LAPPD Needs, Plans, and Requirements for ALD MCPs

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LAPPD Godparent Review

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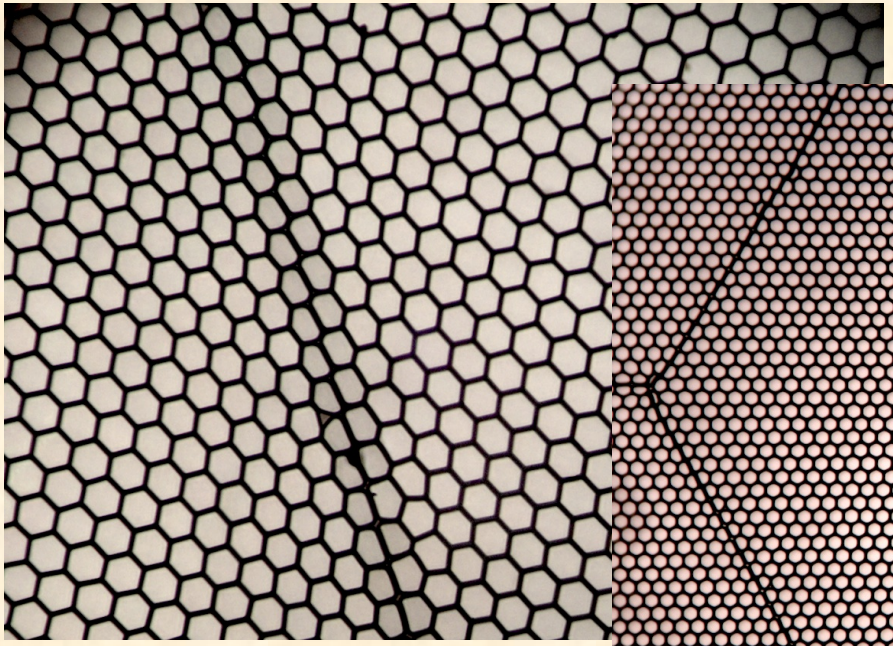
Borosilicate Substrate Atomic Layer Deposited Microchannel Plates

Micro-capillary arrays (Incom) with 10μm, 20 μm or 40μm pores (8° bias) made with borosilicate glass. L/d typically 60:1 but can be much larger. Open area ratios from 60% to 83%. These are made with hollow tubes, no etching is needed. Resistive and secondary emissive layers are applied (Argonne Lab) to allow these to function as MCP electron multipliers.



40μm pore borosilicate micro-capillary MCP with 83% open area.

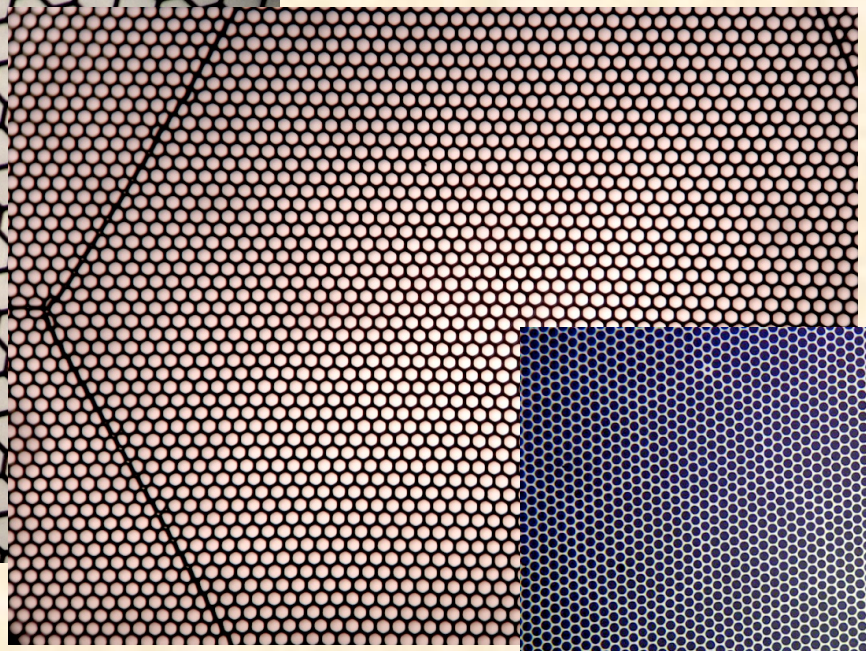


Photo of a 20 μm pore, 65% open area borosilicate micro-capillary ALD MCP (20cm).

Pore distortions at multifiber boundaries, otherwise very uniform.

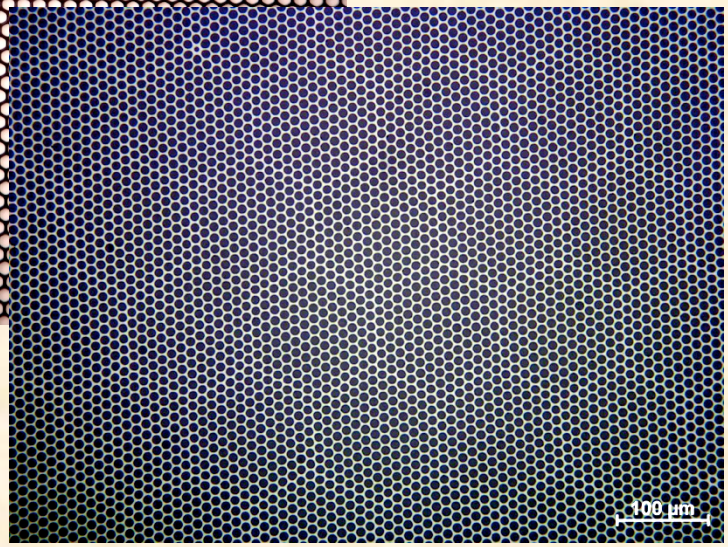


Photo of a 10 μm pore, 60% open area borosilicate micro-capillary ALD MCP.

MCP Basic Specifications for 33mm and 200mm

Standard 32.7mm MCP

• Plate Outside Diameter	32.7mm
• L/D, Thickness	60:1, 1.2mm
• Center-to-Center Spacing	~25μm
• Pore Size	20μm
• Bias Angle	8 Deg ±1 deg
• Open Area ratio	~60%
• Resistance	~500 Meg Ohm
• Electrode end spoiling	1 channel diameter

200mm MCP

• Plate Outside Diameter	200mm
• L/D, Thickness	60:1, 1.2mm
• Center-to-Center Spacing	~25μm
• Pore Size	20μm ±0.5um
• Bias Angle	8 Deg ±1 deg
• Open Area ratio	~60%
• Resistance	~10 Meg Ohm, bottom MCP, > for top
• Electrode end spoiling	1 channel diameter

ALD Functionalized MCP Test Tasks

Test and evaluate MCP materials and techniques to provide feedback for MCP production, and establish performance and expectations for MCPs in the final tube configuration.

- Full evaluations of 20μm material, 33mm
  - Gain, imaging, background in singles/phosphor
  - Single MCP lifetest characteristics
  - Pairs with XDL, imaging, gain, background, PHD, uniformity
  - High temp vac bake for tube compatibility tests,
  - MCP pair lifetest characteristics – "burn-in"
  - Pair MCP spacings, spacing bias, anode bias, for charge footprint, imaging and timing tests
- 8" x 8" MCPs
  - Institute test detectors for 8" MCPs (rapid feedback, & detailed)
  - Full up evaluations of 8" MCP configurations
  - Verification of "sealed tube" compatibility

33mm ALD-MCP Test Summary

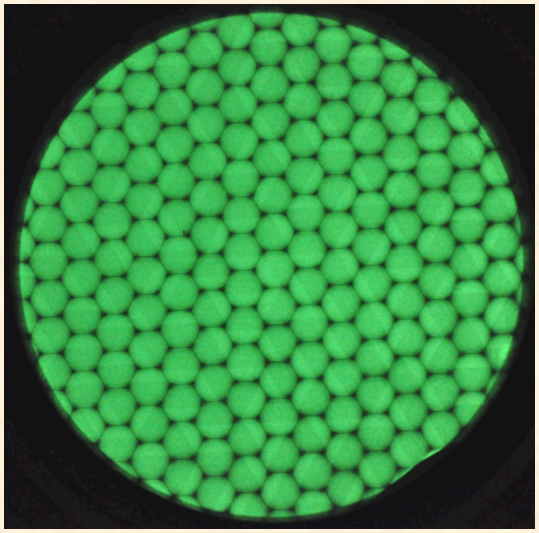
Achievements and implications

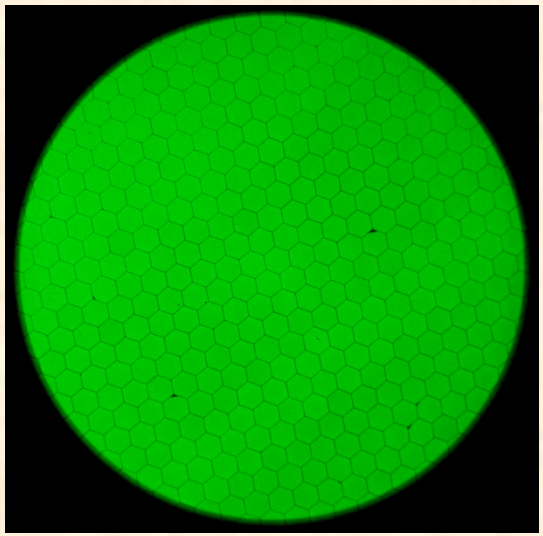
- Micro-capillary arrays in borosilicate glass with 20μm material offer a robust, adequately low distortion/defect substrate for atomic layer deposited MCPs, and quality is still improving.
- Gain, imaging, and detection efficiency same as standard MCPs
- Background rate is a factor of >4 better than standard MCPs
- High temp vac bake for tube processing has very positive effects
  - Factor of 10x gain increase with MgO ALD SEY
  - Establishes very low MCP outgassing (borosilicate, ALD, MgO)
- Excellent MCP pair lifetest characteristics – "burn-in"
  - Essentially no gain drop at the nominal gain over 7 C cm^{-2}
  - Very stable to dry N2 exposure thereafter
- ALD functionalized borosilicate MCPs are a good match to the 20cm sealed tube process and may afford significant improvements in tube/cathode lifetime and in reduction of the tube fabrication/processing turn around time.

Imaging Performance of ALD MCPs, 33mm

Early 2010 | 2011

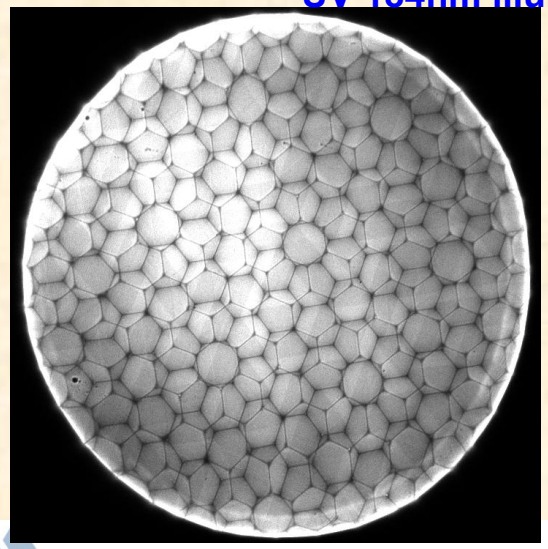
1 MCP, Phosphor readout

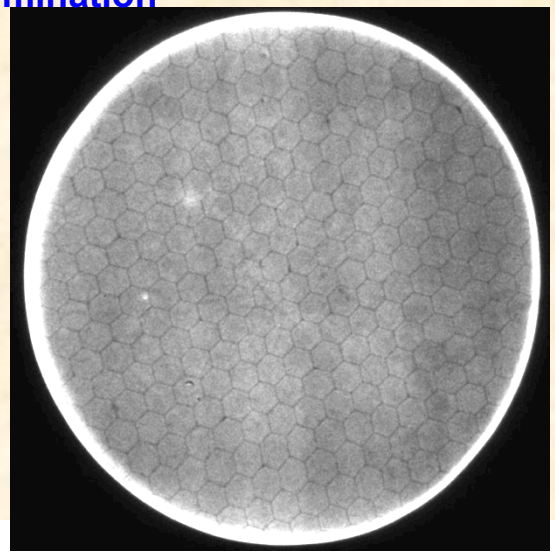




UV 184nm illumination

2 MCPs, Photon counting





20µm borosilicate MCP substrates, 60:1 L/d, 8 degree pore bias.

~1000v applied to each MCP.

Single MCP tests in DC amplification mode show imaging and gain very similar to conventional MCPs.

MCP pairs operated in photon counting mode also show imaging and gain very similar to conventional MCPs.

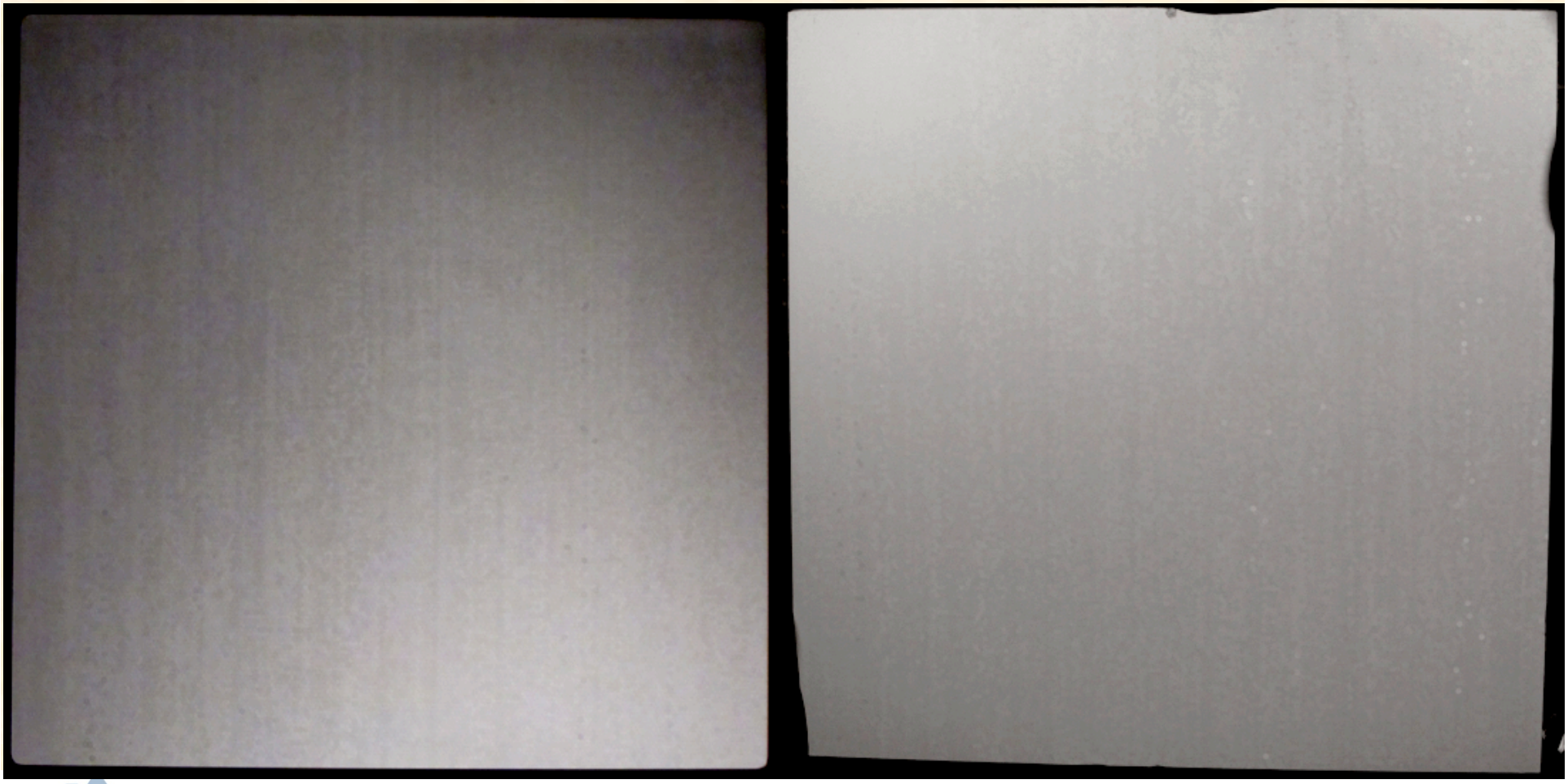
Sample performance has improved dramatically over the last 24 months due to process improvements.

8” 20µm MCP Inspections

Block 14020 (-006/-009) Initial Inspections vs block 13600

Block 13600, vertical striations, dark multis and a pair of oversize pores in some multis.

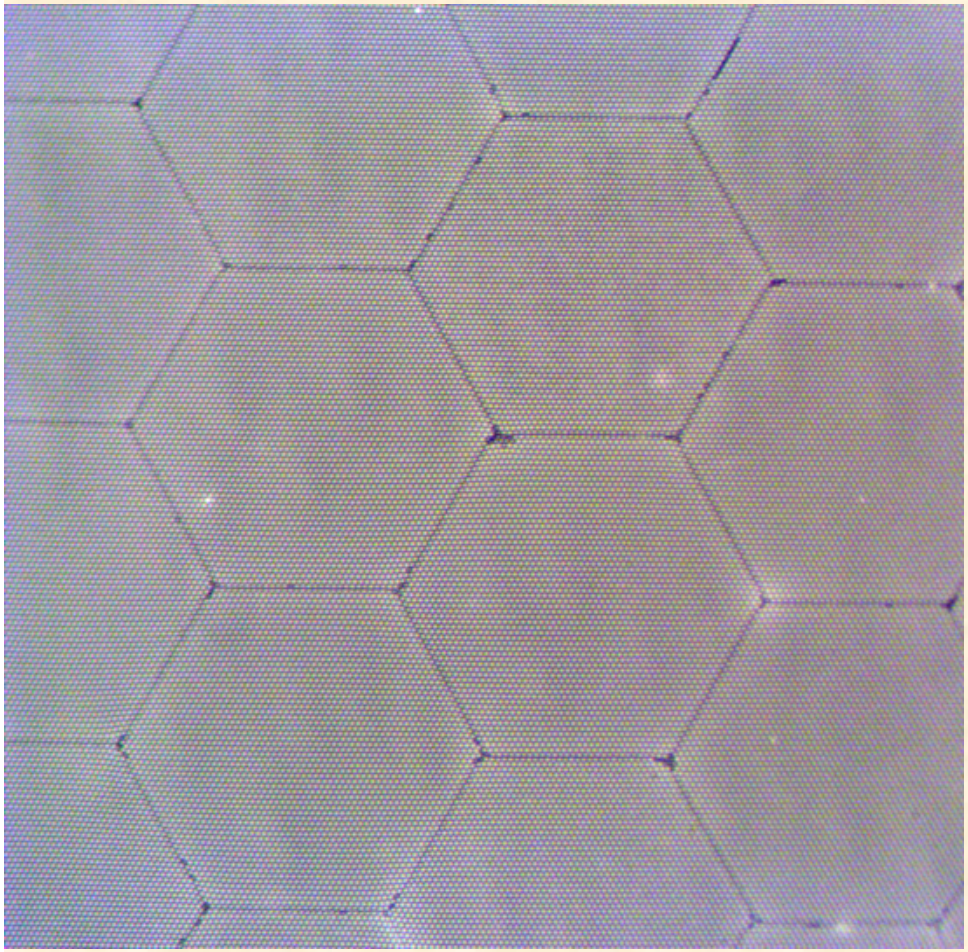
Block 14020 vertical striations, bright multis but fainter multi borders.

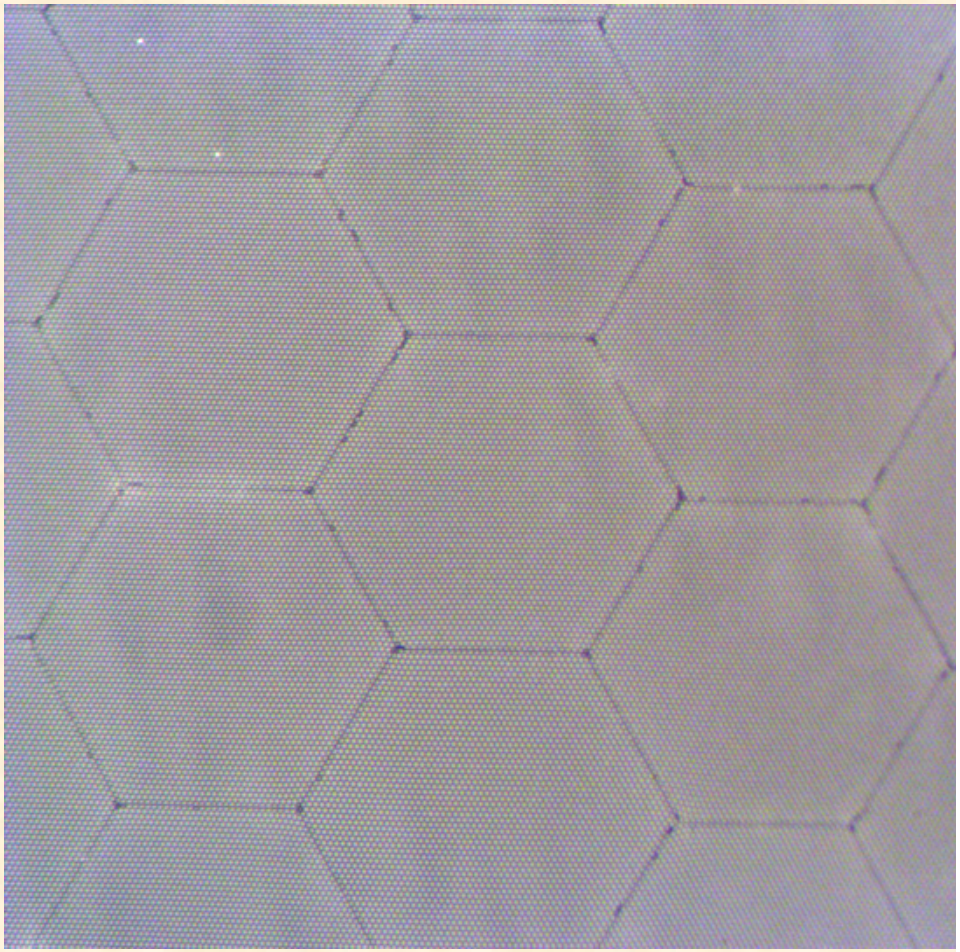


8” 20μm MCP Inspections

Block 14020 (-006/-009) Initial Inspections vs block 13600

Block 14020, no triple point voids, no oversize pores



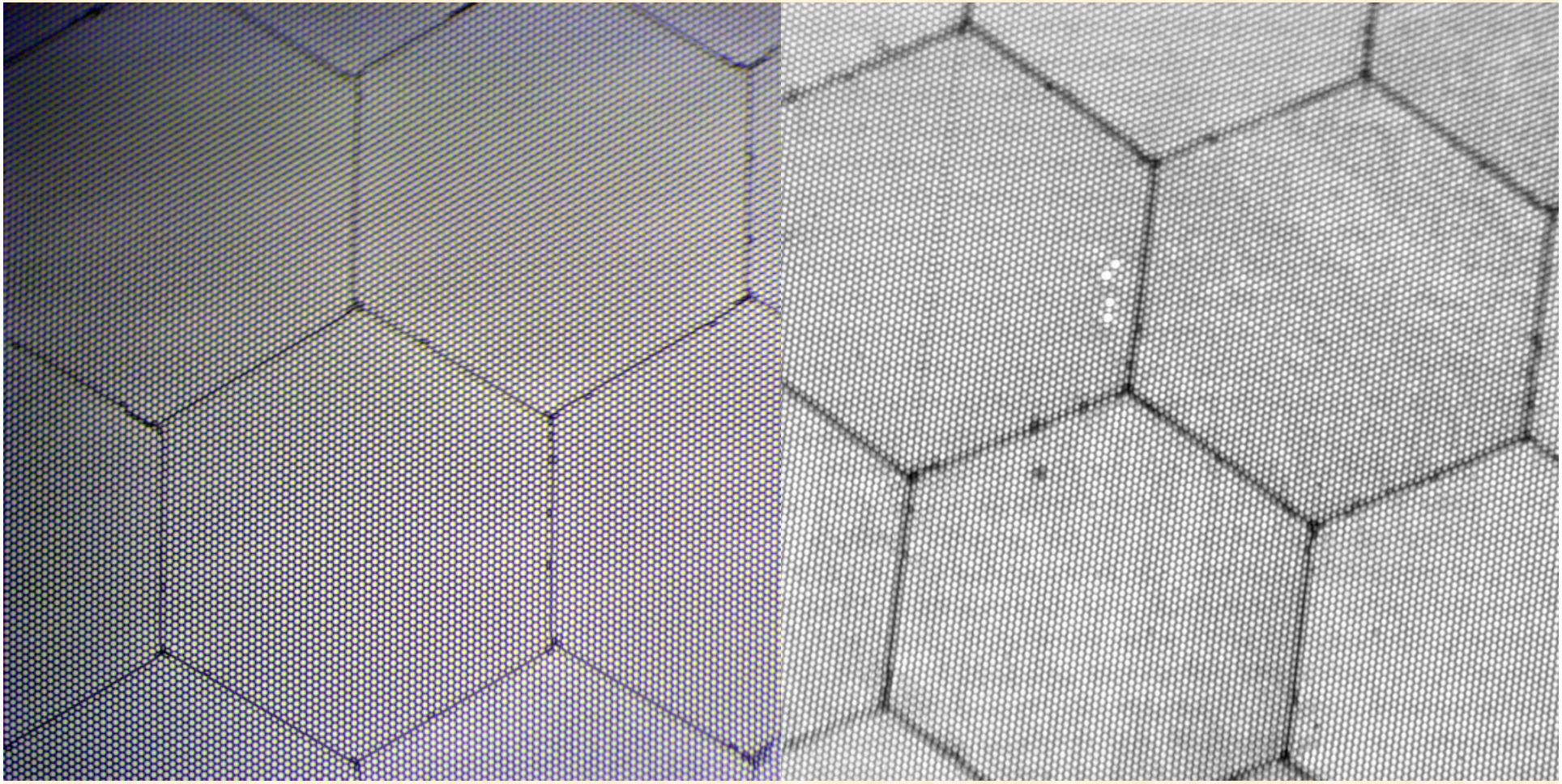


8” 20µm MCP Inspections

Block 14020 (-006/-009) Initial Inspections vs block 13600

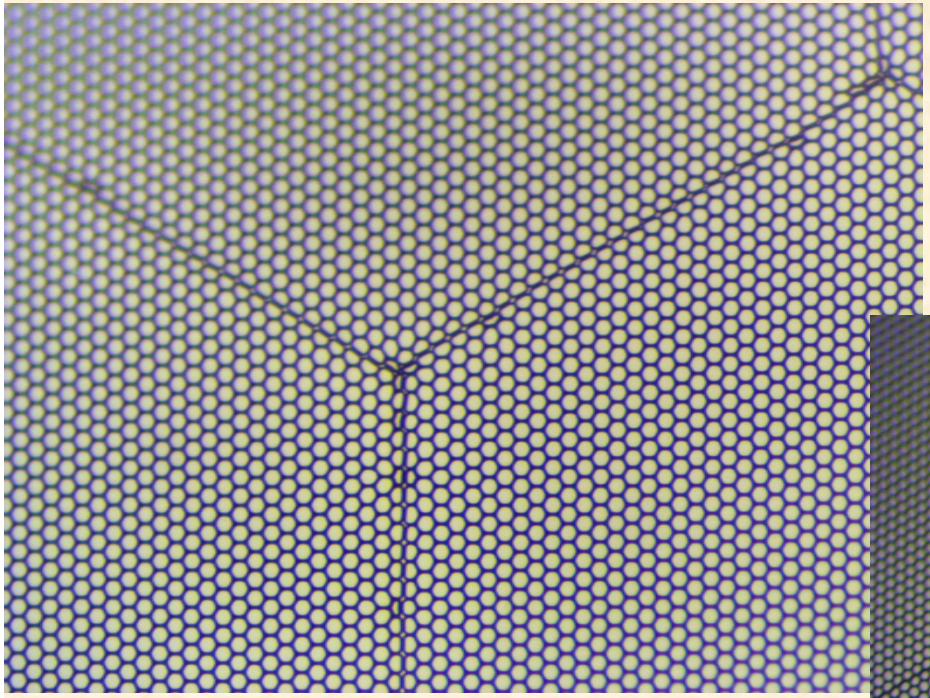
Block 14020 fainter multi borders.

Block 13600, strong multi borders
and a pair of oversize pores in some multis

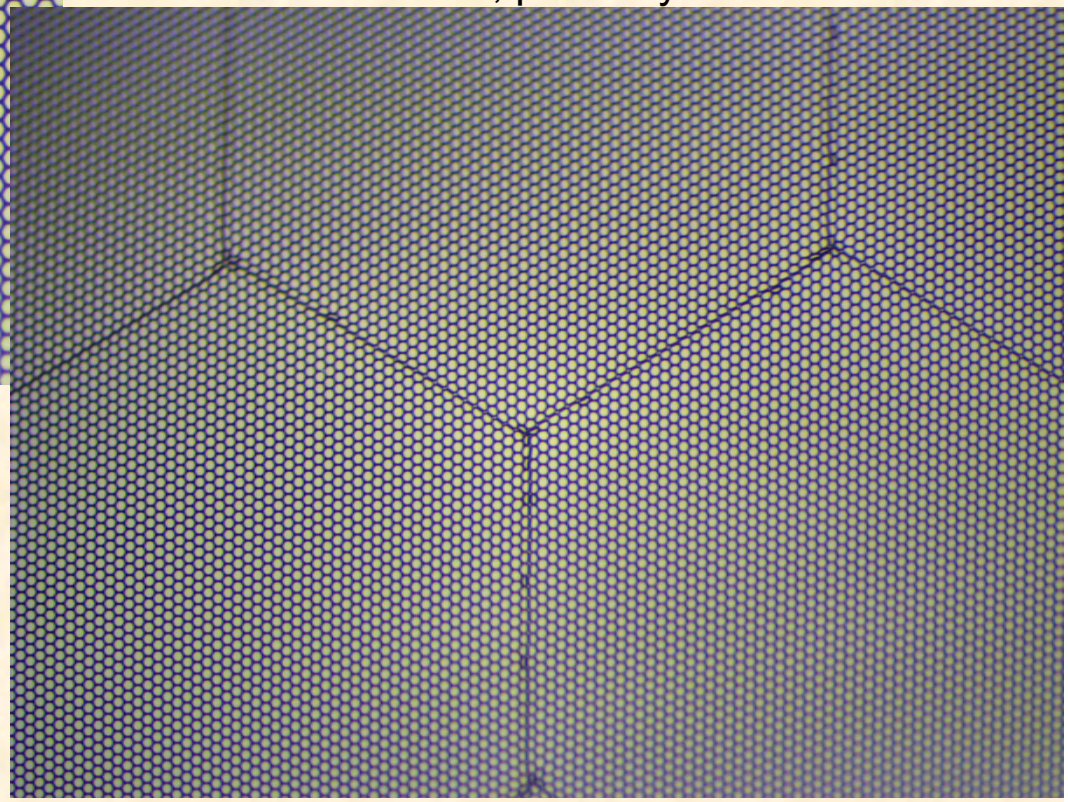


8” 20µm MCP Inspections

Block 14020 (-006/-009) Initial Inspections vs block 13600



Block 14020 fainter multi borders, maybe better open area ratio? Want to see what a completed MCP is like vs 13600, probably better.

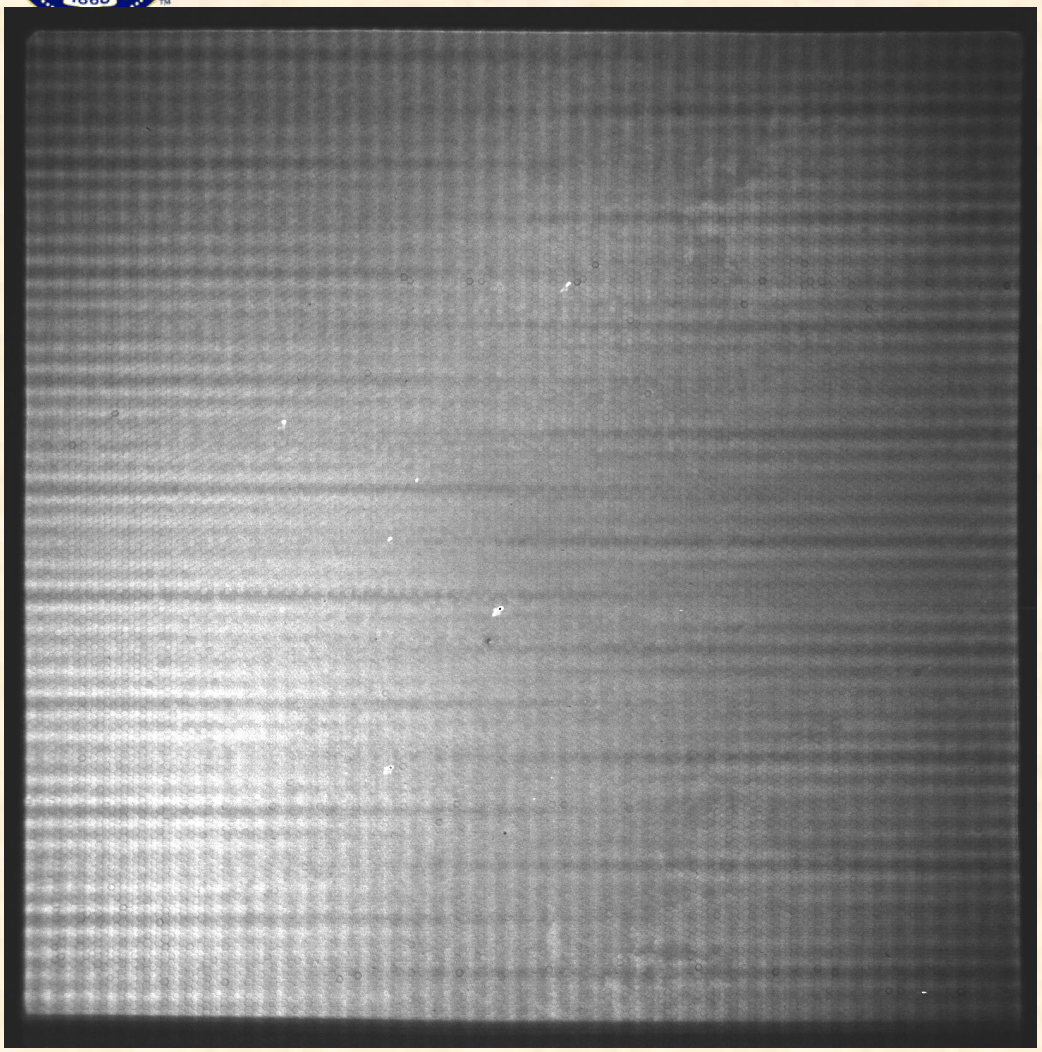


8” 20μm MCP Inspections

MCP significant dust inclusions on the blue side and shows the usual 13600 multifiber pattern. One side is blue and the other side is purple. Edge lighting.

•MCP 13600-046

8” 20µm MCP Pair Photon counting Tests



1050V for 13600-003 and 1000V for 13600-081

MCP 13600-003 - 25 MΩ – top

MCP 13600-081 - 19 MΩ - Bottom

Top MCP
Bias direction

Bottom MCP
Bias direction

The overall response is much flatter with an electrode on top of the ALD as expected, but there are “watermarks” and hotspots

Illumination is not uniform and NEW electrode “over” the SEY Al_2O_3. Bright spots are hotspots. Odd watermark patterns??

8” 20μm MCP Pair Photon Counting Background

500sec, 1050v on top and 1000v on bottom MCP

MCP 13600-003 - 25 MΩ – top
MCP 13600-081 - 19 MΩ - Bottom

The background is 4000 events/ sec mostly in 5 hotspots and a bright patch in the middle.

Bright patch only occurs with the MCP one way up!

Borosilicate -ALD MCP Needs

ALD functionalized MCPs in 33mm and 20cm formats with 20µm pores and 8° bias using Chem 1 and MgO, Al_2O_3

- 33mm MCPs needed to characterize Chem 1 and SEY layers.
  - Do not have any lifetest data for Chem 1, Bake, scrub, etc
  - Need both Al_2O_3 and MgO SEY layers
- Need a number of 20cm Chem 1 MCPs (6 -10) for evaluation and selection before inclusion in 8" sealed tube production.

  Prefer MgO SEY to reduce scrub / gain change issues

  Can work with Al_2O_3 but will make gain stability an issue

MCP Near Term Plans

- Test incoming batch of 8” Al_2O_3 MCPs for process verification
- MgO SEY application on 8” Chem 1 MCPs for evaluation
- 33mm MCP Chem 1 + MgO lifetesting
  - Vacuum bake to assess outgassing and performance
  - Then “burn-in” to verify gain stabilization and outgassing
- Testing of 8” MCPs in ceramic body for first trial “run through” of tube processing
  - Vacuum bake to assess outgassing and performance
  - Then “burn-in” to verify gain stabilization and outgassing

- Selection and implementation of MCP pairs for the first complete sealed tube process runs