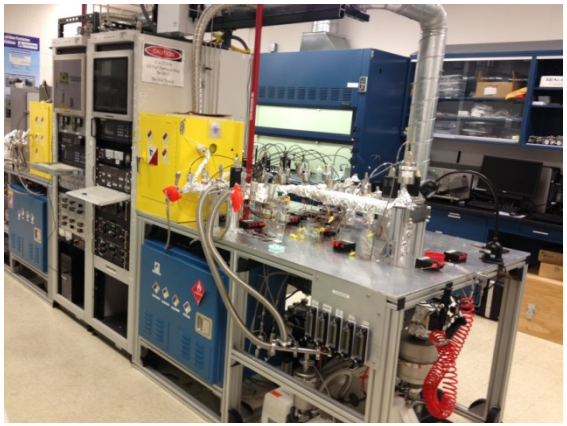
Henry

Incom TTO

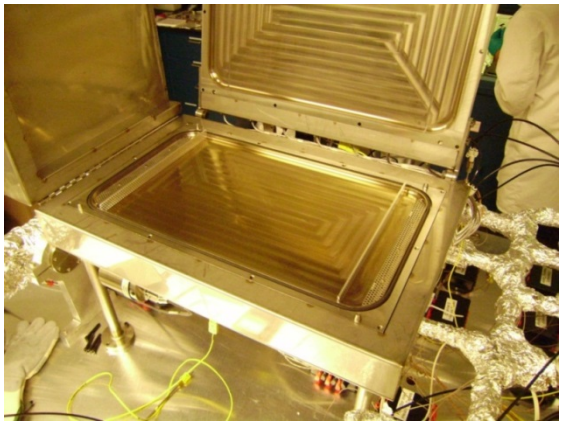
What is the Facilities Status?
- ALD systems for coating 8” MCPs



Beneq



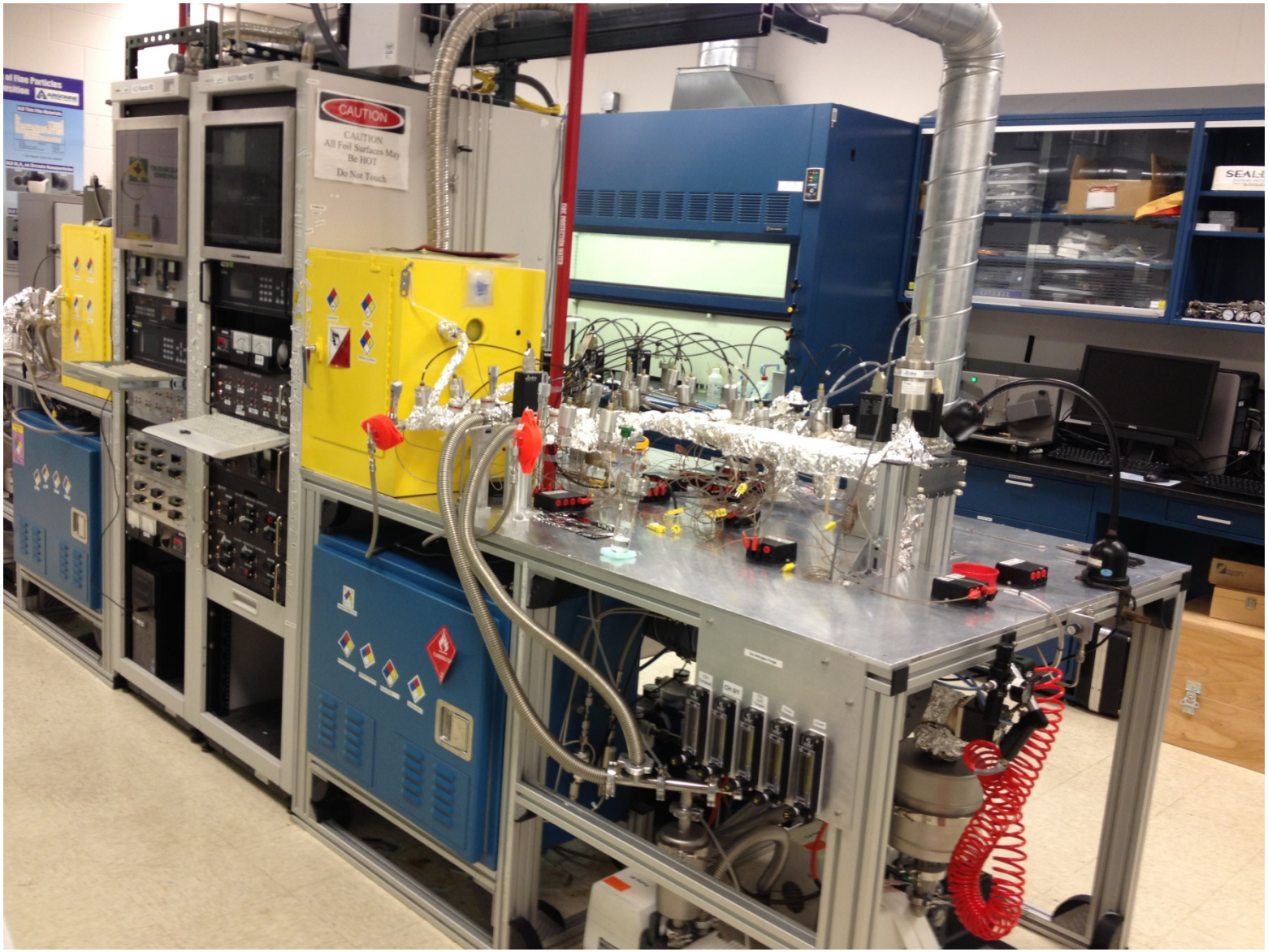
R3 with 200mm chamber



R4 with Large substrate reactor (LSR)

Availability for MCP/LAPPD	75/40%	60/30%	0% (only for crisis)
Non-MCP projects	KLA-Tencor	Basic research PV, batteries, catalysts	Basic research PV, batteries, catalysts
Potential for cross contamination?	low	medium (formerly high)	medium

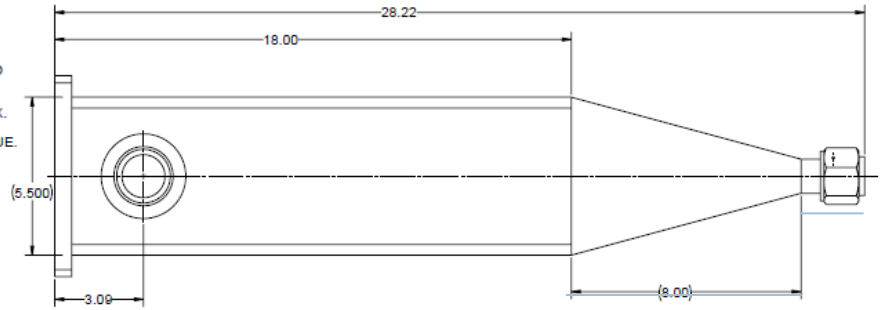
R3

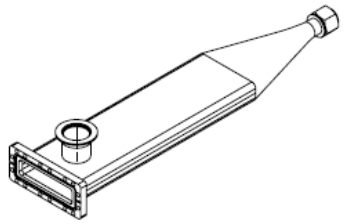


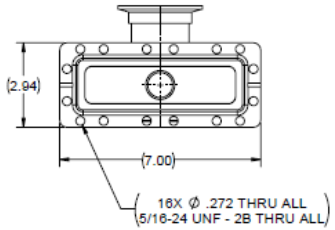
100 mm substrate chamber for R3 “tube reactor”

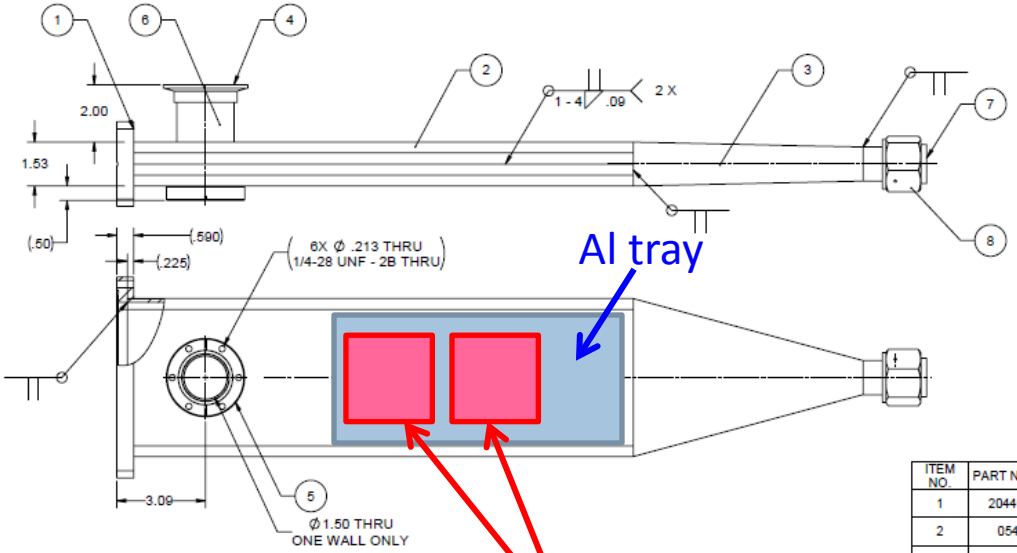
NOTES:

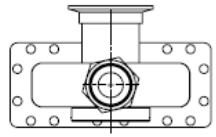
1. LEAK CHECK TO 2 X 10 -¹⁰ SCC/SEC OF He.
2. FACE OFF ALL TUBING 4.00 OD OR GREATER TO LENGTH AFTER WELDED TO MAIN BODY.
3. TOLERANCE FOR ALL FOCAL LENGTHS, TARGET POINTS AND OAL DIMENSIONS ± .030, ANGLES ± 1°.
4. BREAK AND DEBURR ALL NON- SEAL SHARP EDGES .015 MAX.
5. WELDMENT COSMETIC APPEARANCE PER ES0013, CF-3 VALUE.











100mm (4”) MCPs

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	204405-01	FLANGE, REACTOR CHAMBER	1
2	054643	BENDUP, 304SS, 5.50 W X .765 H. X 17.85 LG.	2
3	054644	TRANSITION, PIECE, 304SS, 5.50 W. X 1.20 OD X 8.00 LG.	1
4	713004	REF# K200-W	1
5	930853-01	FLG, 2.73 (F275150T BORED THRU)	1
6	040222	TUBE, WLD, 304SS, 2.00 OD X .065 W. X 1.92 LG.	1
7	042014	FITTING, VCR, GLAND 1.0" SOCKET	1
8	042033	FITTING, VCR, NUT FEMALE 1.0"	1

REV.	DESCRIPTION	DATE	APPROVED
1	INITIAL RELEASE.	12/10/12	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. TOLERANCES: FRACTIONAL ±1/64, ANGULAR ±°, X DECIMAL ±.03, XX DECIMAL ±.010, XXX DECIMAL ±.005. SURFACE ROUGHNESS. MATERIAL: SEE BOM. FINISH: ELECTRO-POLISH.

	NAME	DATE
DESIGNED	H. DIEP	12/07/12
DRAWN	H. DIEP	12/07/12
CHECKED		

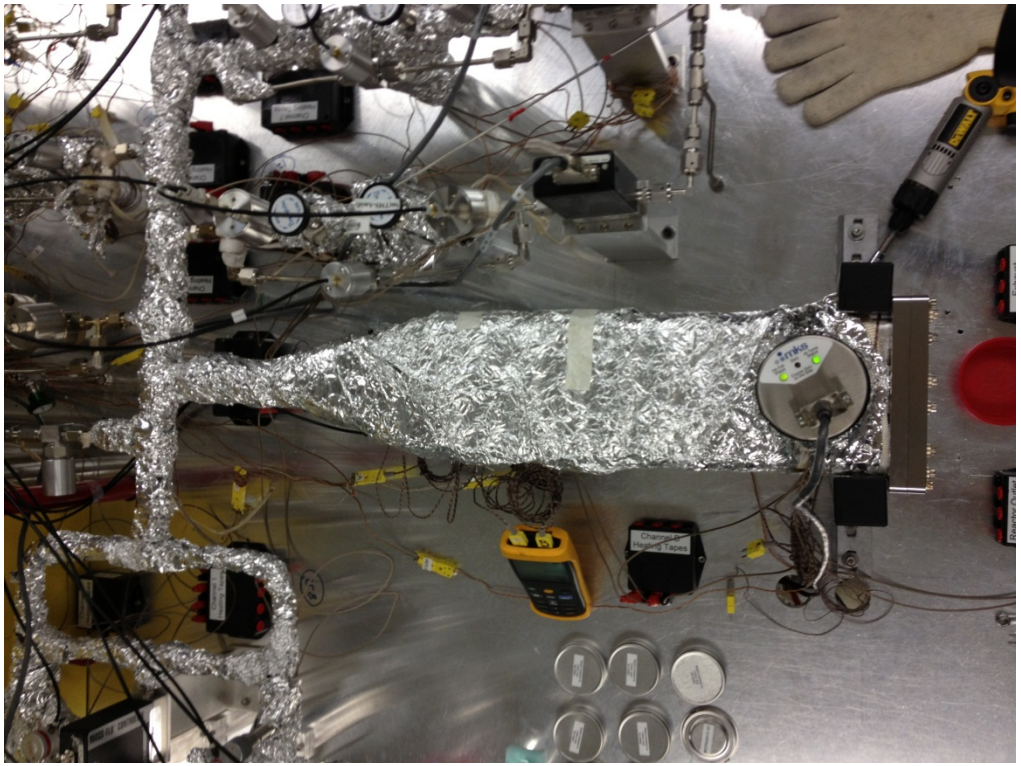
PROPRIETARY AND CONFIDENTIAL

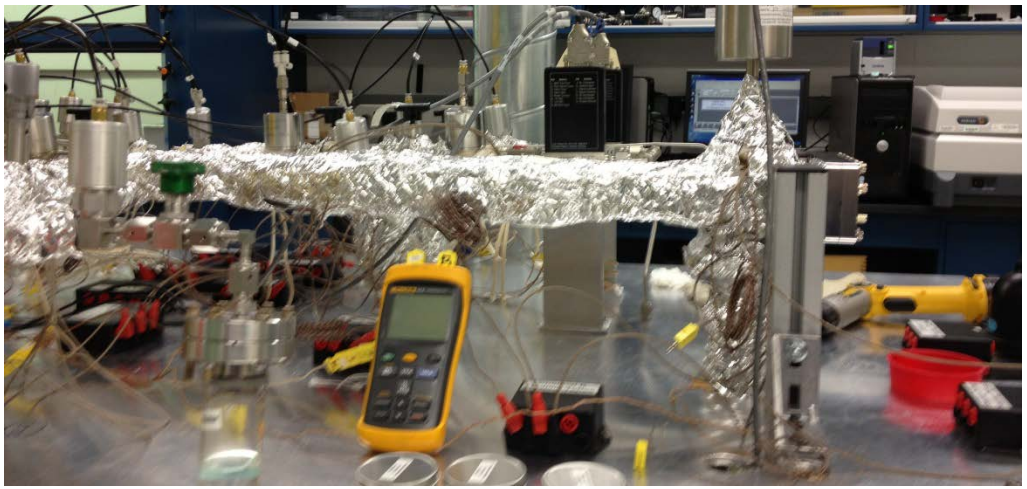
MDC VACUUM PRODUCTS LLC.
23842 Cabot Blvd., Hayward California 94545

TITLE: RECTANGULAR CHAMBER WELDMENT

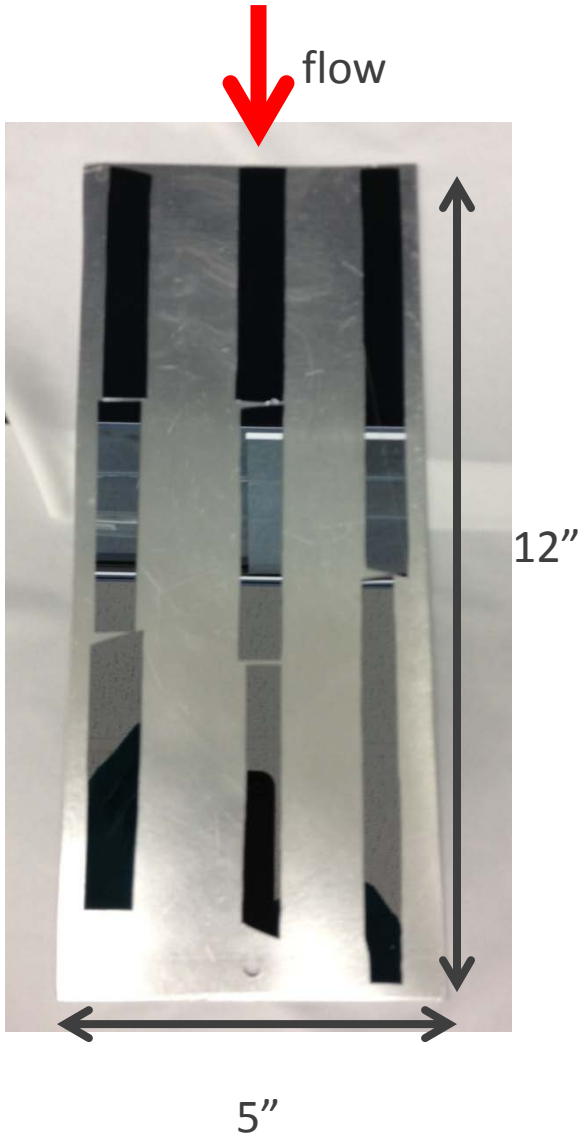
SIZE	PRODUCT NO.	DWG. NO.	REV
D		204405-03	1

SCALE: 3:4 SHEET 1 OF 1





100 mm Chamber Qualification: ALD Al_2O_3



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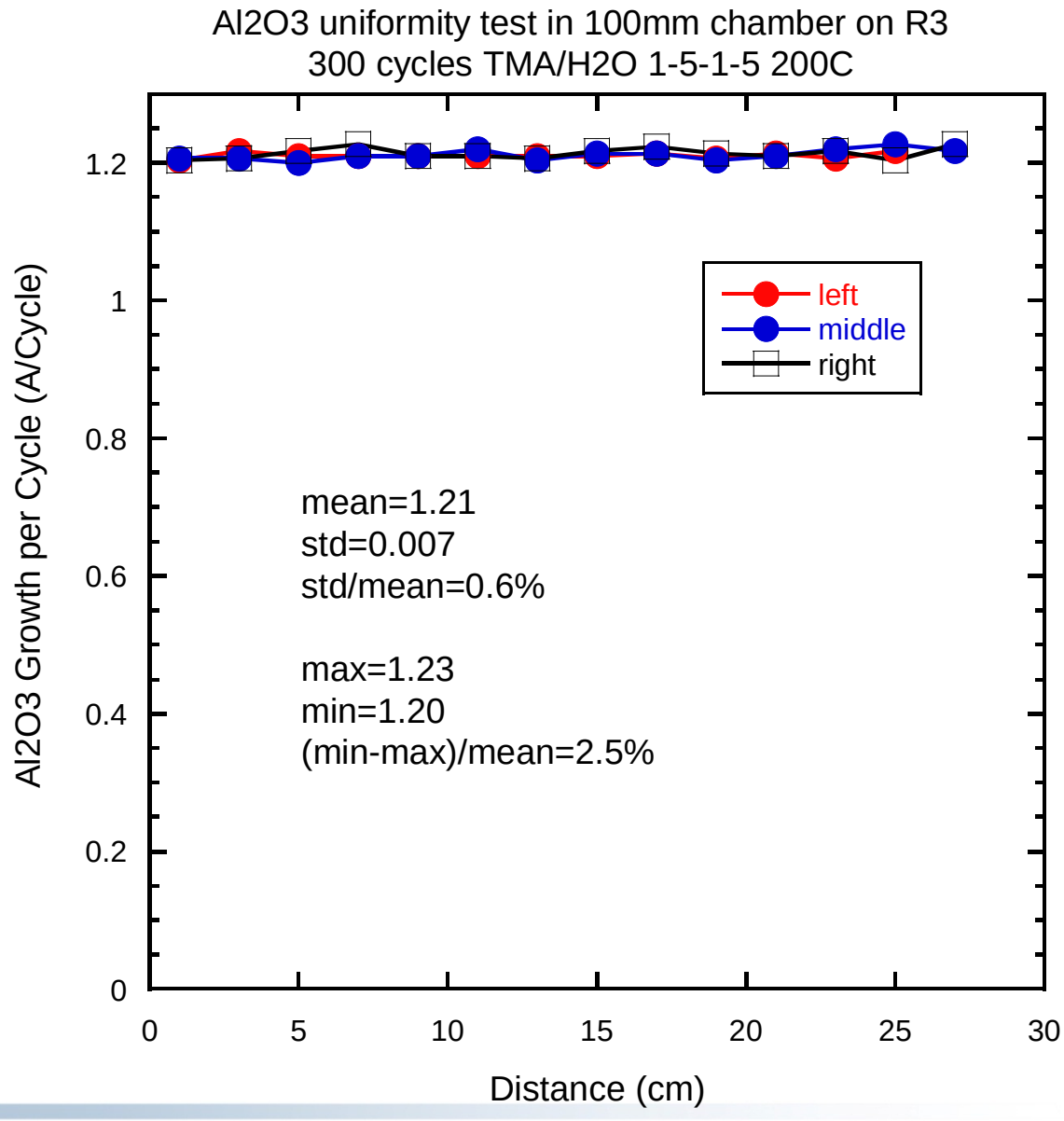
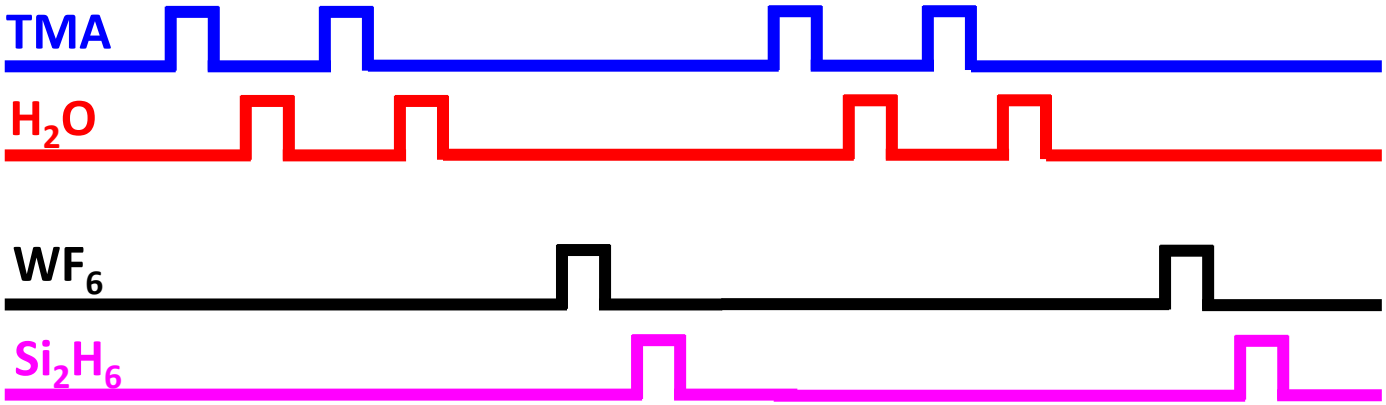


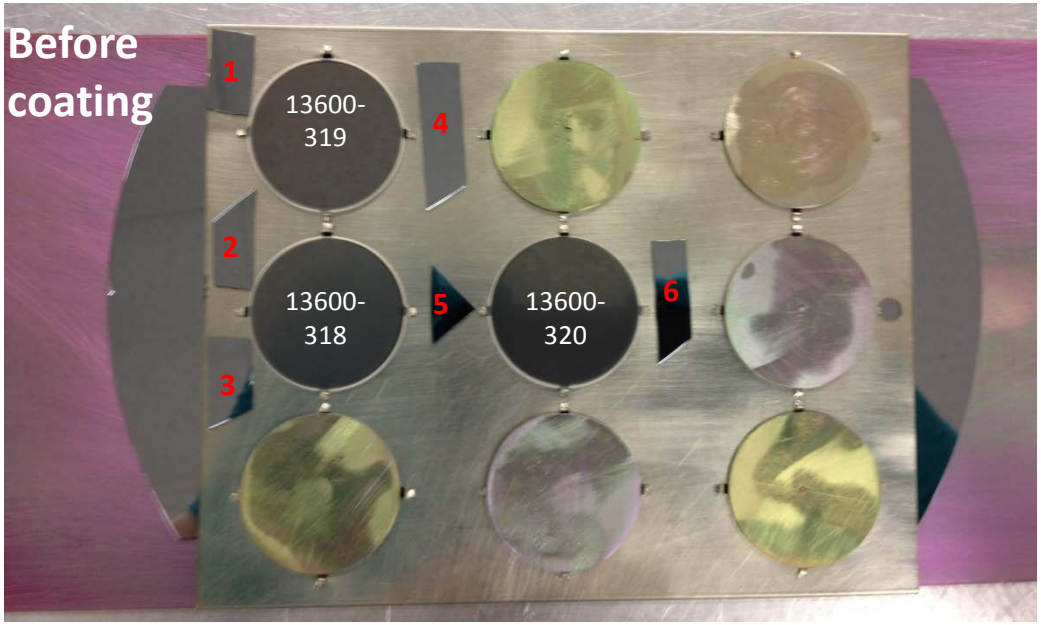
ALD of W-Al_2O_3 Composite Films

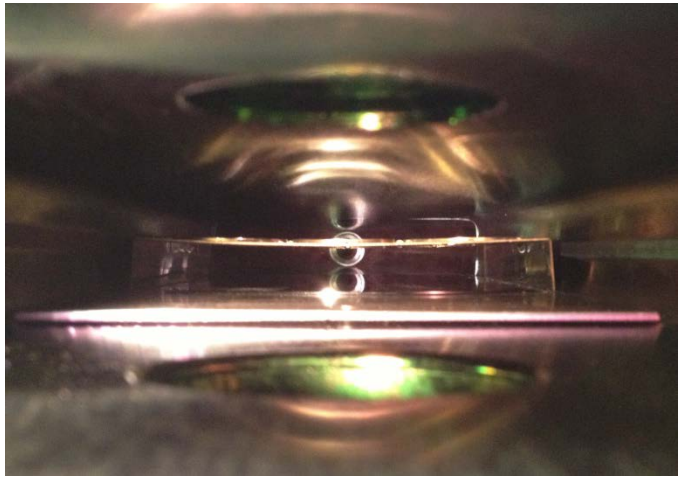
- Combine 2 ALD processes:
  - $TMA/H_2O \rightarrow Al_2O_3$: insulator, $\rho=10^{16}$ Ωcm
  - $WF_6/Si_2H_6 \rightarrow W$: conductor, $\rho=10^{-4}$ Ωcm

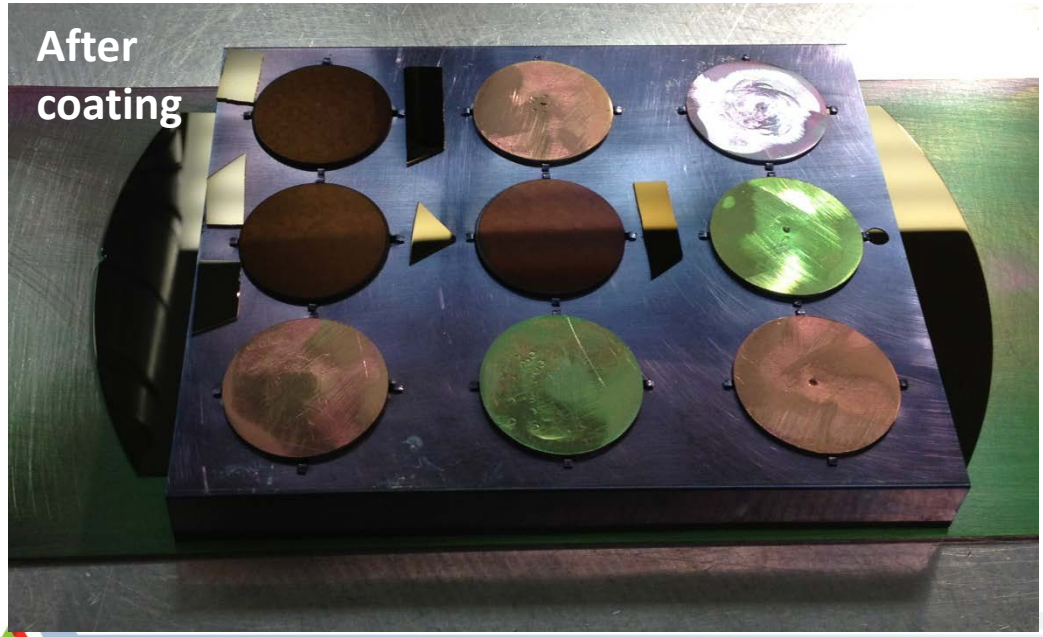


- Tune resistivity with $W/(W+Al_2O_3)$ cycle ratio

Chem1 on 33mm MCPs using Fixture from SSL





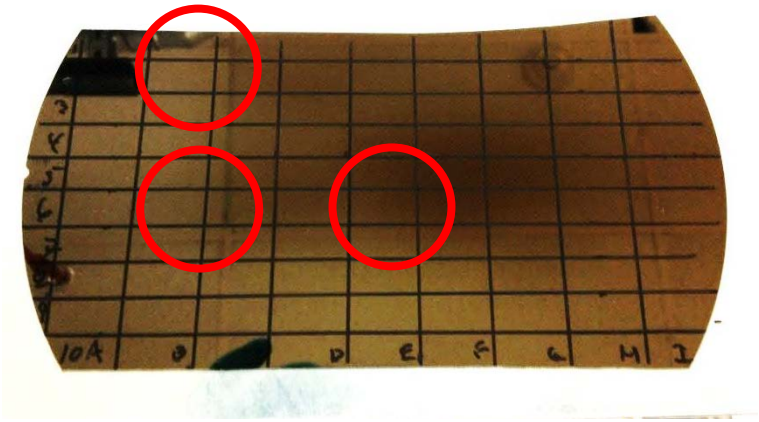


MCP's	R (Ohm)	Rho (Ohm cm)
13600-018	2.3e8	1.1e8
13600-019	2.5e8	1.2e8
13600-020	2.2e8	1.2e8

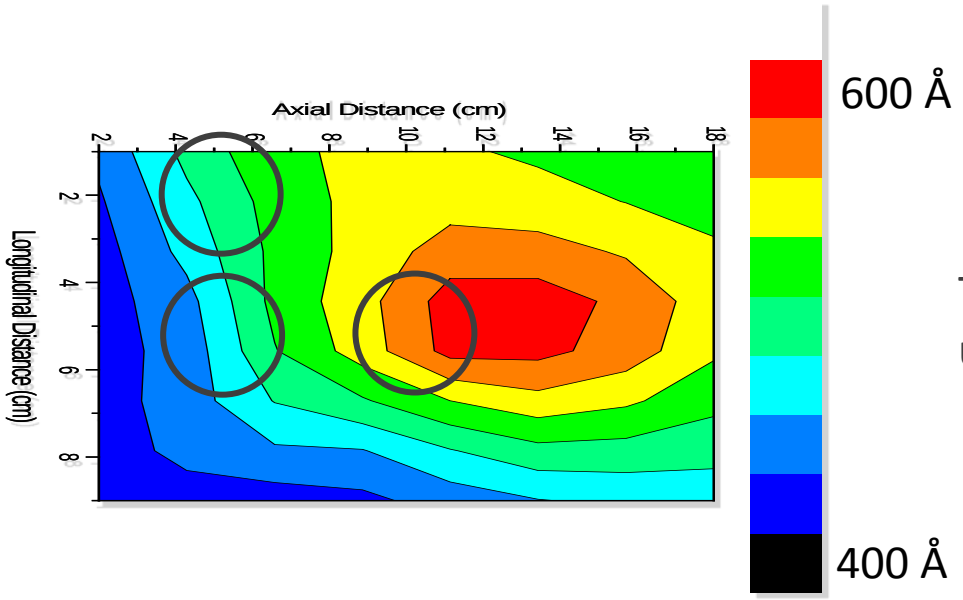
- Very good reproducibility

Silicon	Th(A)	n600	MSE
1	479	1.81	4.0
2	**467**	1.84	4.0
3	471	1.81	3.8
4	575	1.83	6.4
5	567	1.83	6.0
6	**618**	1.84	7.7

- Thicker downstream
- Th, n, MSE all correlated



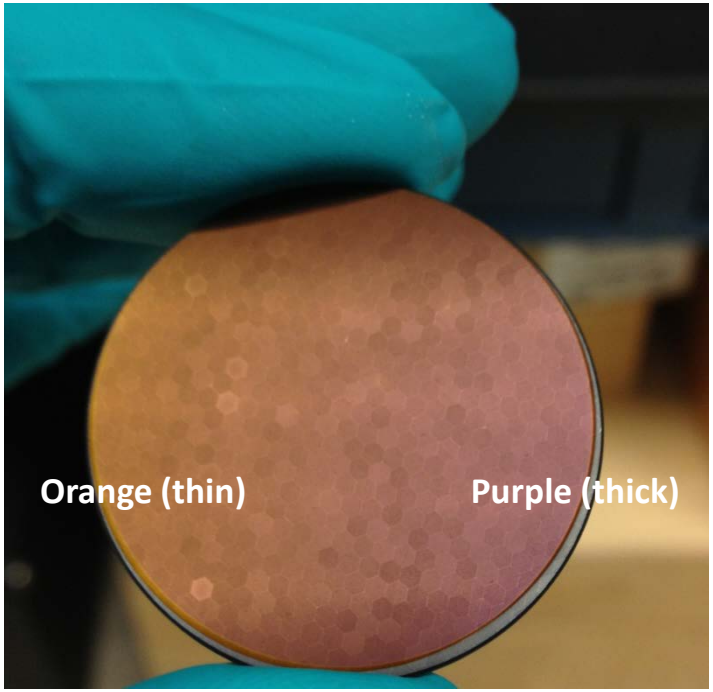
Darker downstream and under MCPs

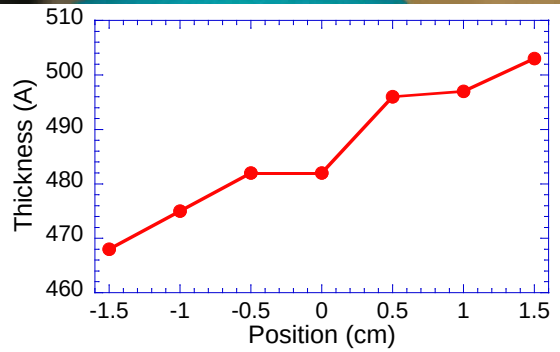


Thicker downstream and under MCPs

13600-297: 25% chem1, R=2.4e8

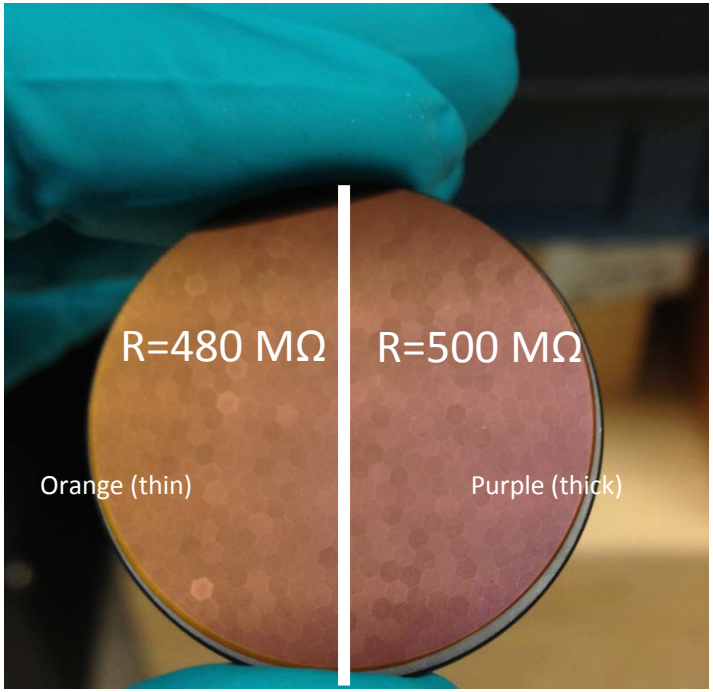
Flow →





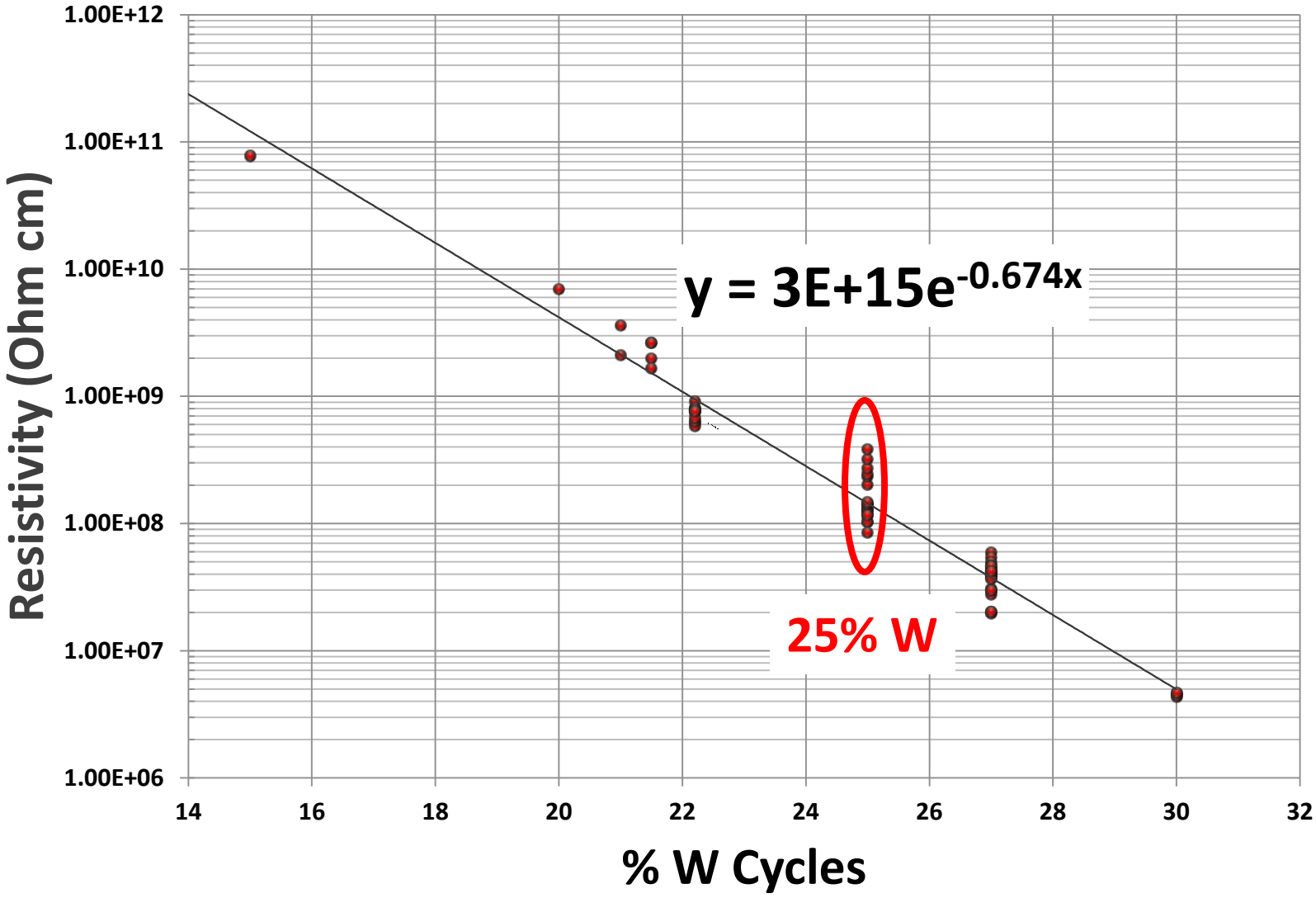
- Thickness gradient across all of the 33mm MCP (regardless of position in tray)

13600-297: 25% chem1, R=2.4e8
Crack in half:

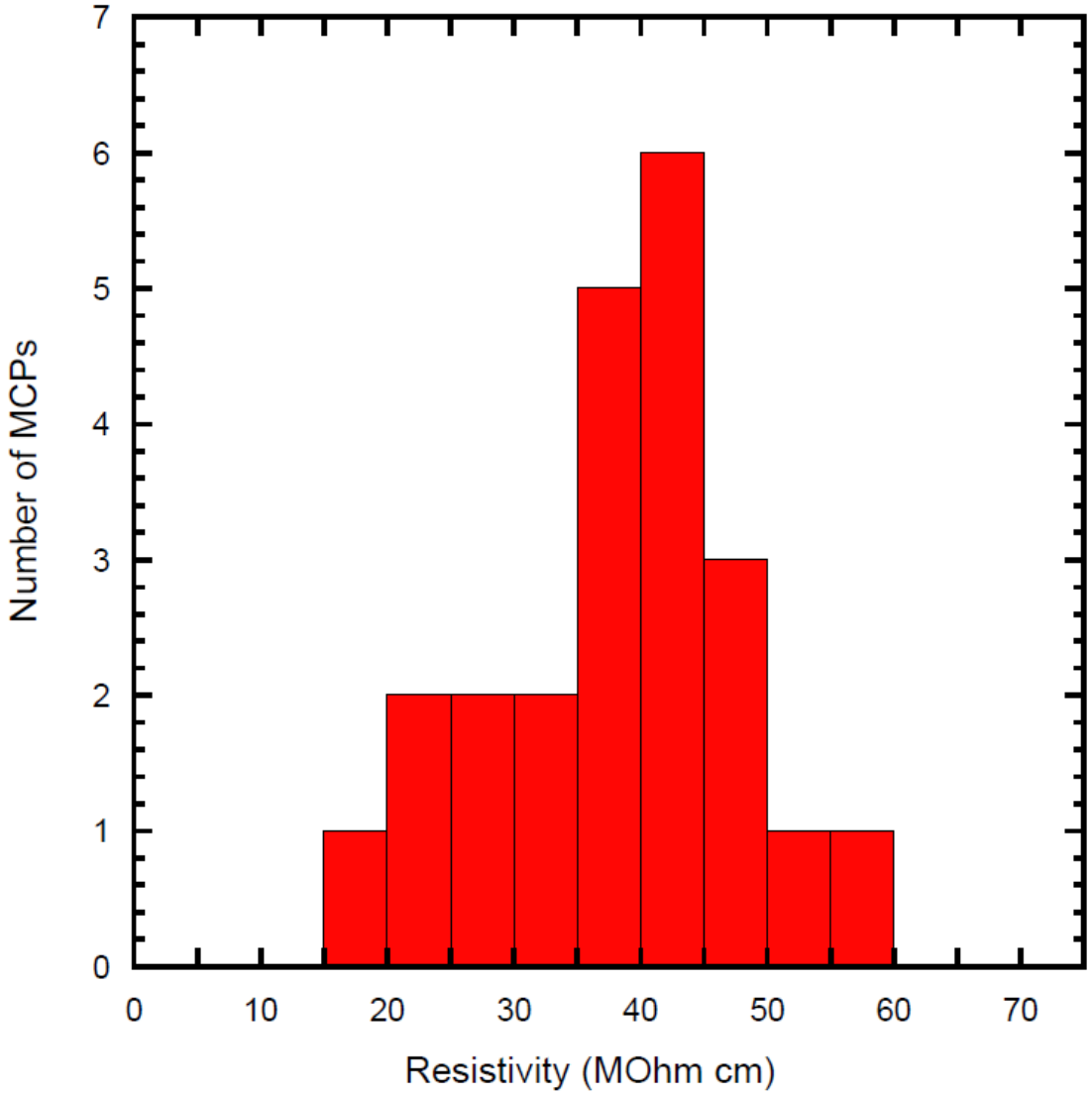


- Apparently thickness gradient does not extend into pores since resistance of both thin and thick halves is the same
- Much better uniformity by rotating the fixture ½ way through the Chem1 coating
- *No ALD optimization has been done yet!*

Resistivity Summary for 65 MCPs Coated in R3



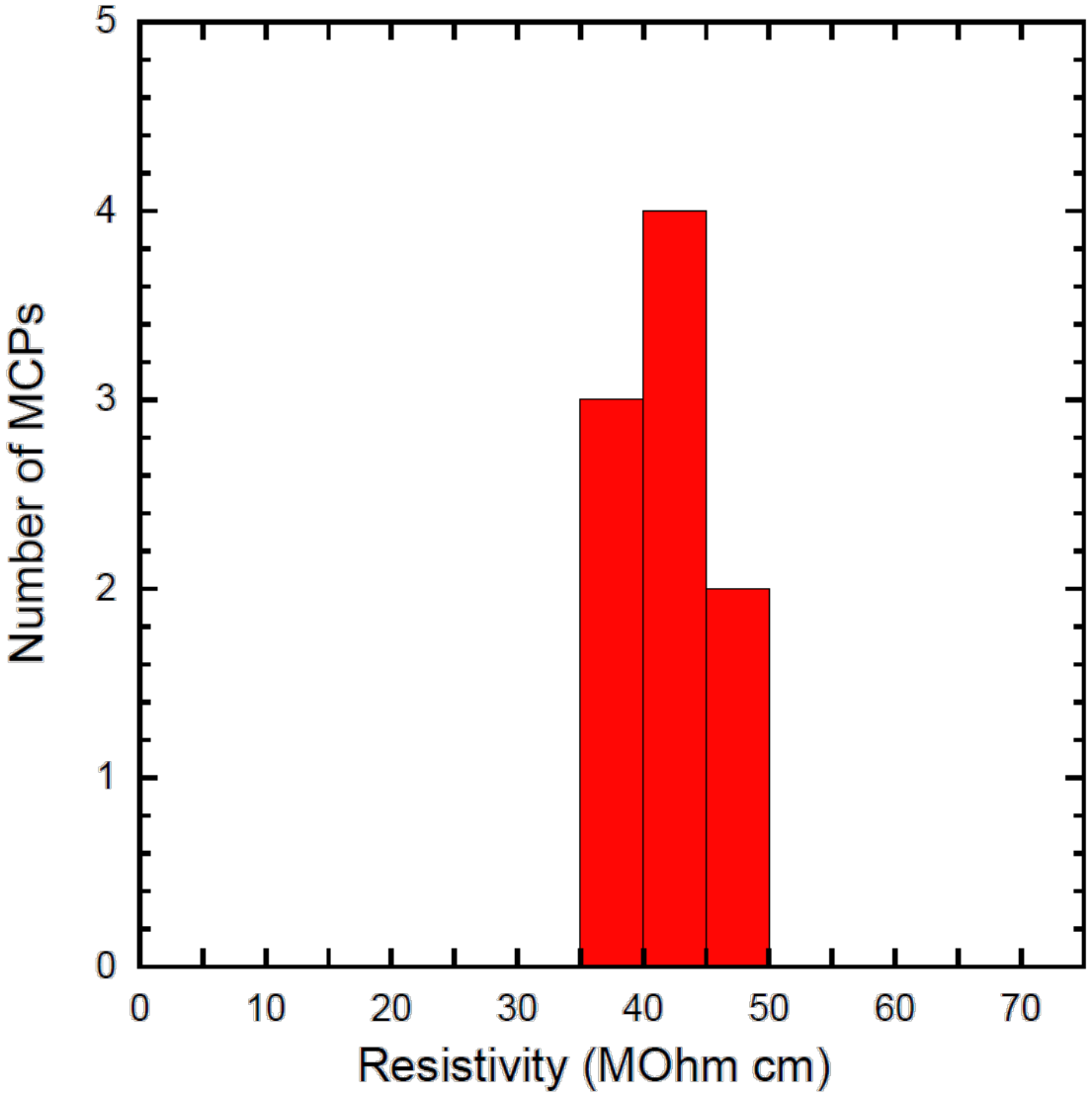
Resistance Distribution for 25% W Chem1 MCPs



22 MCPs:
Different batches, different days, different operators

Mean = 38(±10)MΩ cm

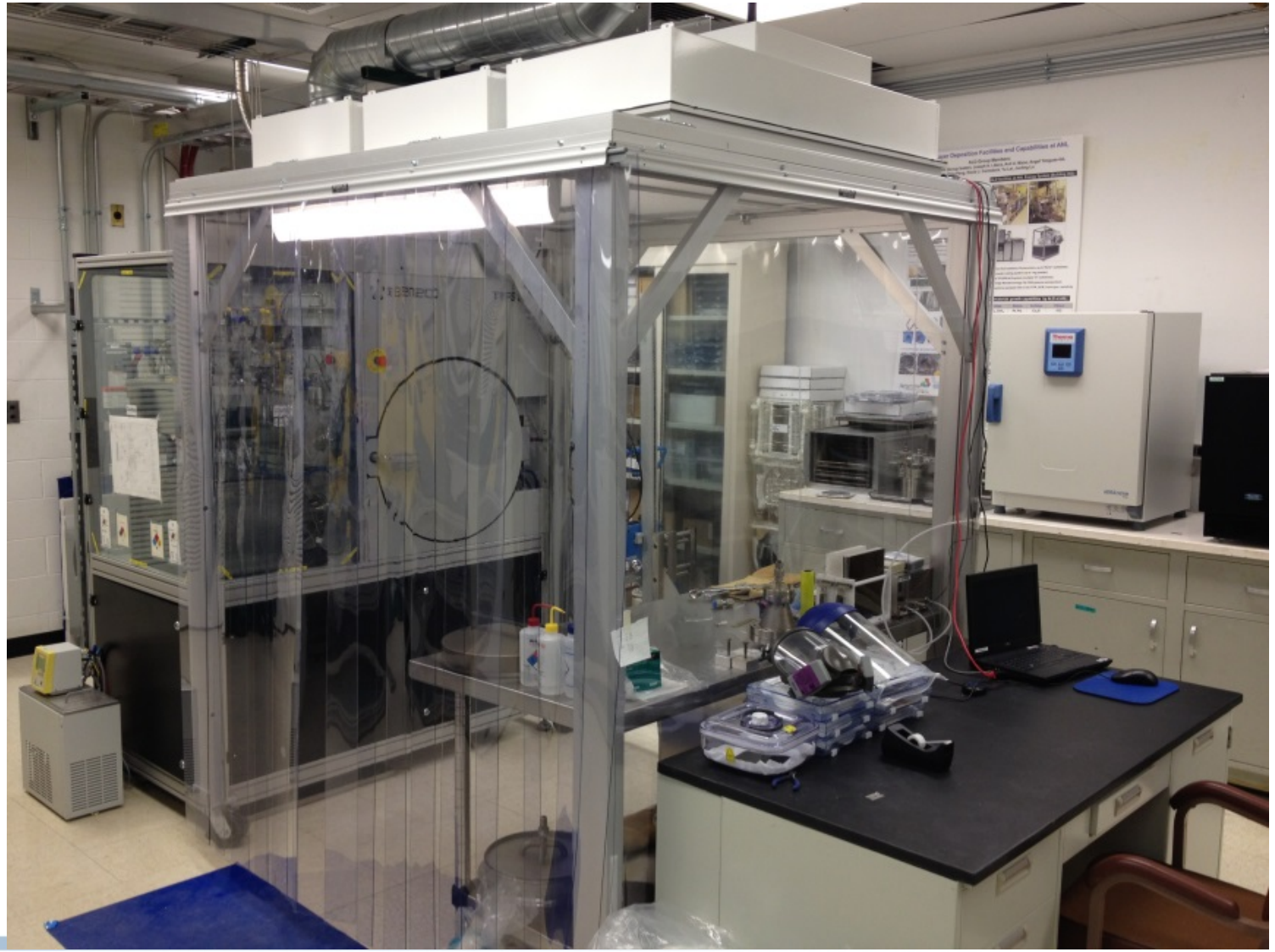
Resistance Distribution for 25% W Chem1 MCPs



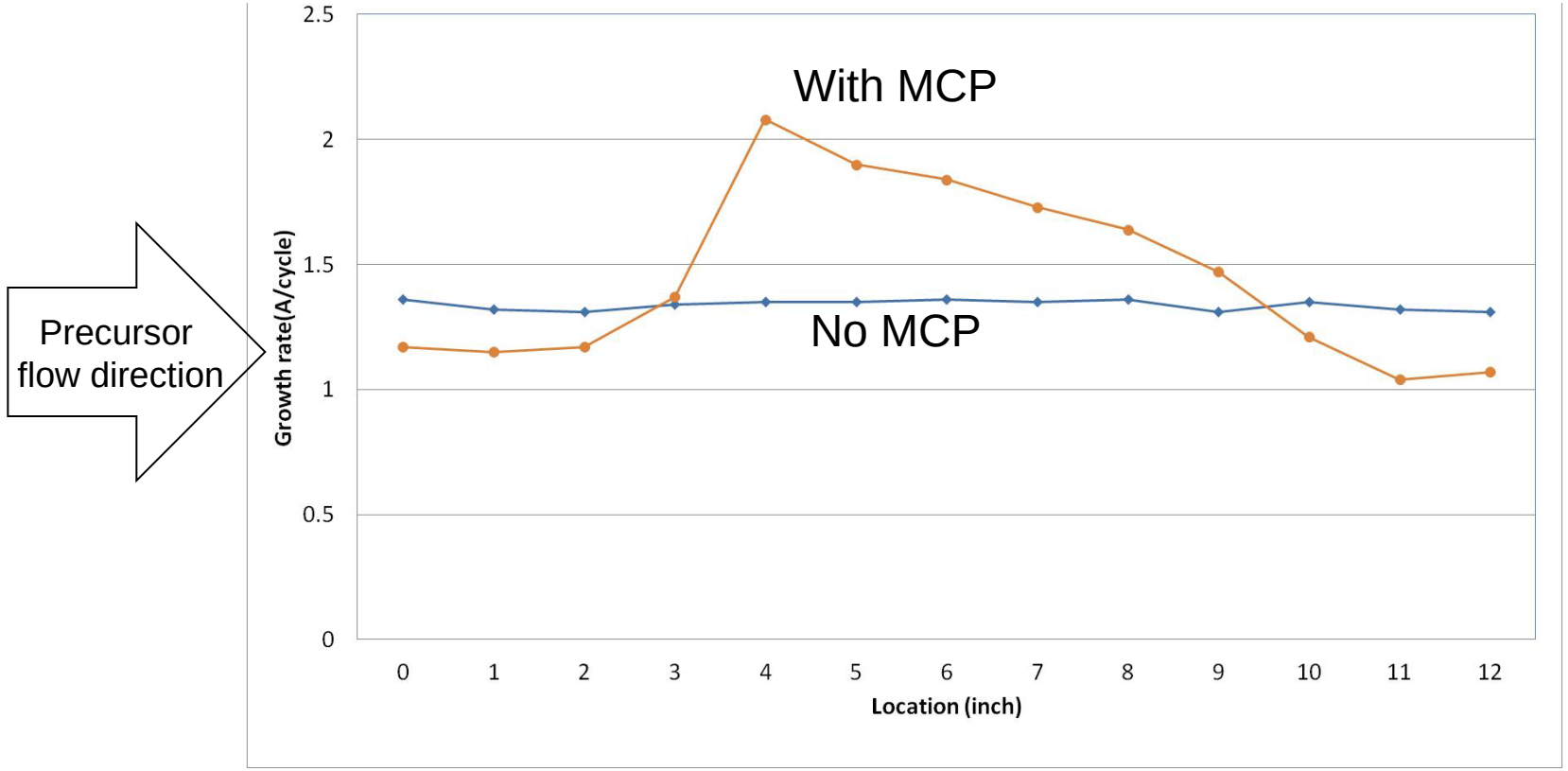
9 MCPs:
Single batch

Mean = 42(±3)MΩ cm

Beneq

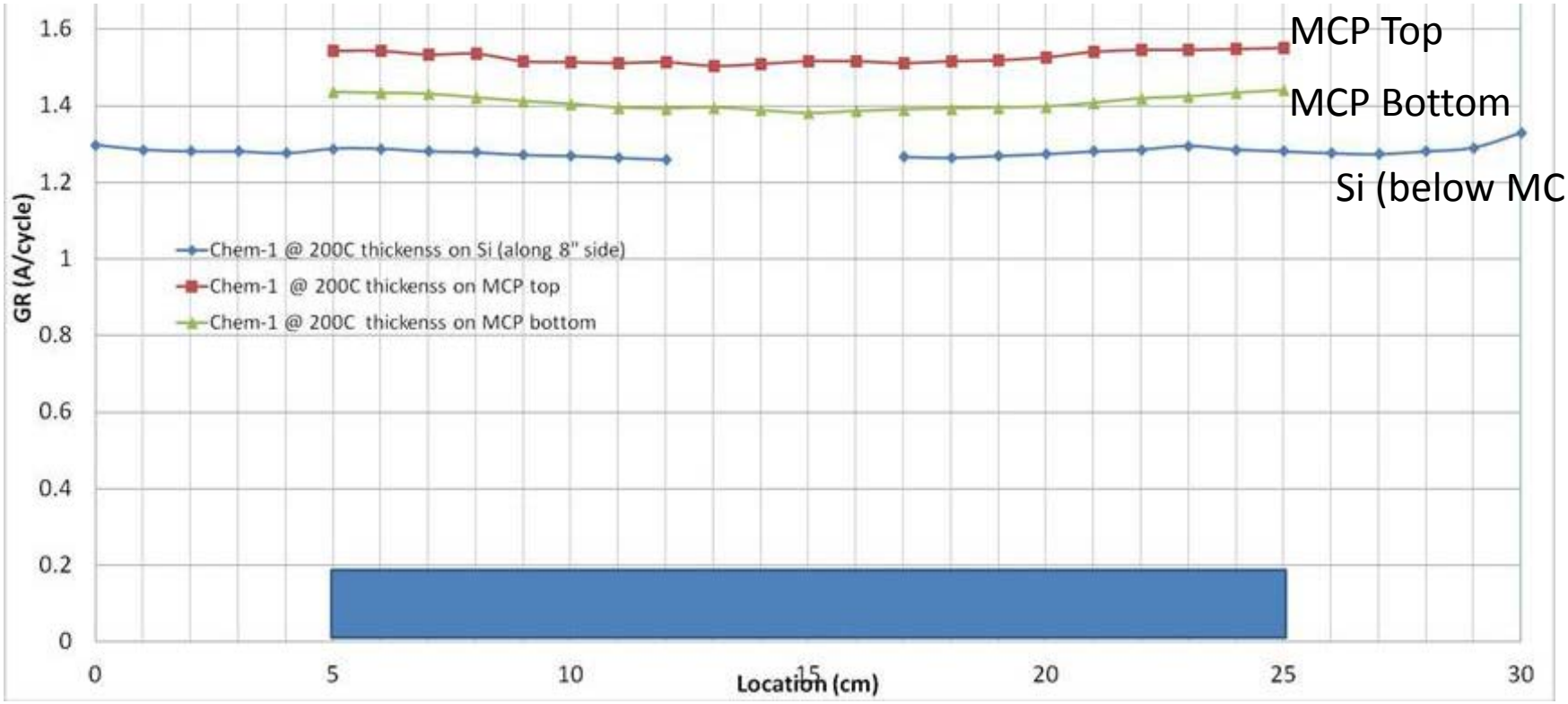


MgO Thickness Gradient in Beneq using Cross-Flow

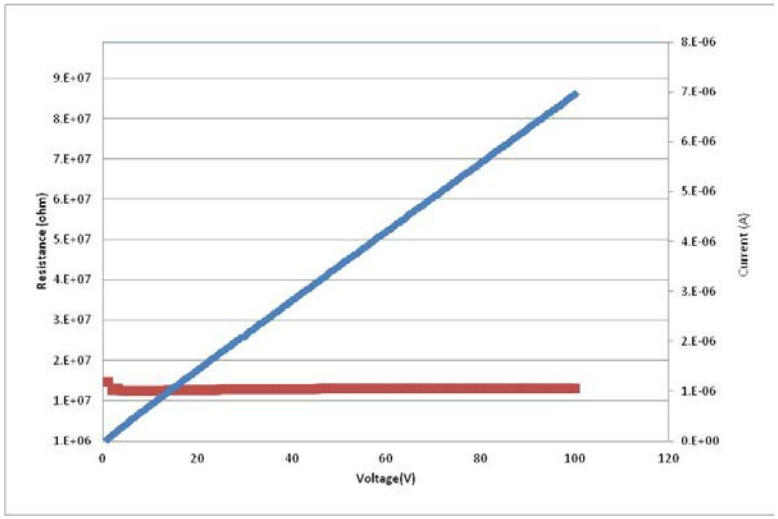


“Before”

Chem1 on Actual MCP and Si after Hardware and Process Development

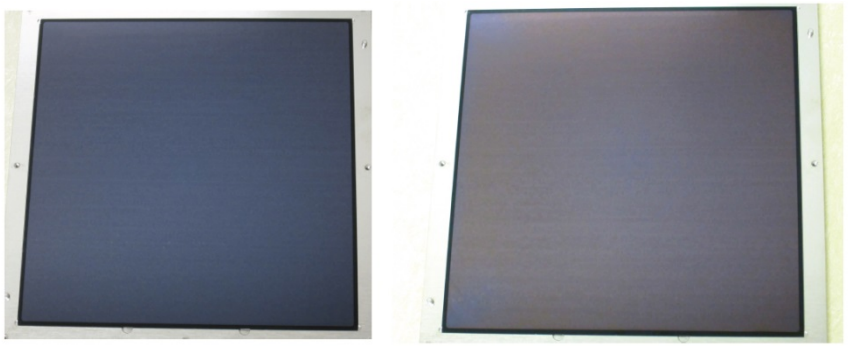


"After"



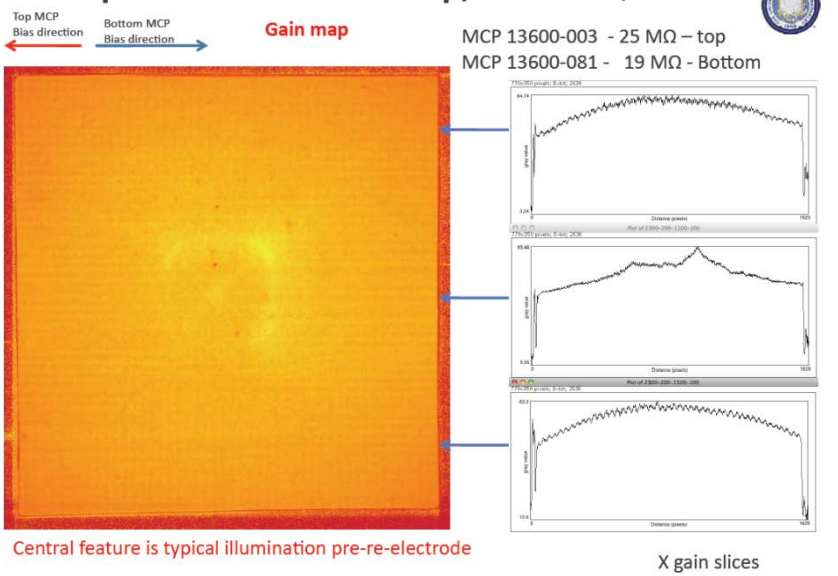
13600-003 – 12% W, rho=5e9 ohm cm

Resistance as dep=14.5 Mohm
Resistance after 400C anneal = 25 Mohm



Air resistance 23MΩ, vacuum resistance 25MΩ

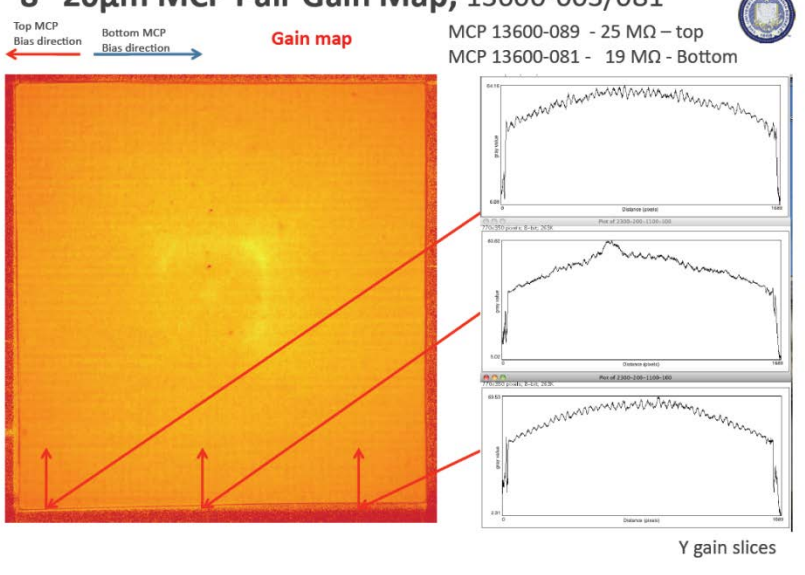
8” 20µm MCP Pair Gain Map, 13600-003/081



Central feature is typical illumination pre-re-electrode

X gain slices

8” 20µm MCP Pair Gain Map, 13600-003/081

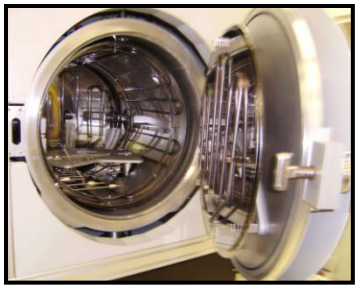


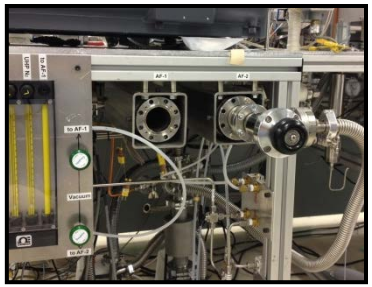
Y gain slices

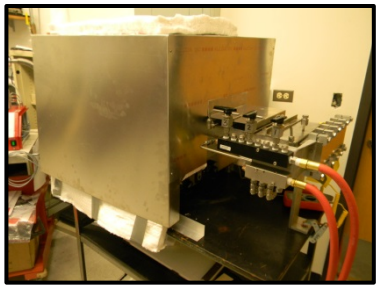
8” MCPs from Beneq, Chem1 + Al_2O_3

	Argonne ID	MCP ID	R as deposited (MOhms)	comments
1	BSHWALO11	13600-003	14	Ossy tested, Matt
2	BSHWALO12	13600-002	13	Ossy tested, Matt
3	BSHWALO13	13600-007	0.3	TMA ran out
4	BSHWALO14	13600-051	29	Ossy
5	BSHWALO15	13600-046	14	Ossy
6	BSHWALO16	13600-077	34	Ossy
7	BSHWALO17	13600-069	24	Ready to ship
8	BSHWALO18	13600-053	19	Ready to ship
9	BSHWALO19	13600-068	13	Ready to ship
10	BSHWALO20	14020-013	TBD	In Beneq

What is the Facilities Status? - Annealing Ovens

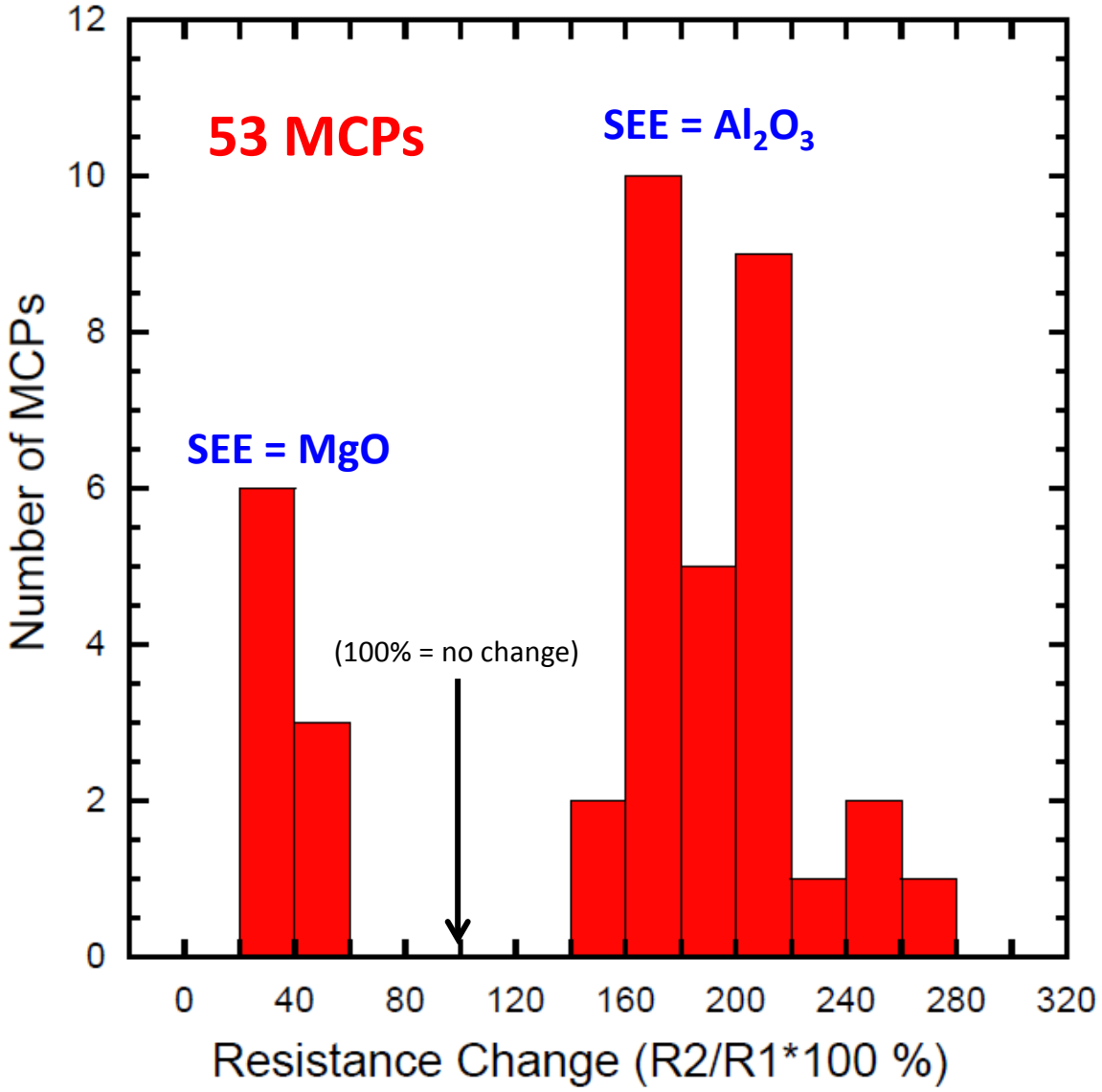






	Beneq	R4 tube furnace	Elnik	Pizza oven + insert
Pros	• 8” substrates • Located in ALD lab • Located in clean room	• Always available • Located in ALD labs	• 8” substrates	• 8” substrates • Located in ALD labs • Located in clean room • No delamination dust • No interruption of ALD
Cons	• Thermal cycling creates dust • Interrupts ALD	• 46mm max substrates • Not in clean room	• Located in 380 • Not in clean room	• ???
Comments	• UHP N2	• UHP N2	• HV	• UHP N2

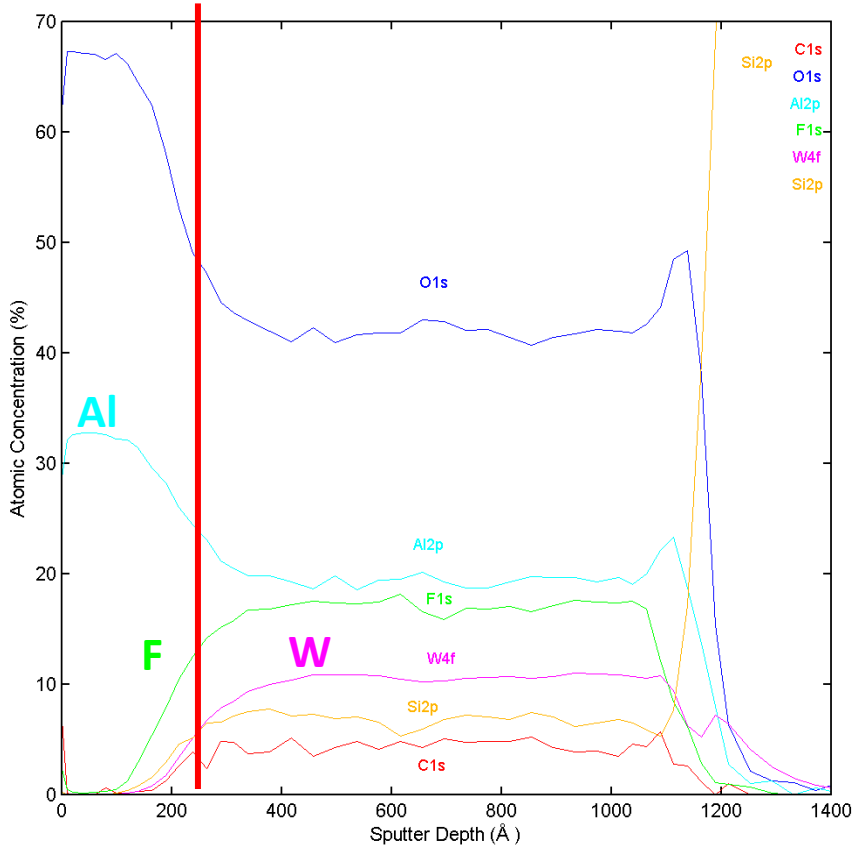
Resistance Change From Anneal, Chem1, 15-30% W



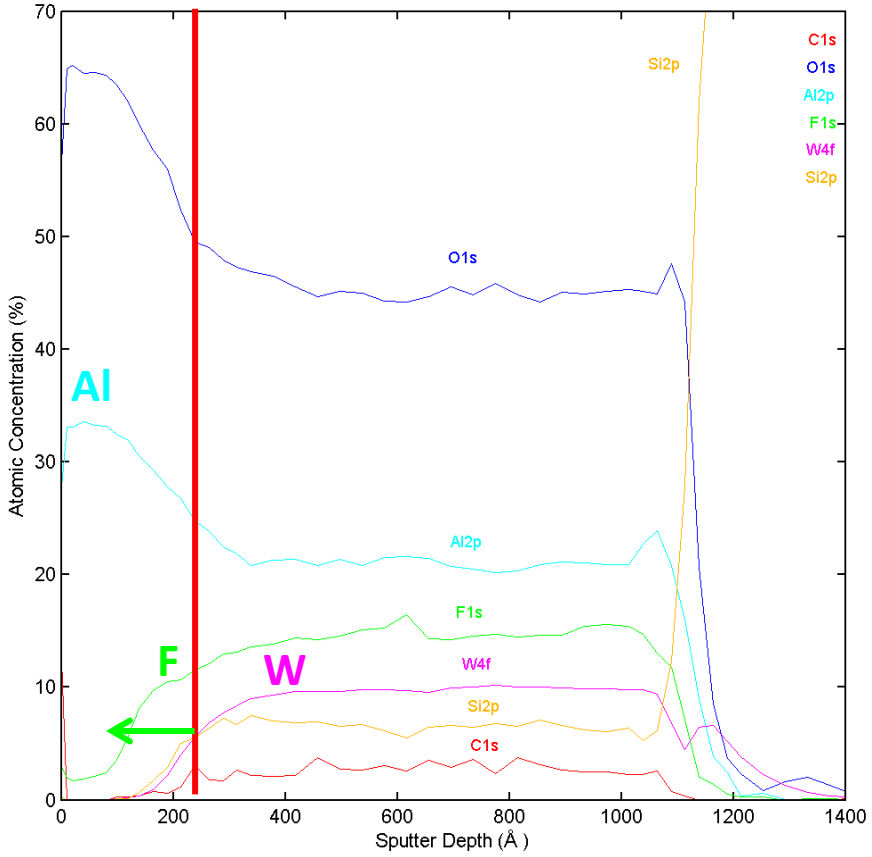
Conditions:
400C, 4 Hrs.
UHP N2, 360 sccm flow
1 Torr pressure

Fluorine Migration During Anneal of Chem1 + Al_2O_3

Before anneal

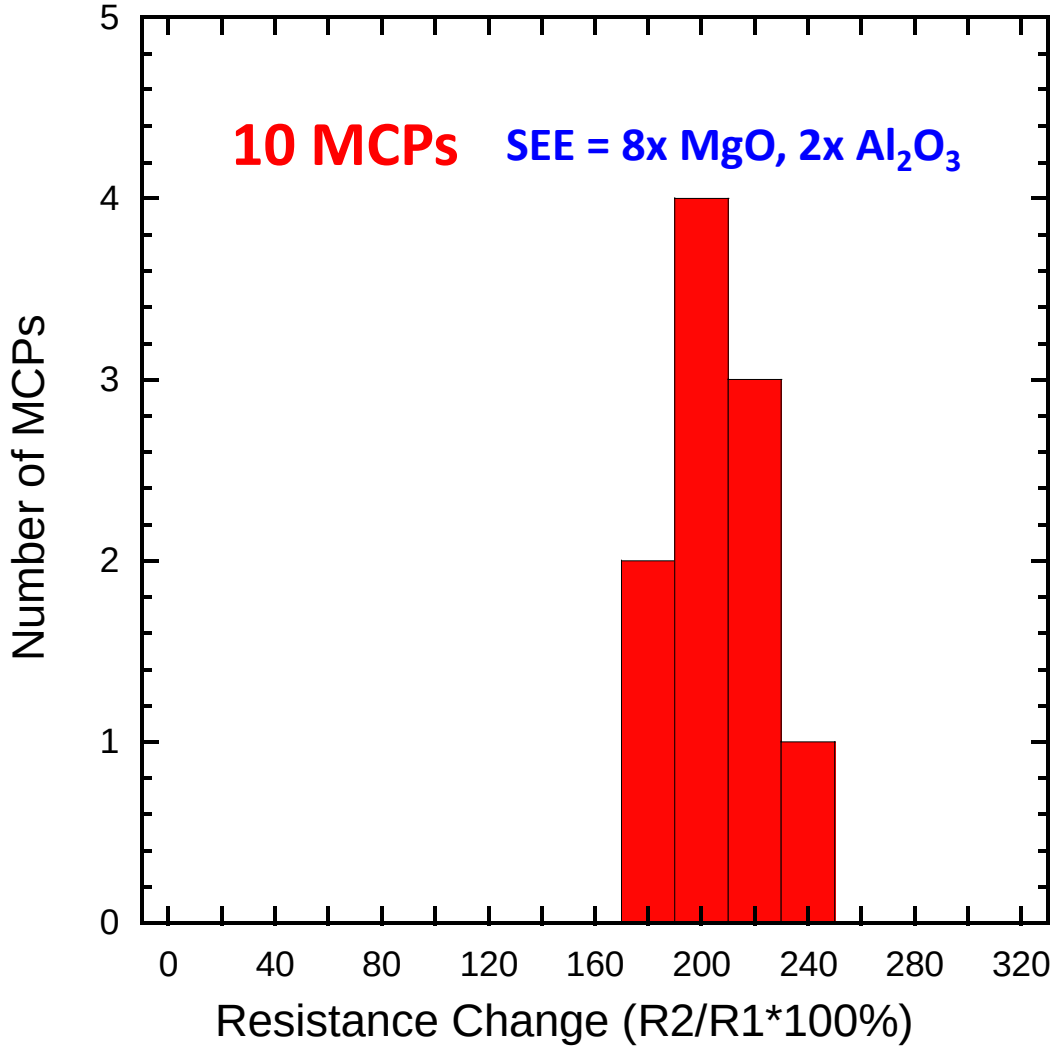


After anneal



- F migration might increase resistance of Chem1 coating
- But F also migrates into MgO – why then does Chem1 resistance *decrease*?

Resistance Change From Anneal, Chem 2, 9-10% Mo



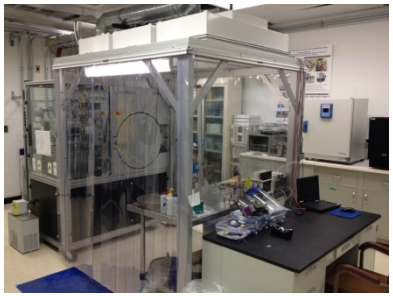
- Chem2+MgO also shows F migration in XPS
- F migration might be a “red herring”

What's Needed?
- Annealing Studies

- Is the annealing necessary?
- What are the effects of annealing temperature, time, N_2 versus UHV?
- During the anneal, what happens to the:
  - Resistive coating (crystallization, F diffusion, chemistry)?
  - Emissive coating (crystallization, F diffusion, chemistry)?
  - Glass substrate (alkali, lead diffusion into ALD, ALD diffusion into glass)?
- Can the resistance changes be controlled/eliminated using diffusion barrier layers?

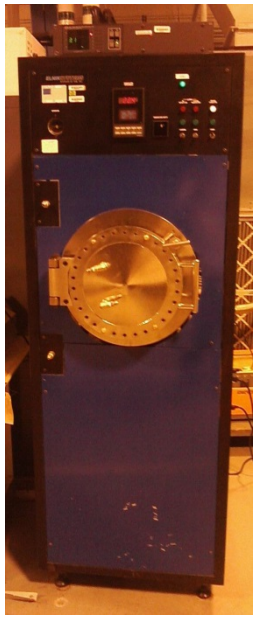
What is the Facilities Status?
- Current MCP Process Flow:

Coat



Measure R

Anneal



Measure R

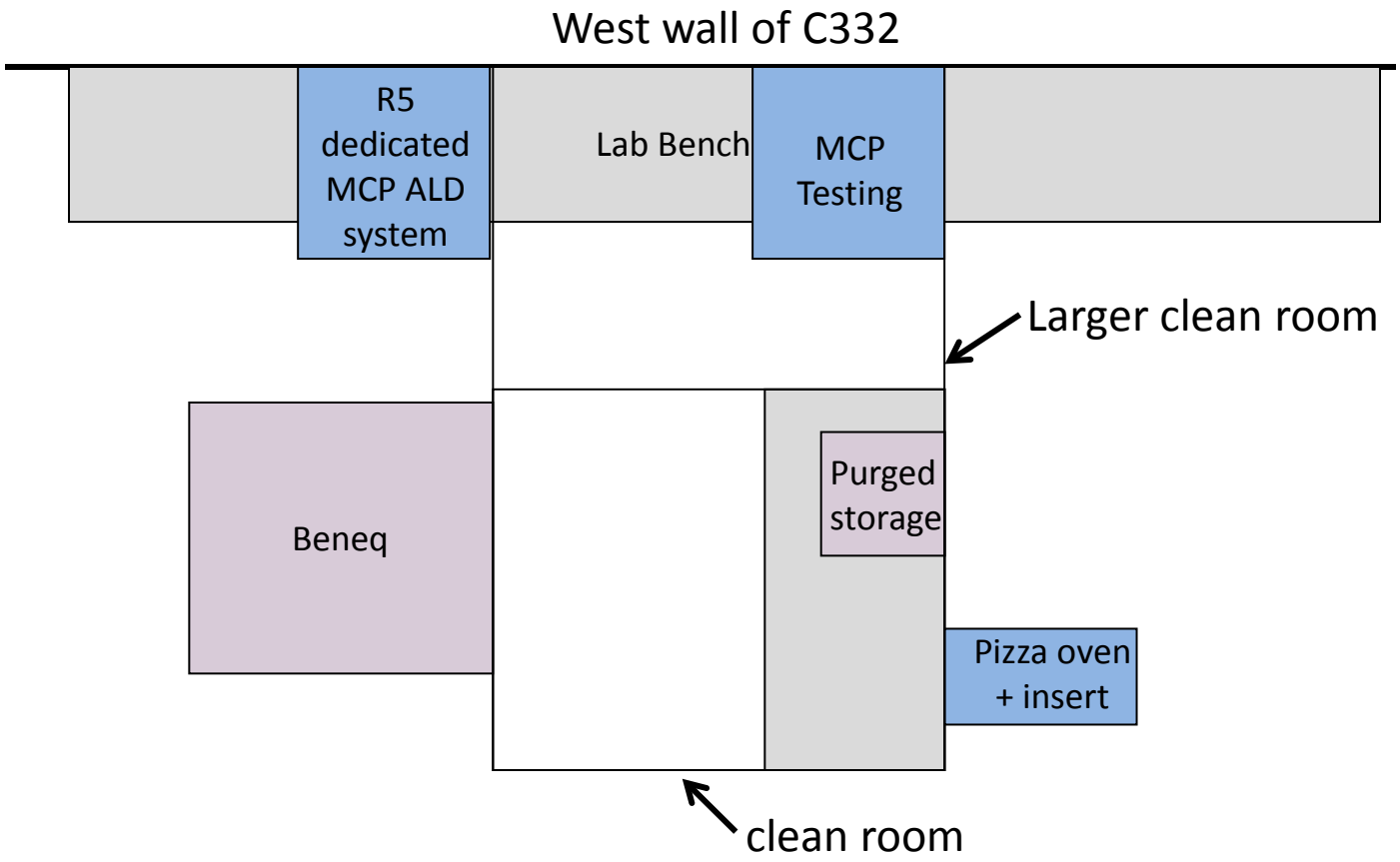
Ship to Ossy

Problems:

- Dust
- Availability of personnel
- Availability of equipment

What's Needed?

- Larger clean-room, consolidation of equipment, dedicated ALD system



What's Needed?
- More People

Production

- Aileen O'Mahony

- Tony Fracaro
  - ES technical staff, 10+ years experience in lab management
  - Manage ALD labs – equipment, supplies, ES&H, design and build
  - Started April 1

- Wade Eberle
  - BA Chem and Phys - 2009
  - Hire as temp – fabricate and test MCPs
  - Start date ~ April 22

Science

- Postdoc