High Dynamic Range Photon Counting Imagers Using Nano-Engineered Microchannel Plates

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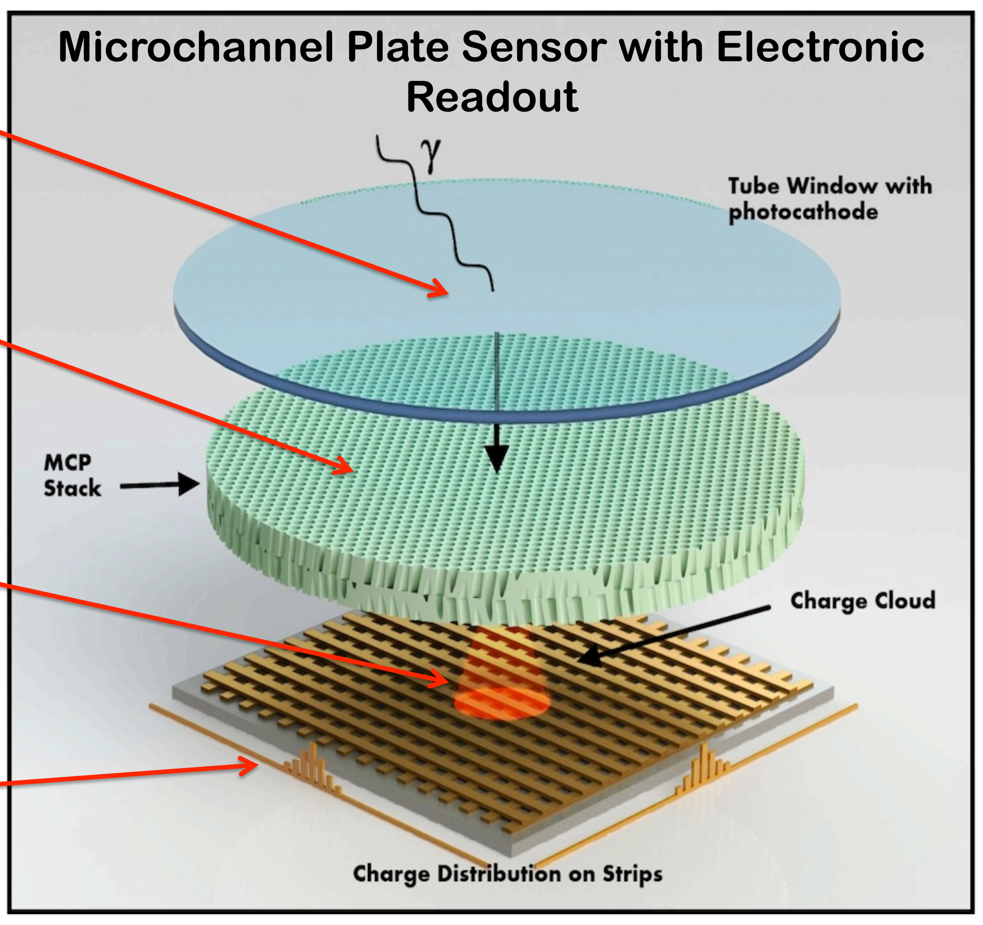
Microchannel Plate Imaging Sensors

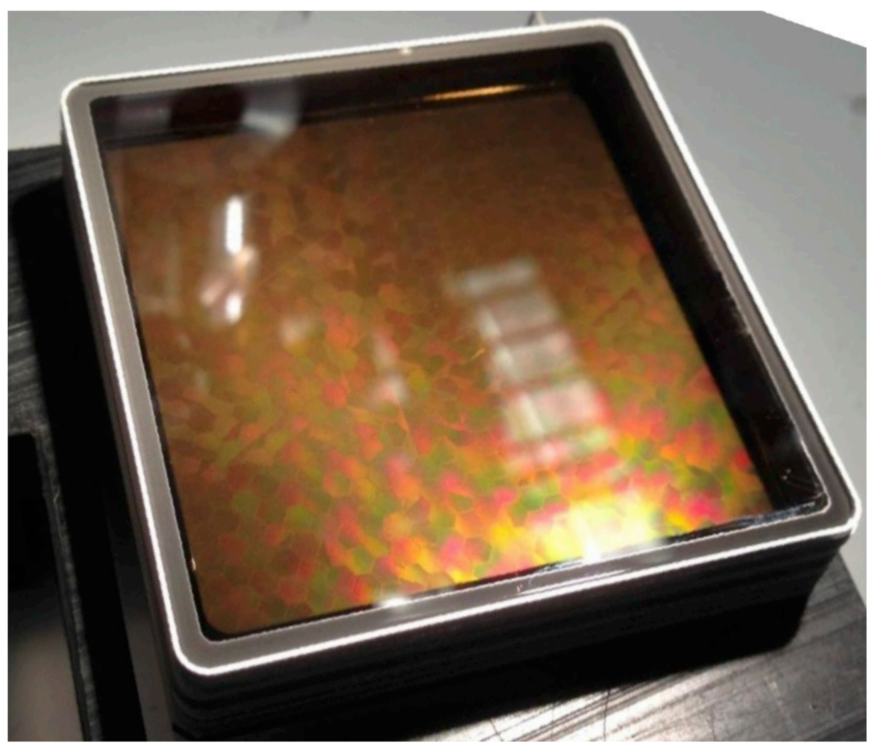
Photocathode converts photon to electron

MCP(s) amplify electron by 10^5 to 10^6

Rear field accelerates electrons to anode

Strip anode encodes charge cloud





Planacon 50mm detector with a bialkali photocathode and a pair of 53mm, 10µm pore, 60:1 L/d, 8° bias ALD borosilicate substrate MCPs, 32 x 32 anode array.

This work focuses on the development of novel nano-engineered microchannel plates (MCPs) to enhance a new generation of NUV-visible light photon counting detectors that have a wide range of applications in LIDAR, 3D topographic imaging, high-speed photography, bio-medial fluorescence microscopy and astronomical imaging. The MCPs are borosilicate glass micro-capillary arrays functionalized using atomic layer deposition (ALD). MCP's manufactured in this way have many advantageous properties, including the ability to withstand high processing temperatures, high secondary electron yield, and low outgassing. This scheme has the ability to support higher global photon count rates while greatly reducing the deterioration of photocathode efficiency and detector gain. Opaque photocathodes have been deposited onto these nano-engineered borosilicate MCPs and several sealed tube devices have been constructed. Here we report on the progress of this effort, including performance and lifetime characteristics from the sealed tubes and MCPs, and results from the deposition of opaque photocathodes onto nano-engineered MCPs. This work was supported by NASA grants NNG11AD54G & NNX14AD34G and DOE grant 005099.

ALD MCPs

ALD Borosilicate MCPs have potentially significant enhancements:

Higher photon/electron/ion detection efficiency
- larger open area (20% increase), opaque cathodes (50% increase)

Large areas & lower background due to glass composition
- sizes to 8"+, low intrinsic background (x5 less)

Longer device lifetimes, shorter process/fab times
- cathode and gain stable to 10 C/cm-2, burn-in < 1day

Deposit materials & cathodes not otherwise possible
- GaN and other III/V as well as multialkalis on MCPs

Better pulse height at low gain
- supports high rate applications without event threshold losses

Low resistance with stable operation
- supports high rate applications, factors of ~5

Implementation:

Can be immediately inserted into devices like Planacon, 18mm cross strip tubes, 25mm cross delay line tubes, and open face devices for many applications, including nighttime remote sensing, biological fluorescence, Astronomical imaging and spectroscopy, mass spectroscopy and homeland security.

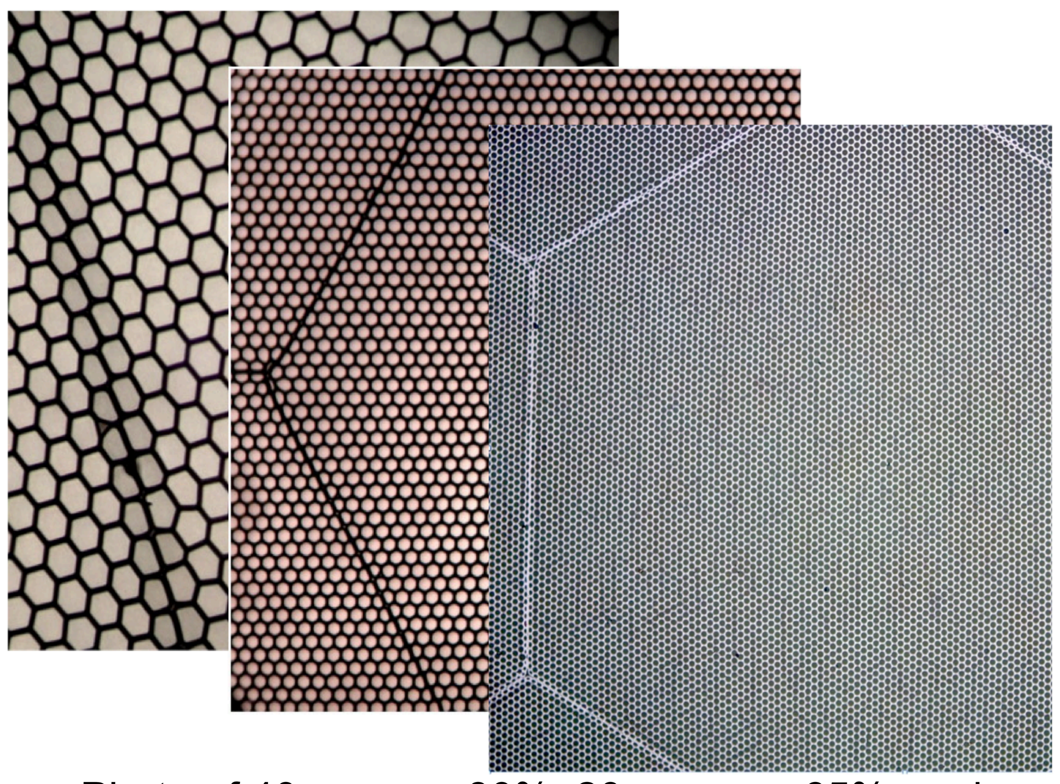
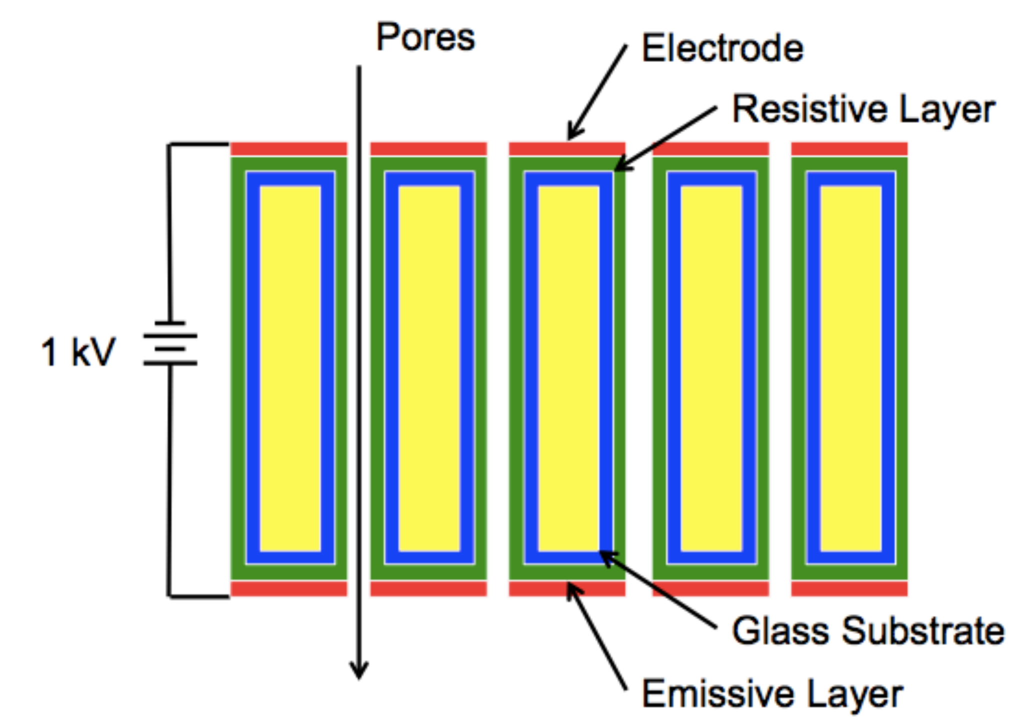
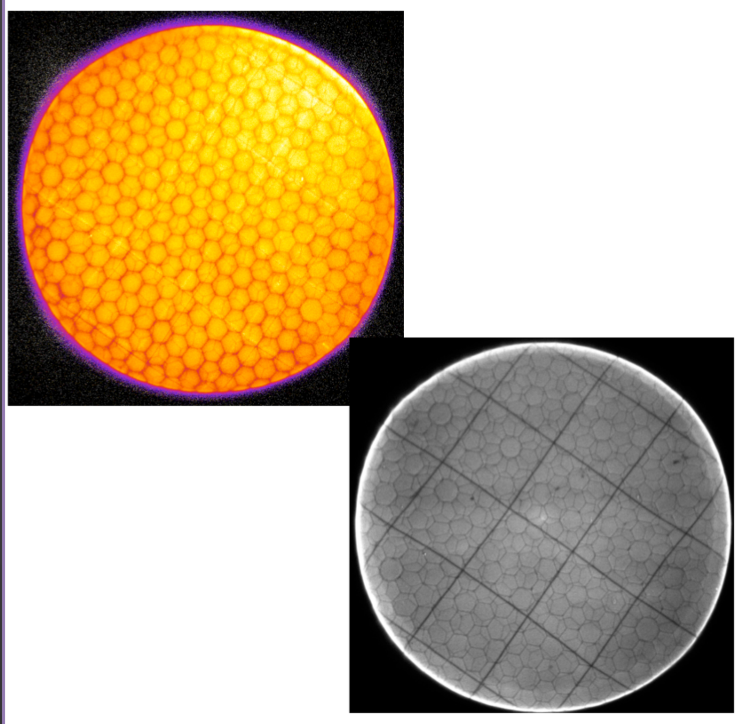


Photo of 40µm pore 80%, 20 µm pore 65%, and 10µm pore 60% open area borosilicate micro-capillary arrays.

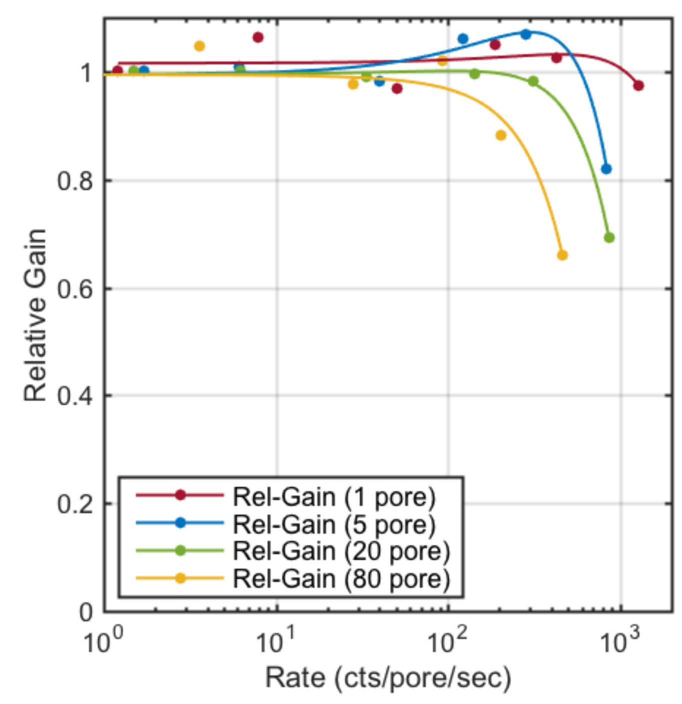


Borosilicate glass substrates are functionalized with atomic layer deposition. Resistances can be tailored to suit the application. Materials with high stable secondary emission can be used since they are decoupled from the substrate.

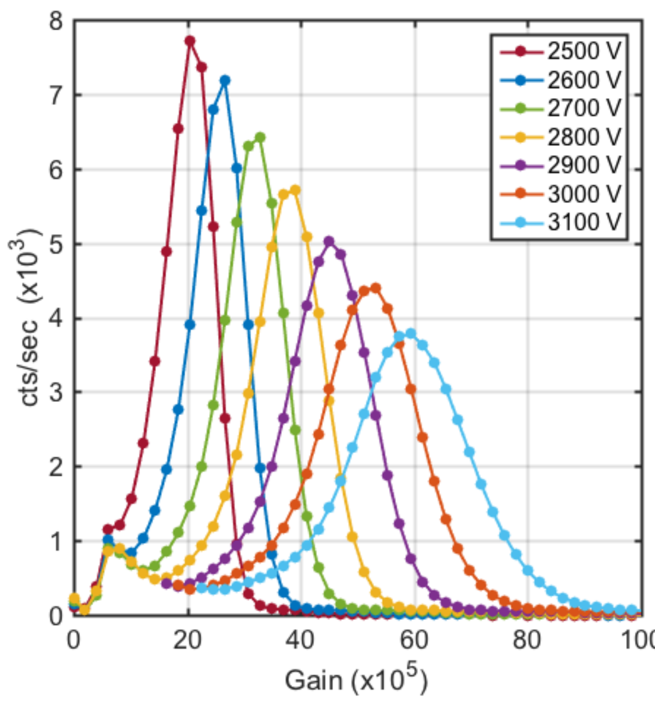
ALD MCP Performance



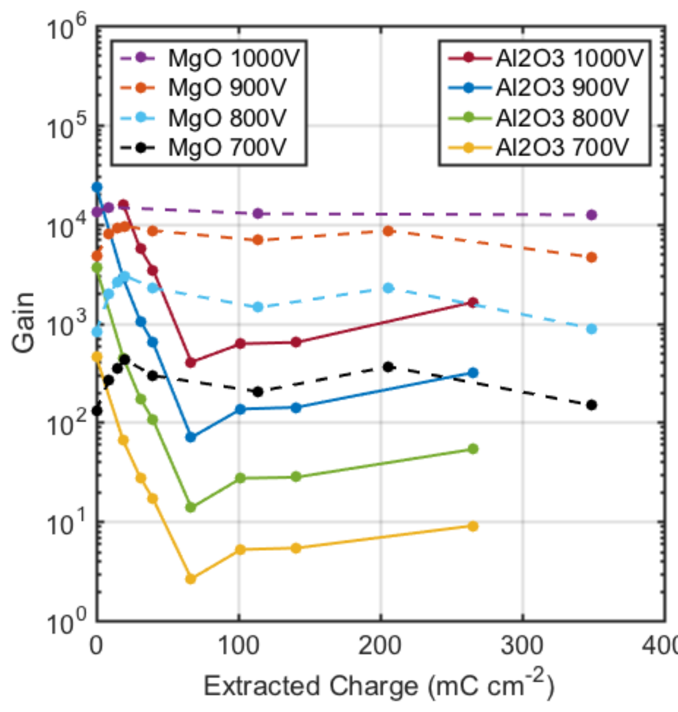
Gain map & intensity image (showing QE grid) for 2nd generation 33mm ALD MCPs. 20µm pores, 60:1 l/d, 8° bias.



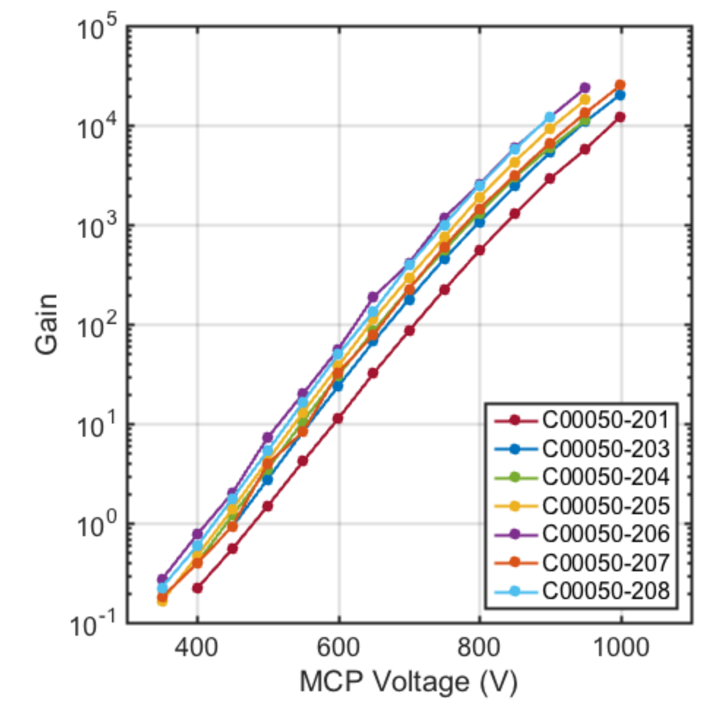
Gain droop for MCP pair (8MΩ each) at high gain ($5x10^6$), high rates in small spots. ~10^3 cts/pore/sec before onset.



Tight pulse amplitude distributions at low gain, 3 MCP stack with 20µm pores, 60:1 l/d, 8° bias.

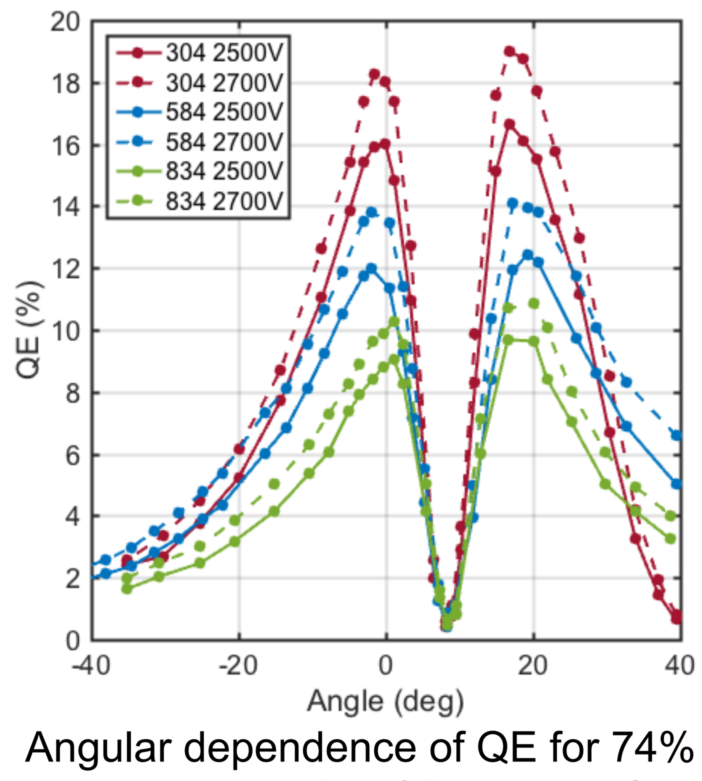


Comparison of 33mm ALD MgO and Al_2O_3 MCP with 2nd gen glass. Gain during electron scrubbing.

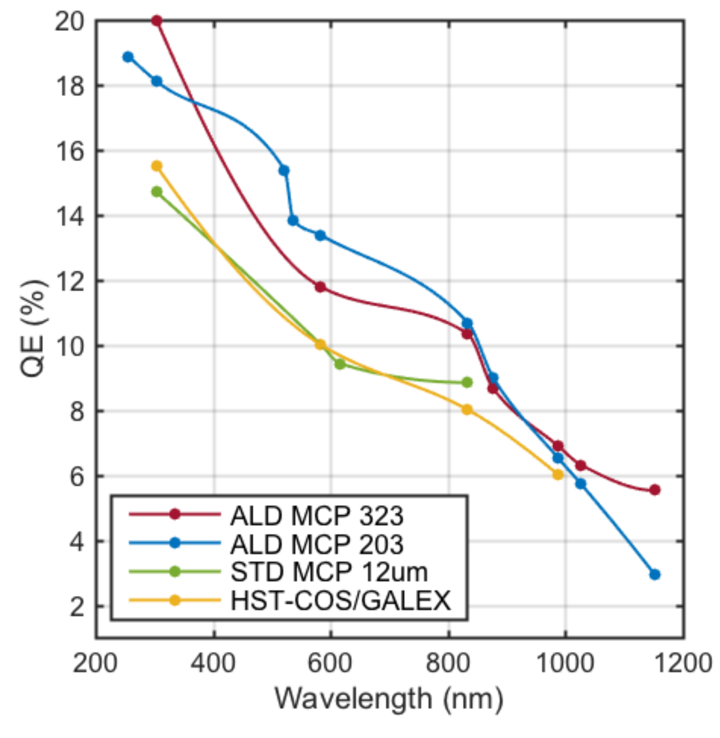


Gain for 33mm ALD MCPs on 2nd generation glass with Al_2O_3 emissive layers, 20µm pores, 60:1 l/d, 8° bias.

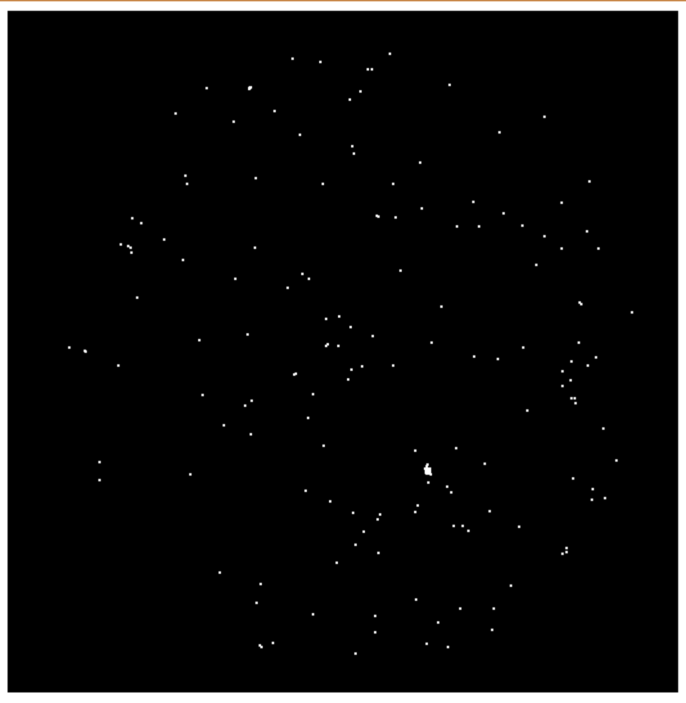
ALD MCP Performance



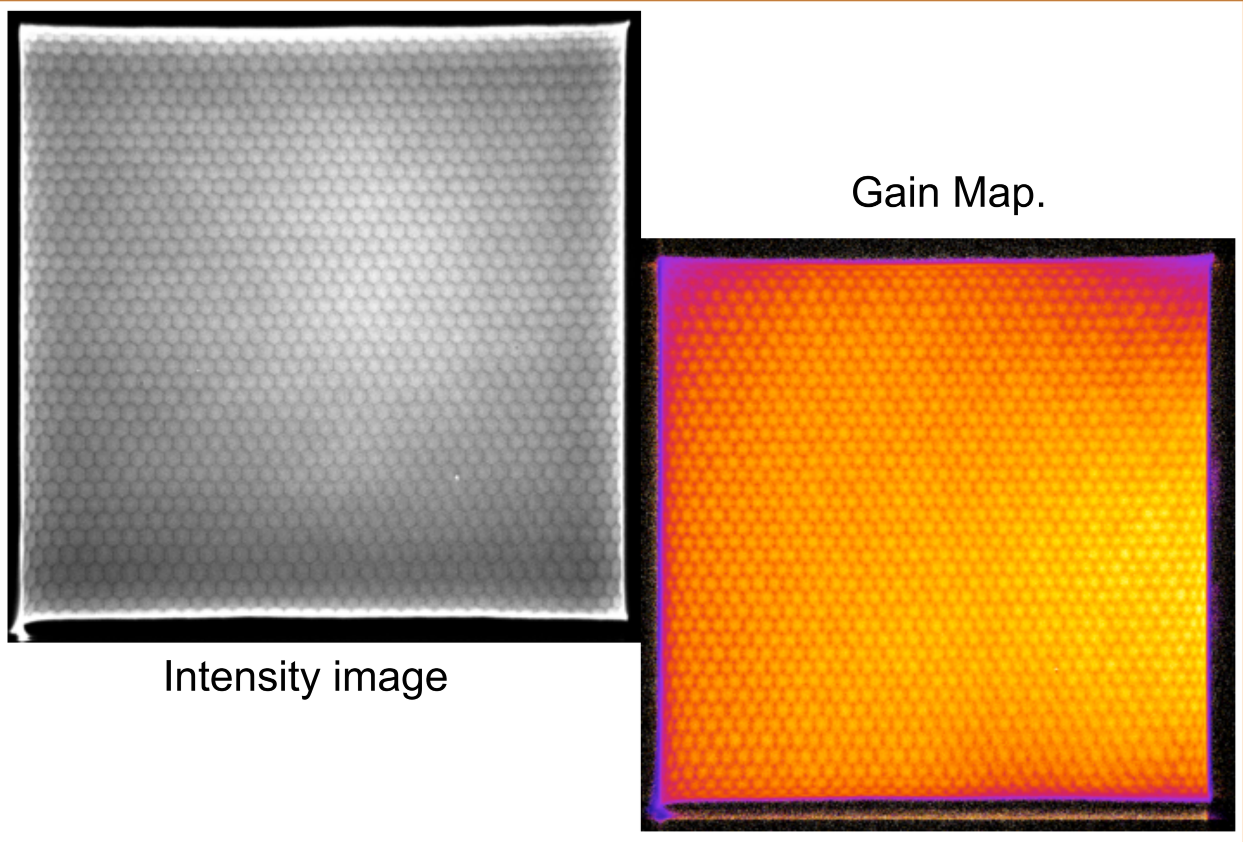
Angular dependence of QE for 74% open area ALD MCPs with Al_2O_3 emissive layer, 20 µm pores, 60:1 l/d, 8° bias, at two bias potentials.



MCP QE for 74% open area ALD MCPs with Al_2O_3 emissive layer, 20 µm pores, 60:1 l/d, 8° bias, vs. standard MCPs.



500 sec MCP background for 74% open area ALD 33mm MCPs with MgO emissive layer, 20 µm pores, 60:1 l/d, 8° bias. Rate is ~0.07 events cm^{-2} sec^{-1} except for one "warm" spot.



53 x 53 mm^2 ALD MCPs with MgO emissive layer, 10 µm pores, 60:1 l/d, 8° bias. Gain is quite uniform, except for multifiber modulation.

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