End Year One Collaboration Meeting

June 10, 2010

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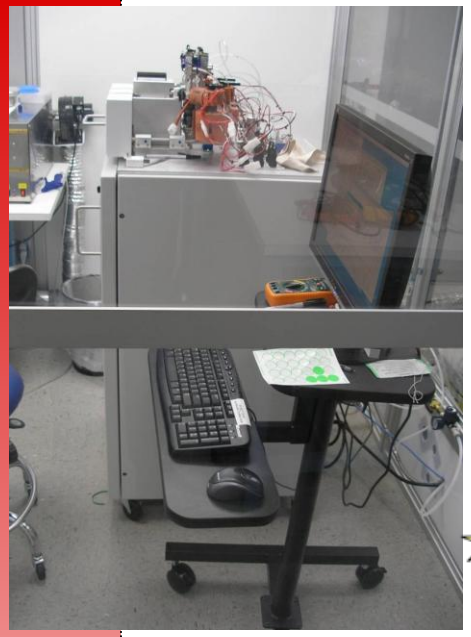
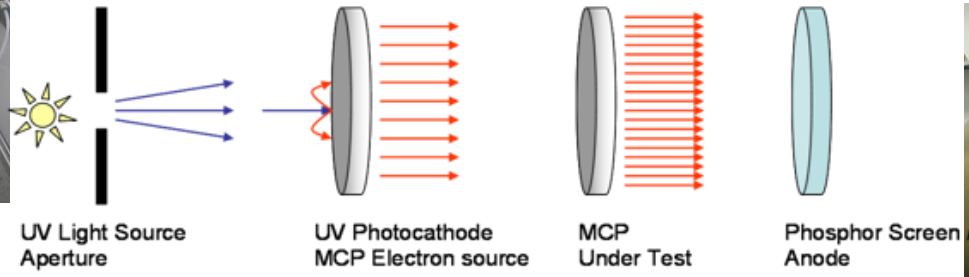
Outline

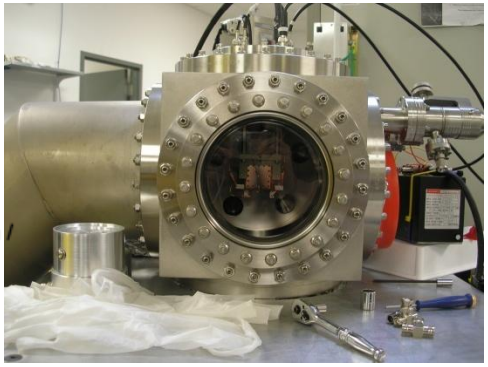
- Arradiance MCP Process Overview
- Conductive film development
- Emissive film development
- Device Results
- Arradiance Status vs Milestones
- Observations

Process



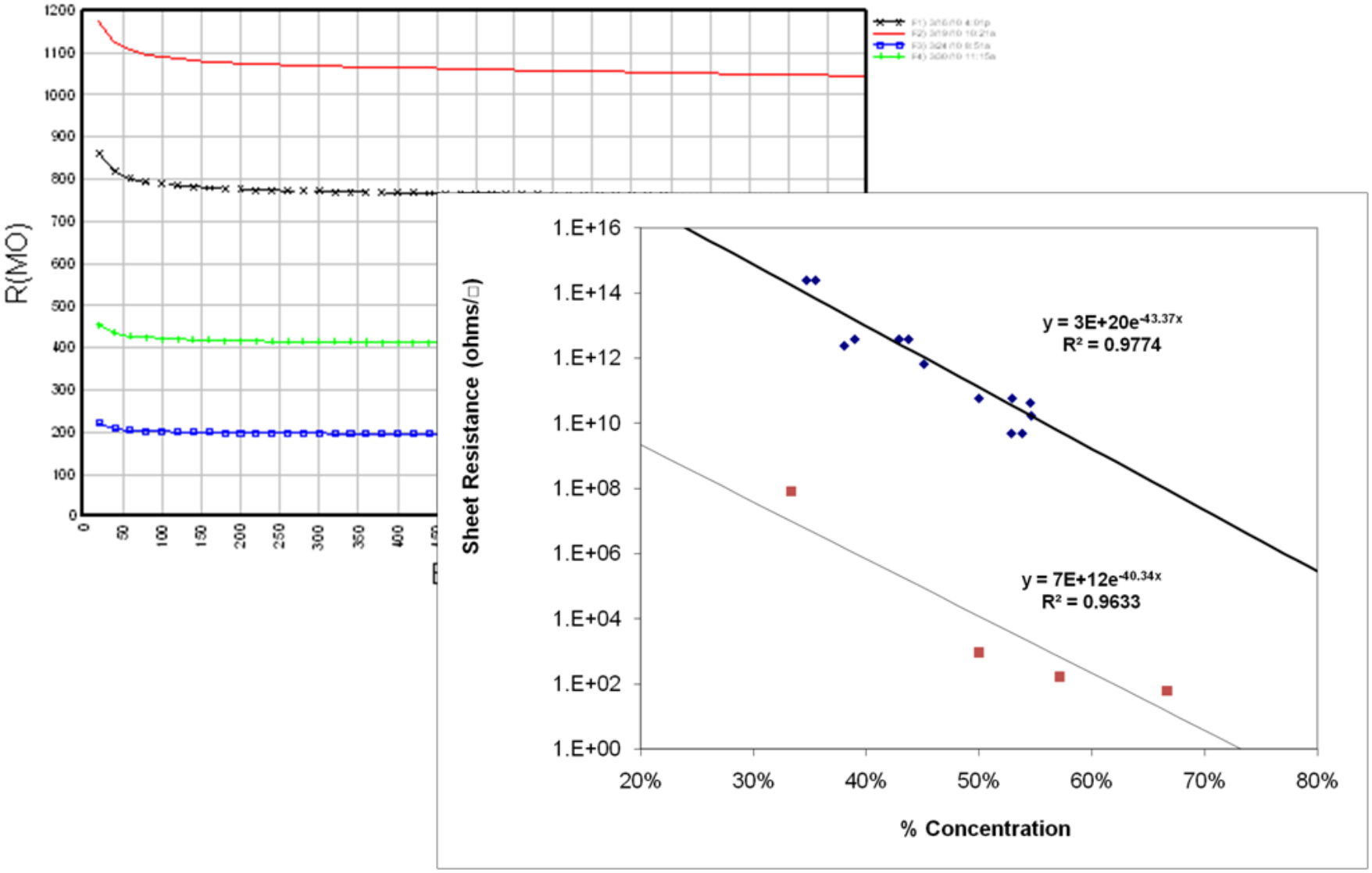
Incom Glass Plates → Argonne Inspection → UCB SSL Inspection / Clean → ex situ Clean Anneal & Ozone clean → Vacuum dry in ALD system (1 Torr flowing UHP N_2) → ALD conductive coating → Post Process Anneal → Electrode coating → ALD Dynode coating → Sample Test Resistance and gain → Deliver to UCB / SSL



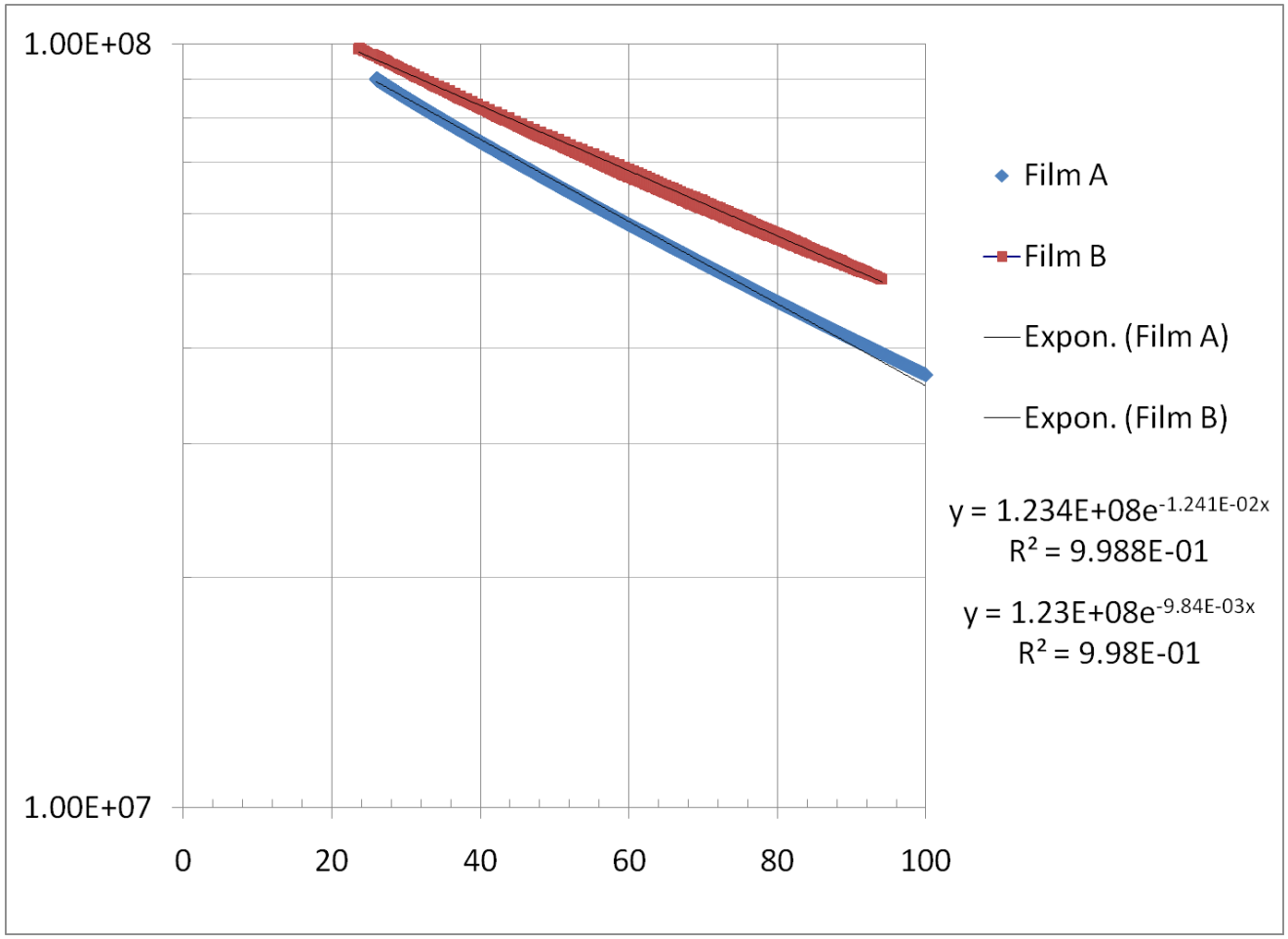


Sample	OD mm	Pore D(µm)	L:D	OAR (nom)	MCP R Target MΩ	#pores	ρ Ratio (nom/DUT)
ARRNom	25	10	40	0.63	100	2.904×10^6	1
UCB1	25	40	40	0.65	< 500	2.539×10^5	5
SN1-6	33	40	40	0.65	100, 500	4.424×10^5	1 5
SN 1,2	33	40	40	0.83	100	5.649×10^5	5
MCP 23-44	33	20	60	0.60	500	1.770×10^6	0.5

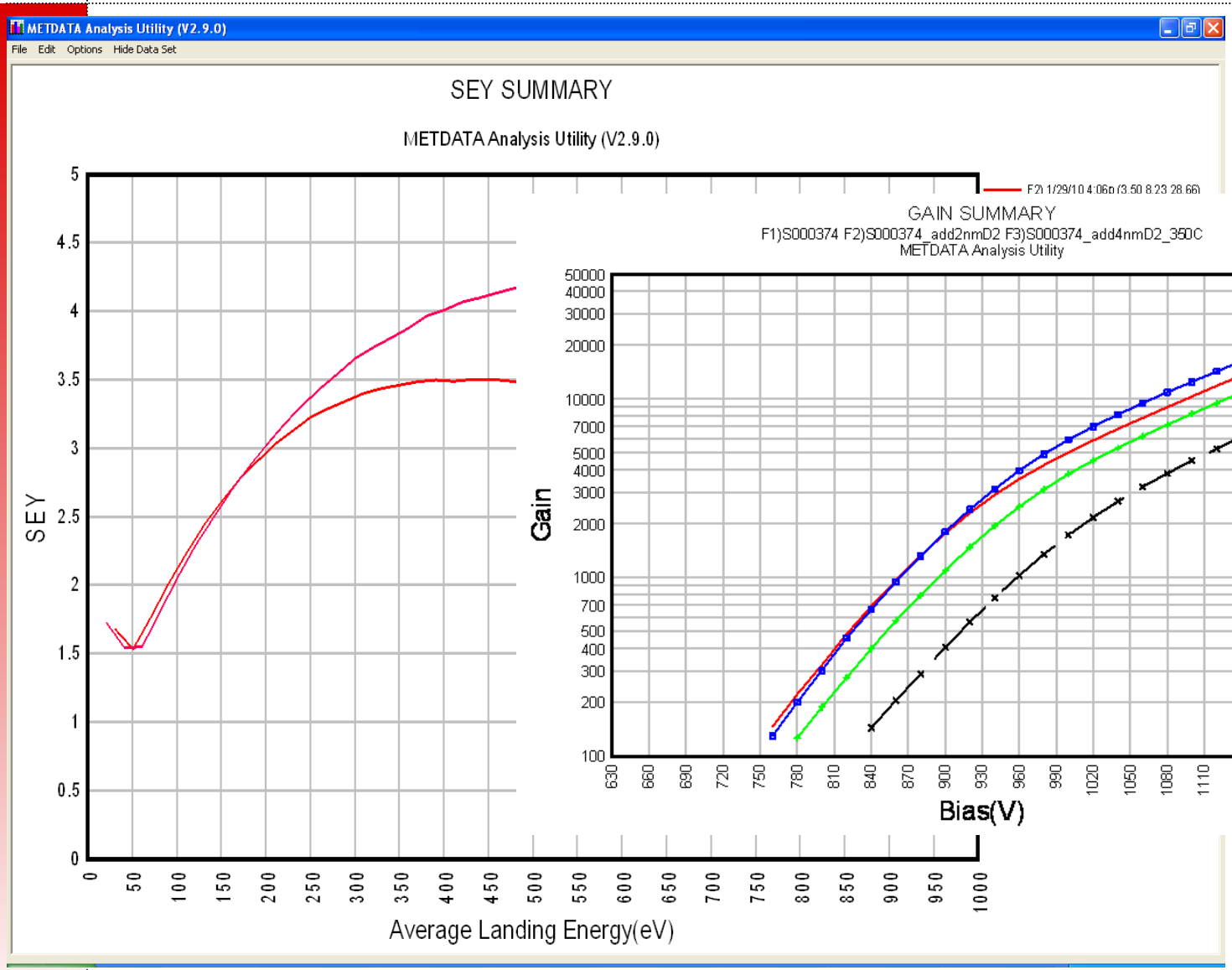
Process: conductive film



Process: Conductive film TCR - $B\tau < 0.01$



Process: Secondary electron yield & device gain

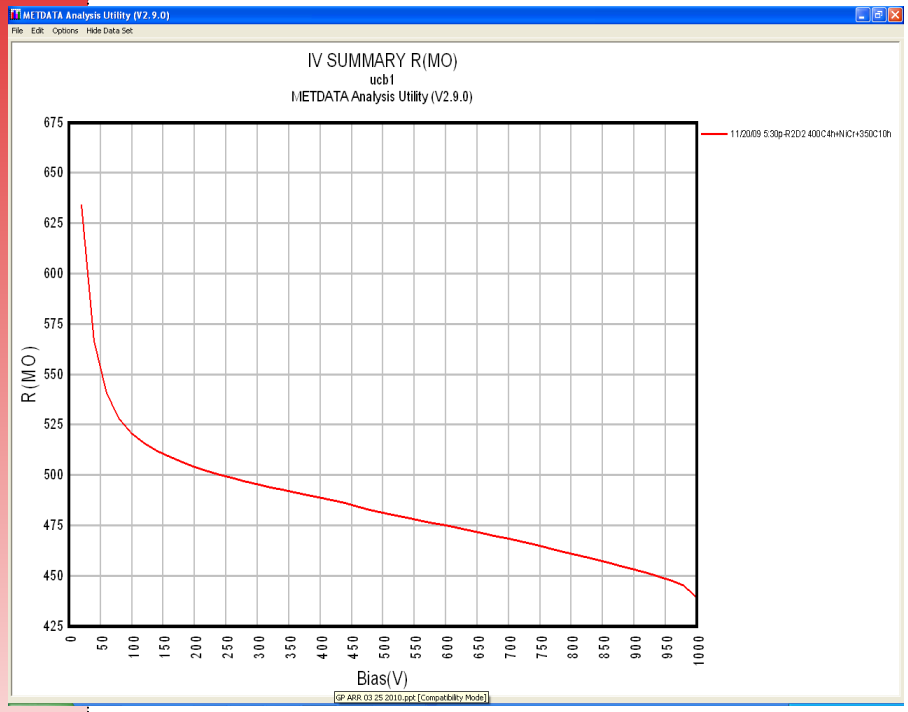


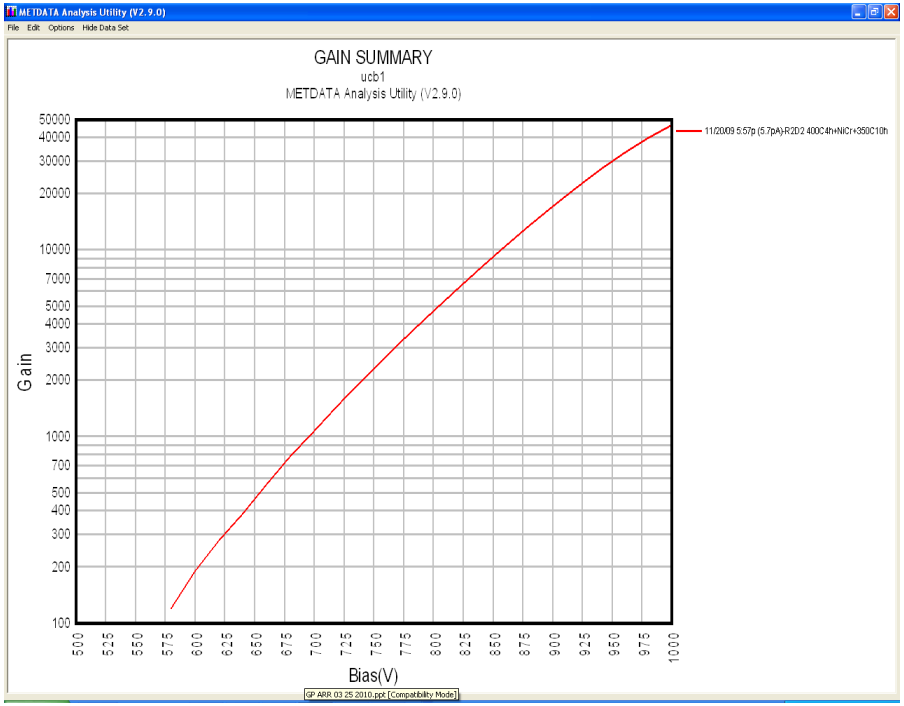
Results – Incom 40:1, 40um, 65% OAR Nov 2009

MetData Report For INCOM 031610
Metrology Data File Report Detail

ARRADIANCE Substrate DataBase (V1.2.1)
3/16/2010

Supplier / Serial#	Lot Description / MDate	System	Filename	Lot ID	Cust	Created	Modified	MetData at 700 and 1000V Last R(MO)	MAX Gain
INCOM	INC-GCA-D25-P40-L40-O65-B8			111209 (SO 08.186) INC-D25-P40-L40-O65-B8					
S000028(UCB1)	11/20/09	CUBE	ucb1.txt		Argonne	11/20/09	11/24/09 10:50 AM	419	396	1,070	46,703





Results - UCB SSL Test

- Project Milestone 5.1 met ***6 months ahead*** of schedule!

Space Sciences Laboratory, University of California, Berkeley

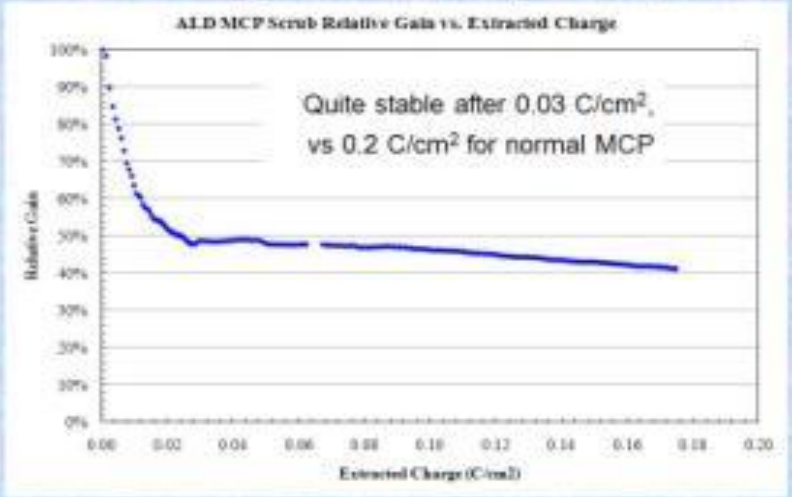
SSL-UCB, ALD/Incom MCP Test

- Incom substrate
  - 40µm pores, 8 deg bias, 40:1 L/D
- Sent to Arradiance for resistive and emissive layer application + electrode
- Resistance approx 750 MΩ in vacuum
- Arradiance tests show 50,000 gain @ 1000v
- UV - bright image, no light - black!
- Tested as a single MCP + Phosphor
- It works! We have a functional, uniform, and stable (1hr) MCP using borosilicate and ALD.
- Project milestone under 5.1 year 1 deliverable

Space Sciences Laboratory, University of California, Berkeley

UV Scrub 25mm 40µm 40:1 ALD MCP

Starts at Bias = 700V, gain x1000, 0.6µA, change to 850v, 0.8µA at 0.03C/cm²



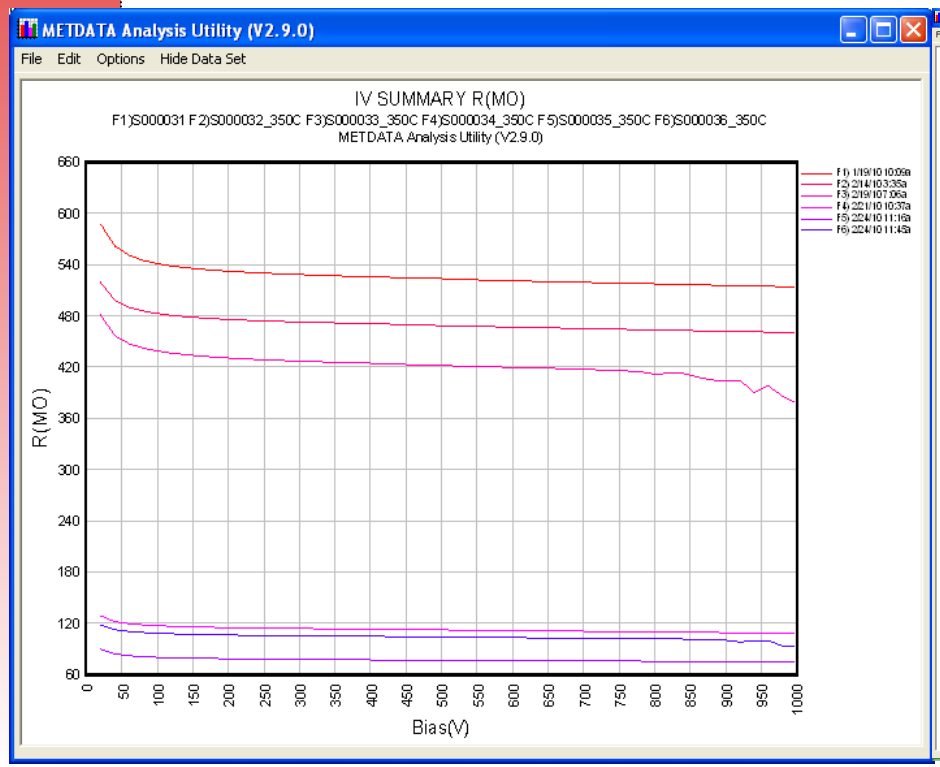
Note: no pre-vacuum bake

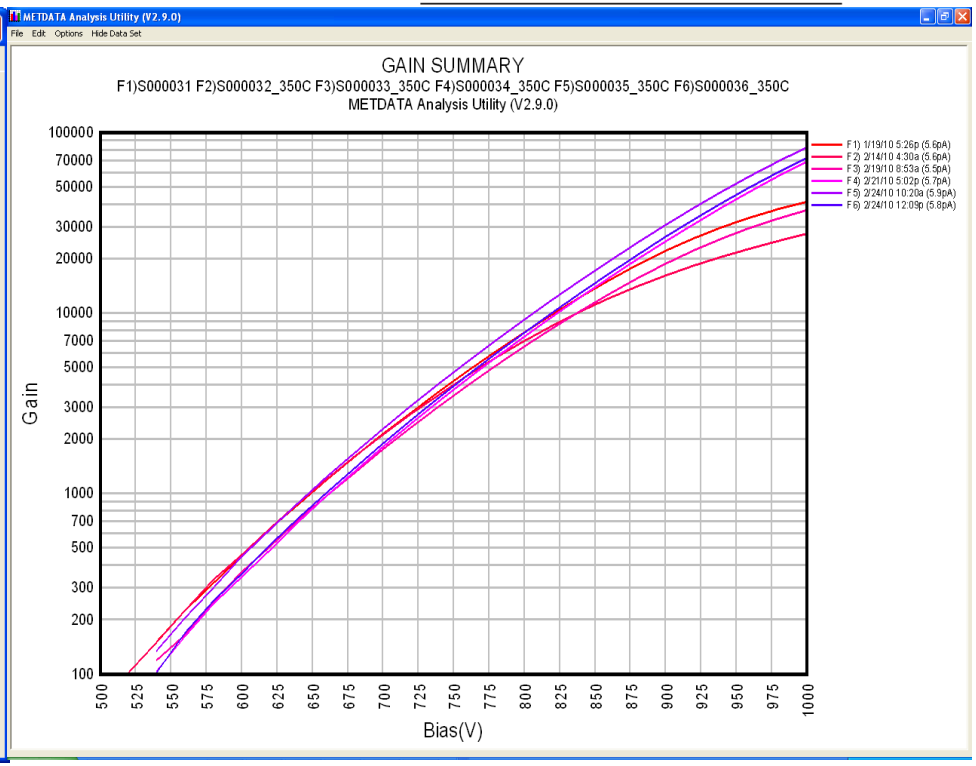
Results - Incom 40:1, 40um, 83% OAR Feb 2010

MetData Report For INCOM 031610
Metrology Data File Report Detail

ARRADIANCE Substrate DataBase (V1.2.1)
3/16/2010

Supplier / Serial#	Lot Description / MDate	System	Filename	Lot ID	Cust	Created	Modified	MetData at 700 and 1000V Last R(MO)		MAX Gain	
INCOM	INC-GCA-D33-P40-L40-083-B8			011310 (SO 08.186) INC-D33-P40-L40-083-B8							
S000031(1)	1/19/10	CUBE	S000031.txt		Argonne	1/19/10	1/19/10 6:50 PM	519	514	2,136	41,249
S000032(2)	2/12/10	CUBE	S000032_350C.txt		Argonne	2/14/10	2/14/10 5:37 PM	465	460	2,111	27,461
S000032(2)	2/12/10	CUBE	S000032.txt		Argonne	2/12/10	2/12/10 2:17 PM	439	435	1,432	28,028
S000033(3)	2/17/10	CUBE	S000033_350C.txt		Argonne	2/19/10	2/19/10 11:11 AM	417	378	1,752	37,082
S000033(3)	2/17/10	CUBE	S000033.txt		Argonne	2/17/10	2/18/10 11:46 AM	403	398	1,246	22,567
S000034(4)	2/19/10	CUBE	S000034_350C.txt		Argonne	2/21/10	2/23/10 11:53 AM	111	108	1,807	68,591
S000034(4)	2/19/10	CUBE	S000034.txt		Argonne	2/19/10	2/19/10 12:37 PM	99	98	1,372	42,487
S000036(6)	2/23/10	CUBE	S000036_350C.txt		Argonne	2/24/10	2/24/10 2:08 PM	101	100	1,886	72,018
S000036(6)	2/23/10	CUBE	s000036.txt		Argonne	2/23/10	2/23/10 2:31 PM	96	94		
S000035(5)	2/24/10	CUBE	S000035_350C.txt		Argonne	2/24/10	2/24/10 12:45 PM	76	74	2,271	82,576



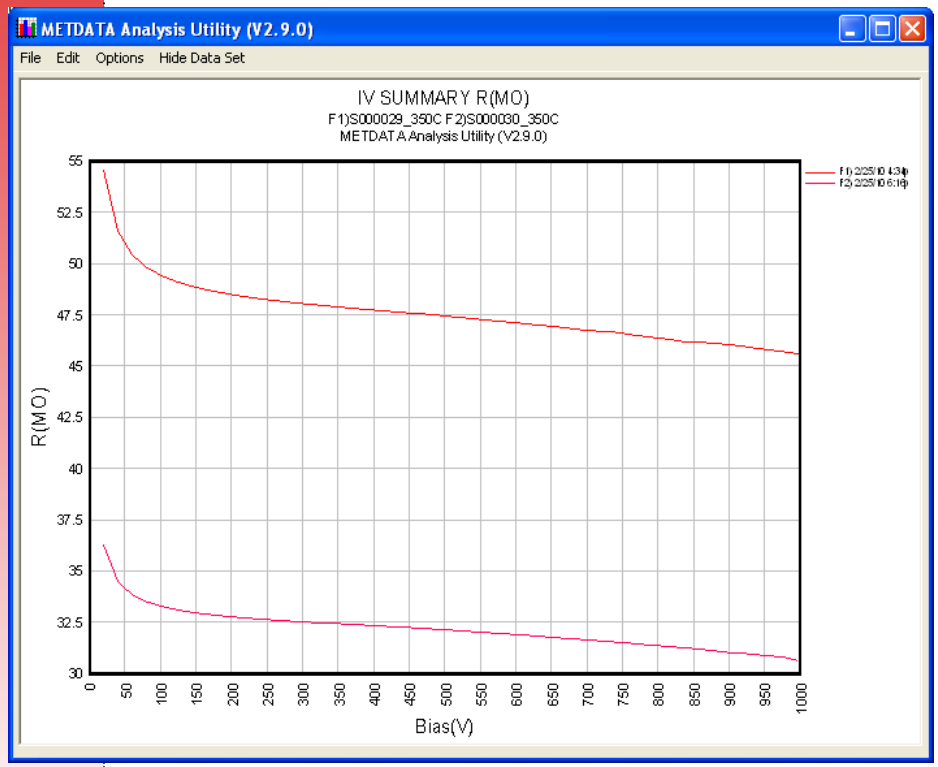


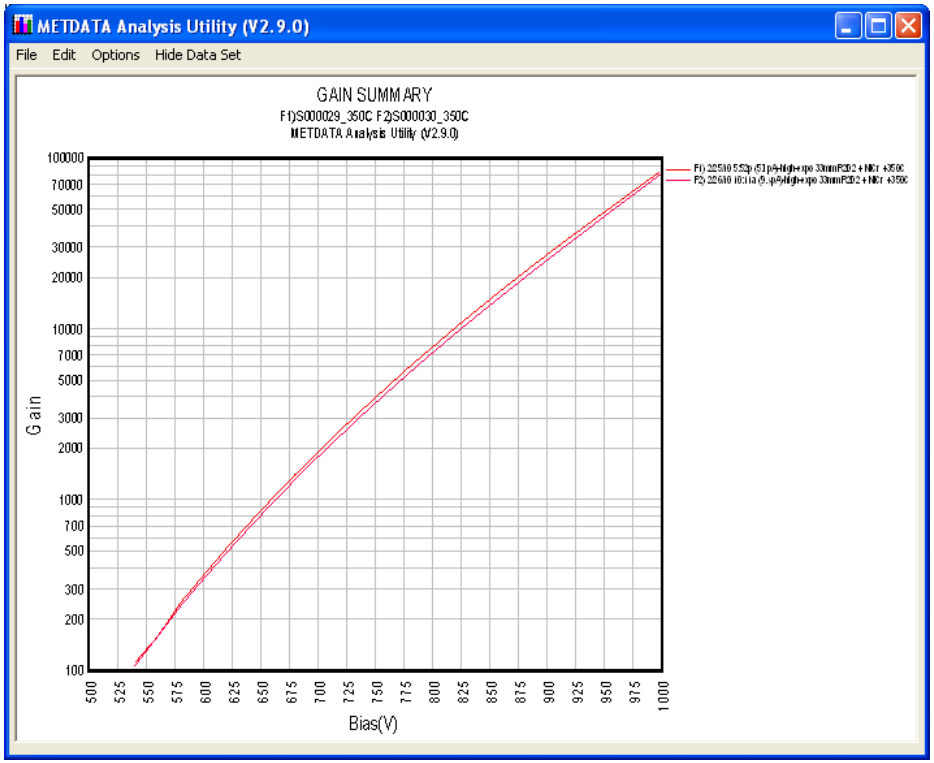
Results - Incom 40:1, 40um, 65% OAR Feb 2010

MetData Report For INCOM 031610
Metrology Data File Report Detail

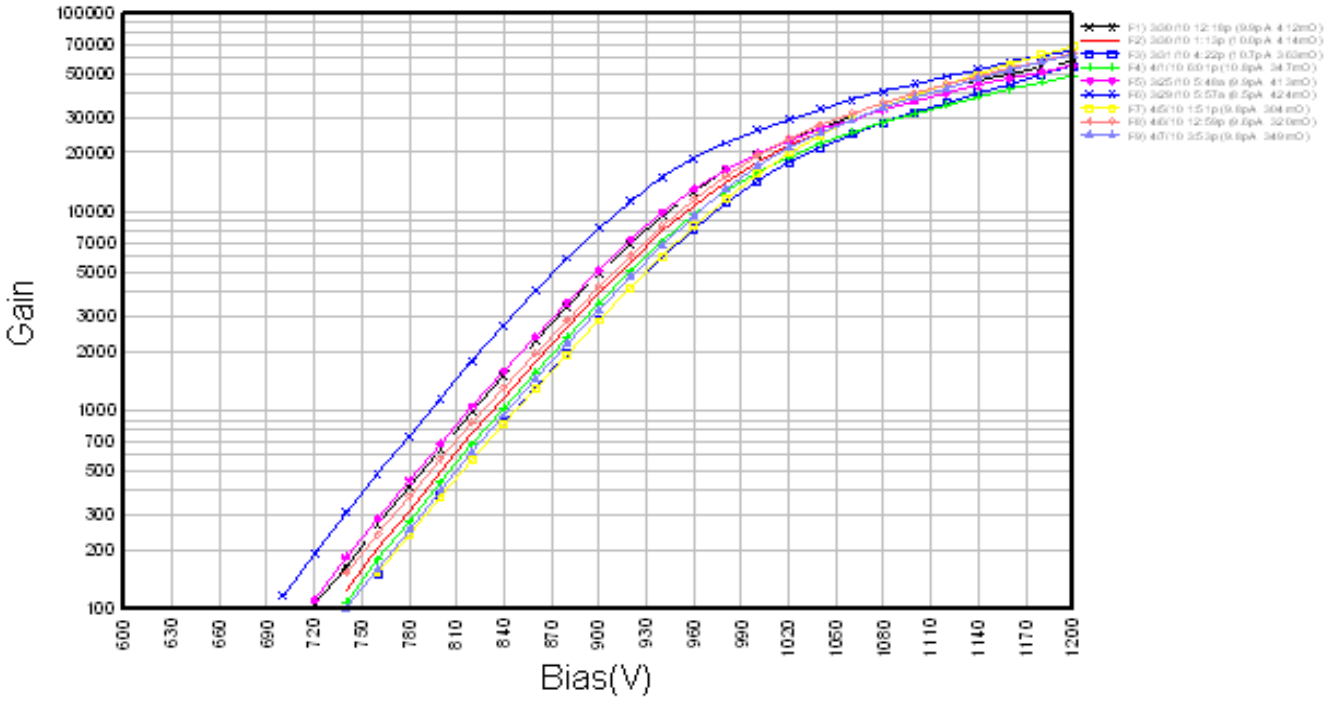
ARRADIANCE Substrate DataBase (V1.2.1)
3/16/2010

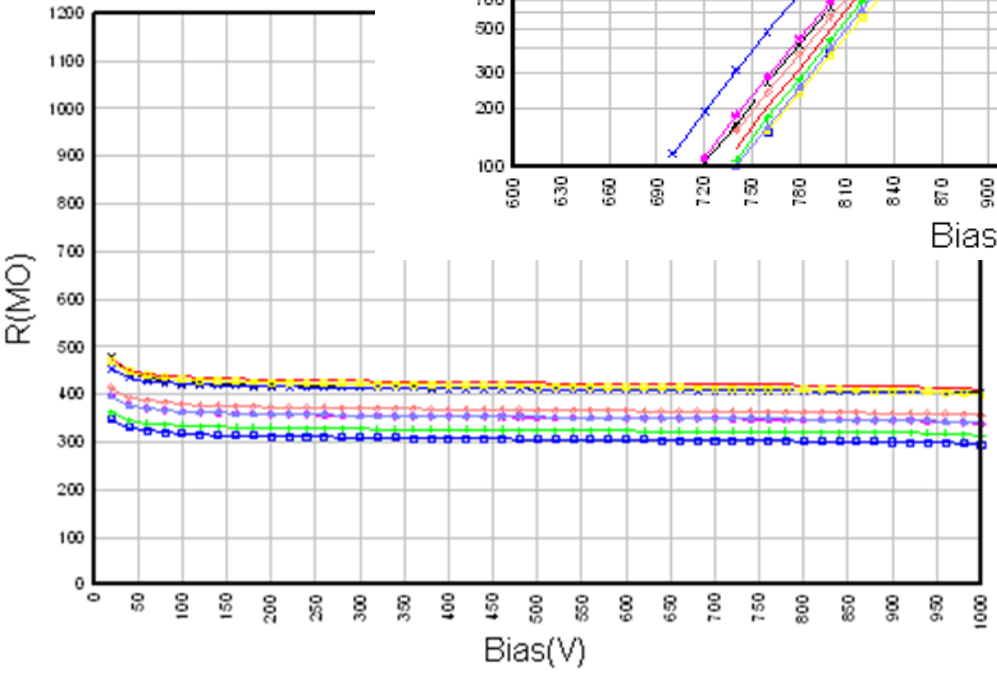
Supplier / Serial#	Lot Description / MDate	System	Filename	Lot ID	Cust	Created	Modified	MetData at 700 and 1000V Last R(MO)		MAX Gain	
INCOM	INC-GCA-D33-P40-L40-O65-B8			011310 (SO 08.186) INC-D33-P40-L40-O65-B8							
S000029(1)	2/25/10	CUBE	S000029_350C.txt		Argonne	2/25/10	2/25/10 7:15 PM	46	45	1,912	84,844
S000030(2)	2/25/10	CUBE	S000030_350C.txt		Argonne	2/25/10	2/26/10 11:42 AM	32	31	1,784	81,553





Results - Incom 66:1, 20um, 60% OAR March 2010





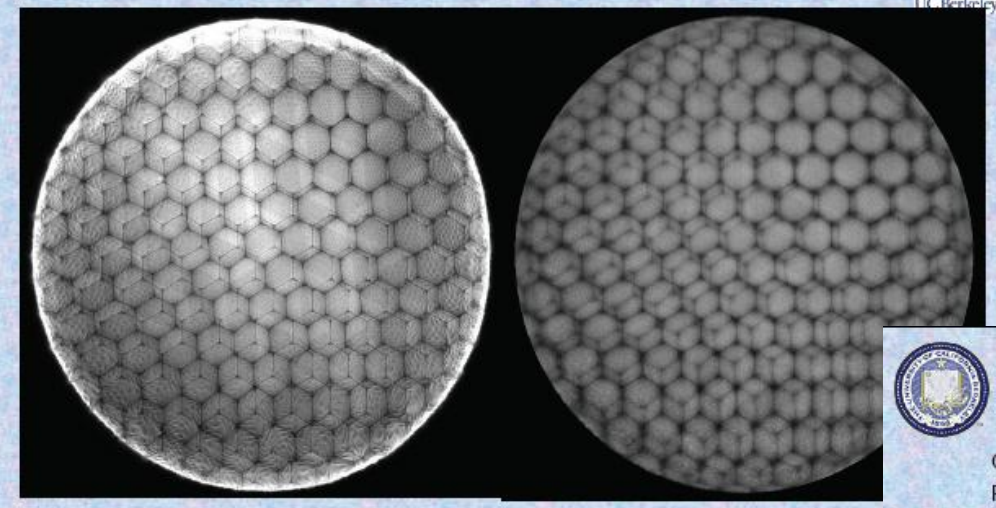
Results UCB SSL Imaging / photon countingTesting: S000376 & 372 R~ 414/412 MΩ; Gain 18k/20k @ 1kV

Arradiance ALD/Incom 20µm MCP Pair Test

MCP Pair voltage 2400v

Image - UV

Gain Map - UV



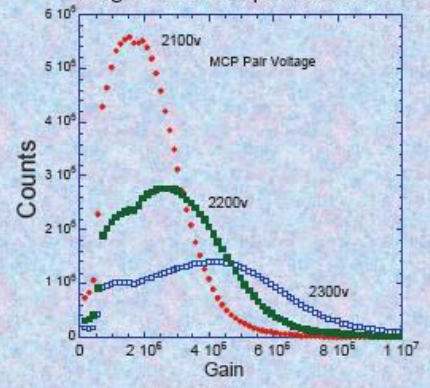
Moire pattern due to pore interference. Strong multifiber edges, top, bottom, MCP.

Gain is higher in center, due to gap, slight
MCP warping. Bad triple point gain.

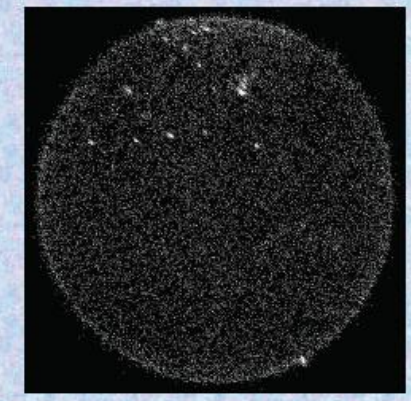
O. Siegmund, UCB, SSL

Arradiance ALD/Incom 20µm MCP Pair Test

Gain - pulse height histograms.
Poor PHD due to poor gain in the multifiber edges. Needs slightly higher voltage than the 40µm 40:1 MCPs.



Gain-voltage for a 20µm, 60:1, 65% OAR Incom/ALD MCP pair

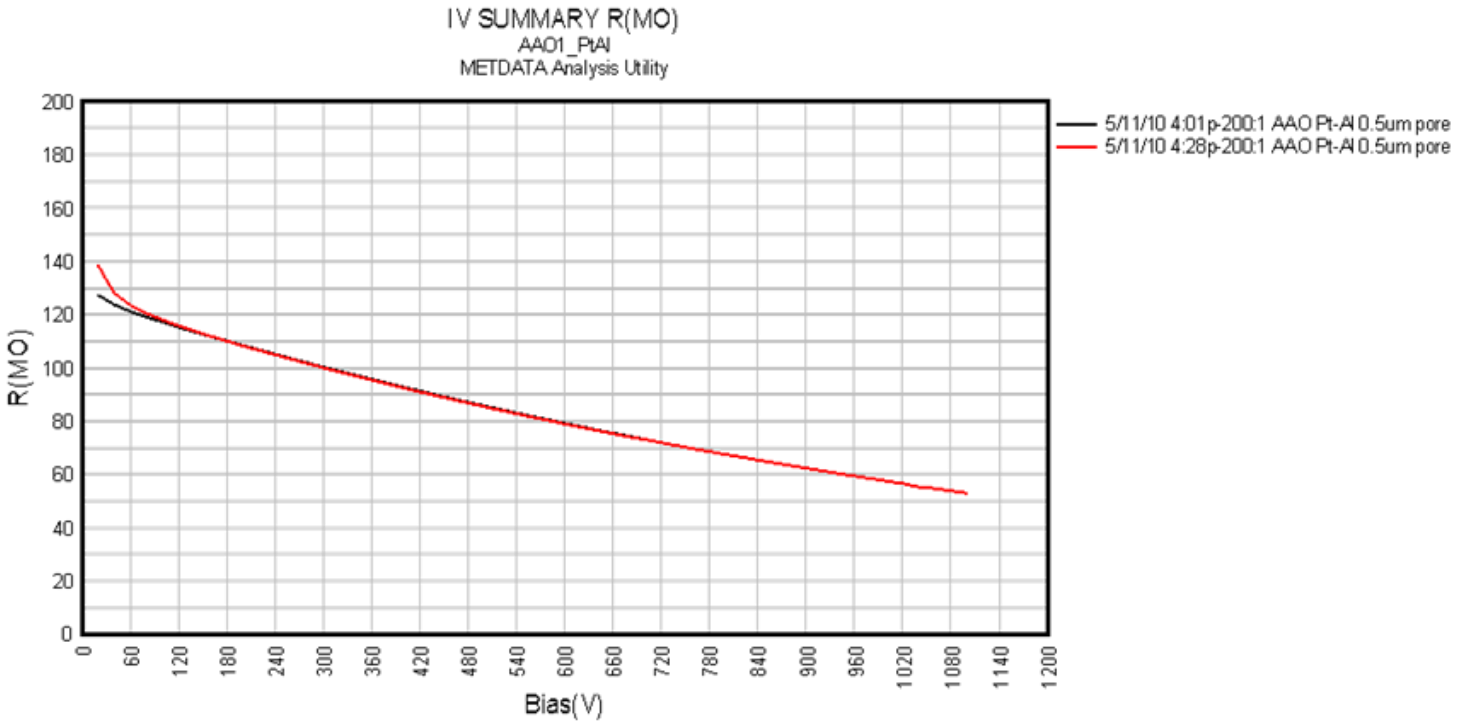


Dark image, 300 sec, ~18 event cm^{-2} sec^{-1}, mostly due to low gain hotspots

O. Siegmund, UCB, SSL

Results: Prototype AAO sample from Synkera – March 2010

- Pore size < 500nm
- 100 – 200 nm NiCr electrode processing (100nm 3 sigma variation).
- Estimated MCP turn on (unity gain) voltage >1800V.



Programmatics

- Year 1 deliverables
  - Optimize Arradiance thin film technology process & process equipment to meet base performance requirements for LAPR-TOF glass & small sample AAO substrate prototype development.
  - Work Plan Deliverables:
    - ALD emissive and resistive films meet gain, resistance & uniformity specifications.
    - Process & test up to 20 Incom & 20 AAO (or glass, depending on availability) MCPs.
    - Proof of Principle Report to the project
- Year 2 deliverables
  - Optimize Arradiance thin film technology process & process equipment to meet base performance requirements for batch processing of small format (33mm) AAO and Incom substrates.
  - Work Plan Deliverables :
    - Report on high surface area production process resistance & gain targeting on small format (33mm) AAO and/or Incom substrates of pre-determined geometry (up to 3 geometry variations).
    - Argonne-supplied substrates [AAO or GCA] coated in a high surface area environment.
    - Report on correlation & optimization of SEE between Argonne & Arradiance for standard or alternative D2 process.
    - Final report and test data of all results from high surface area project.

DOE SBIR Funded! Start July 2010

- Large Area -> 8”
- DOE SBIR Proposal w/ University of Chicago
- Funding from current DOE $$$’s?

Company: Arradiance Inc.
Principle Investigator: Neal T. Sullivan
Project Title: Efficient manufacture of extreme surface area Microchannel plate devices functionalized by atomic layer deposition thin films
Topic 61, Subtopic a

The work proposed in this SBIR proposal is intended to follow the basic R&D effort of a consortium of national laboratories, universities, and industry, led by Argonne National Laboratory and the University of Chicago for the development of new, large area, photo-detector devices. This project proposes to address the commercialization gap that exists between the proof-of-principle large area photo-detector (LAPD) program and the efficient manufacture of large area Microchannel plate devices using atomic layer deposition (ALD). For programs such as the Deep Underground Science and Engineering Laboratory (DUSEL) project and other applications in high energy physics, medical discovery and diagnostics and homeland security applications this will be transformational.

Arradiance, as the key commercial ALD component of the Argonne LAPD collaboration, will develop productive recipes, without sacrificing MCP performance, for the LAPD device. In parallel, Arradiance will develop production equipment that can effectively and efficiently produce the large area MCP devices, in which a single 8” square device comprises the same surface area as nearly 100 state-of-the-art 300mm integrated circuit wafers.

The techniques required for large-scale commercial ALD production of LAPD a family of large-area robust detectors that can be tailored for a wide variety of applications for which large-area economical photon detection would be transformational. We believe that the success of this program, namely efficient coating of high surface area MCP devices, has the potential to extend far beyond this niche of ALD application and could impact other applications where ALD is used to coat extremely high surface area materials in technology areas such as: catalysis, fuel cell, energy storage and filtration.

Key Words: microchannel plate, atomic layer deposition, special nuclear material detection, particle physics, medical imaging, advanced detectors, nanomaterials, nanomanufacturing, thin films

Summary for members of Congress:

Efficient manufacture of extreme surface area Microchannel plate devices functionalized by atomic layer deposition thin films is an essential component of next generation high energy physics detector designs as well as novel detection applications in medical discovery and diagnostics and homeland security applications.