Recent update on ANL MCP-PMT

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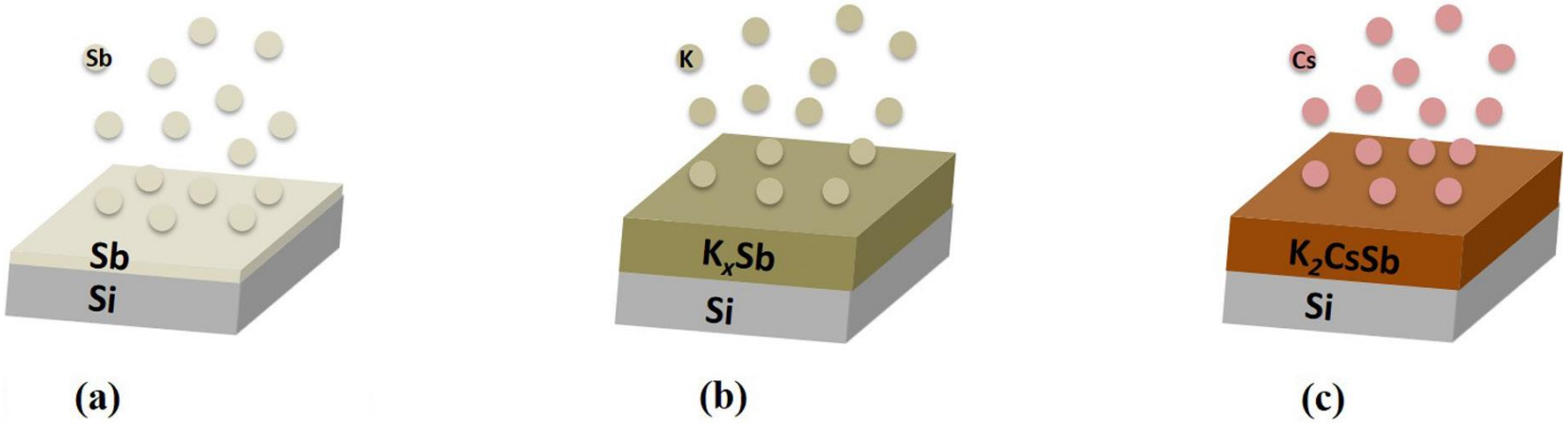
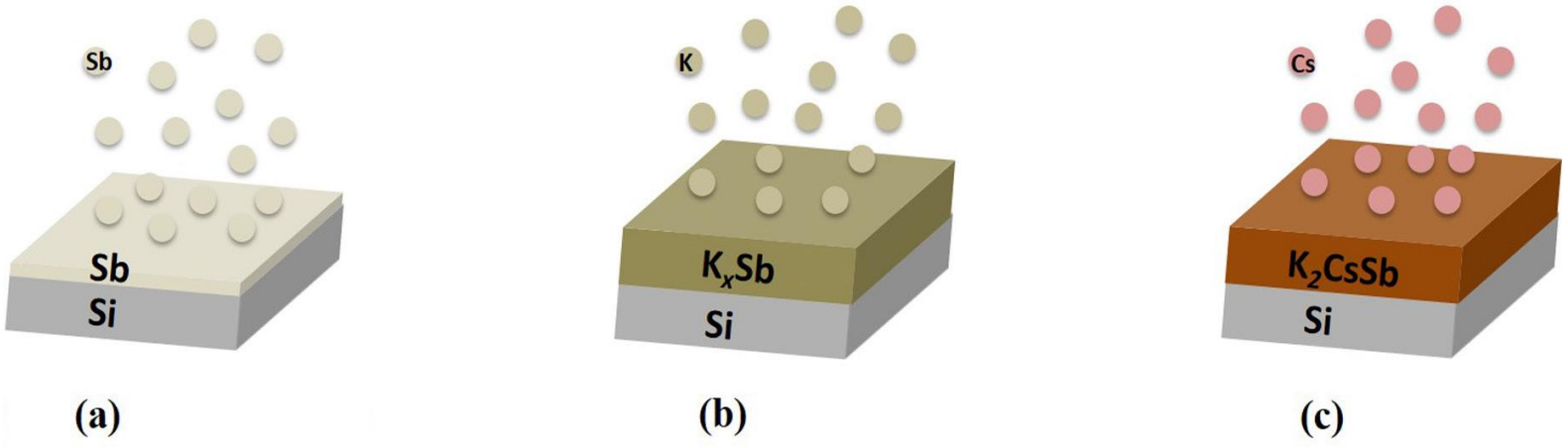
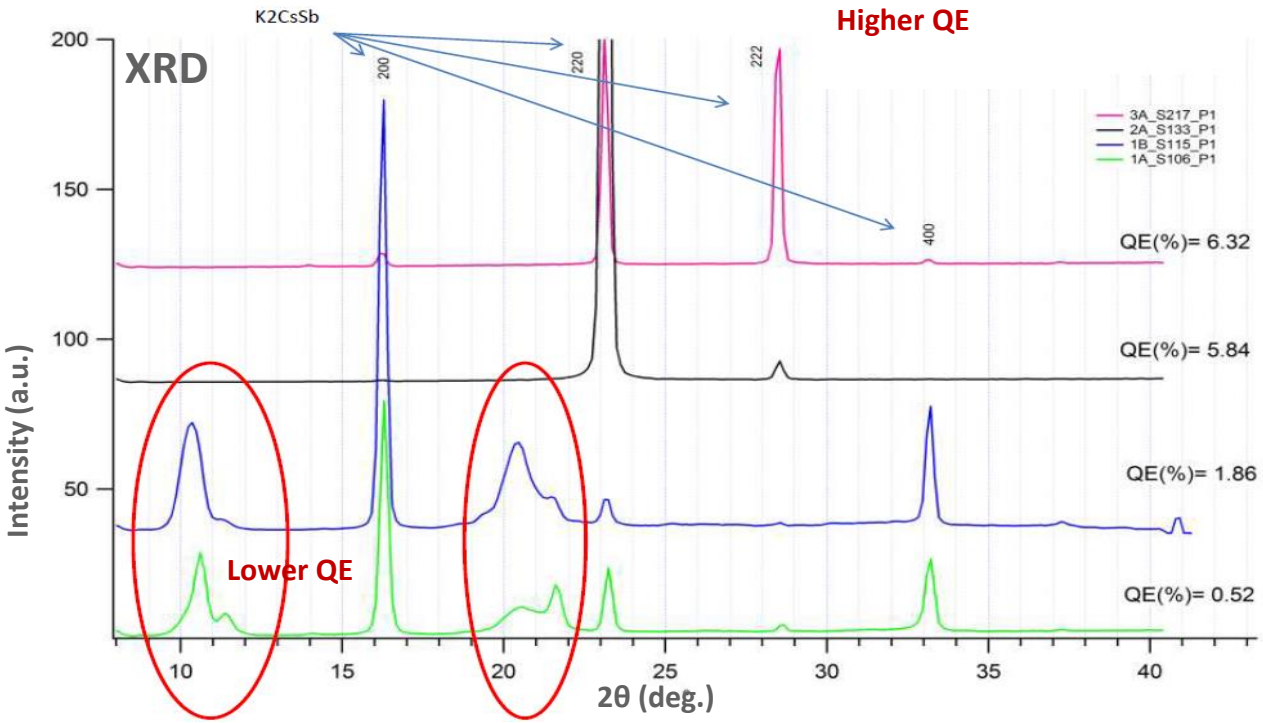

Sb
Sb
Si
(a)
K
K_xSb
Si
(b)
Cs
K_2CsSb
Si
(c)

Traditional diffusion deposition process



Schematic diagram shows the diffusion process of the K_2CsSb photocathode: (a) Sb thin film deposition; (b) K diffusion forming a K_xSb compound; and (c) Cs diffusion forming a K_2CsSb photocathode.

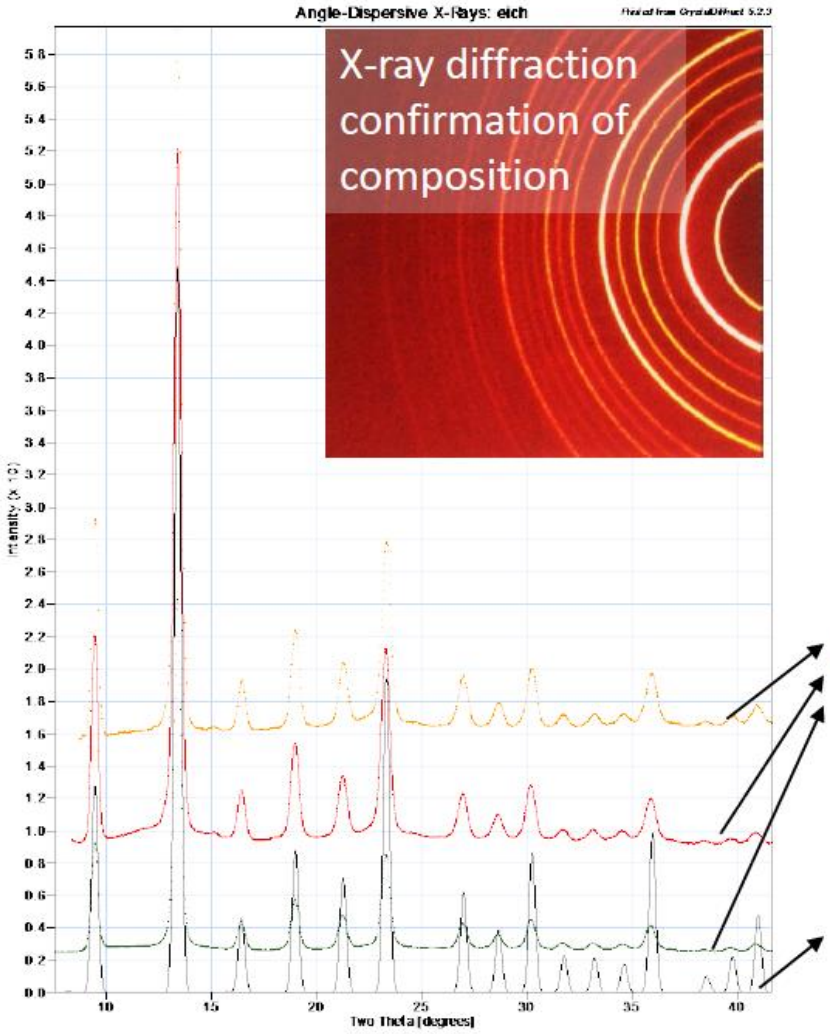
X-ray analysis results

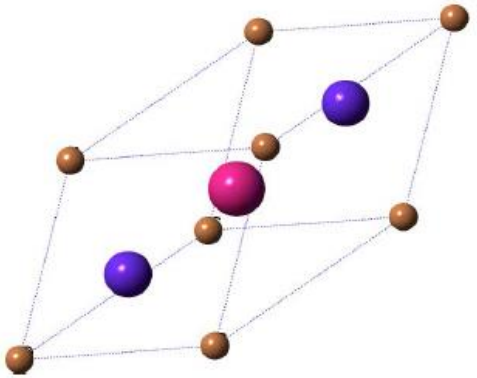


- Stoichiometry was not able to control preciously
- Photocathodes display various QE values (low and high)
- High QE cathode exhibits **single K_2CsSb compound**, low QE cathodes exhibit mixture of different compositions.

New think – Synthesize the compound first, then do the deposition

The Breakthrough Chemical Synthesis





As-synthesized K_2CsSb compound

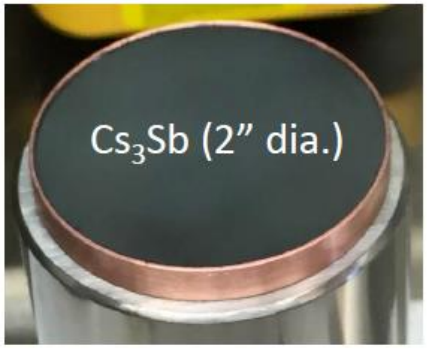
A good match !!!

Calculated diffraction data for the desired cubic K_2CsSb

- > 95 % pure phase
- Nanocrystalline Material (15-30 nm)

K_2CsSb – the predicted structure is confirmed experimentally

Solid State Synthesis

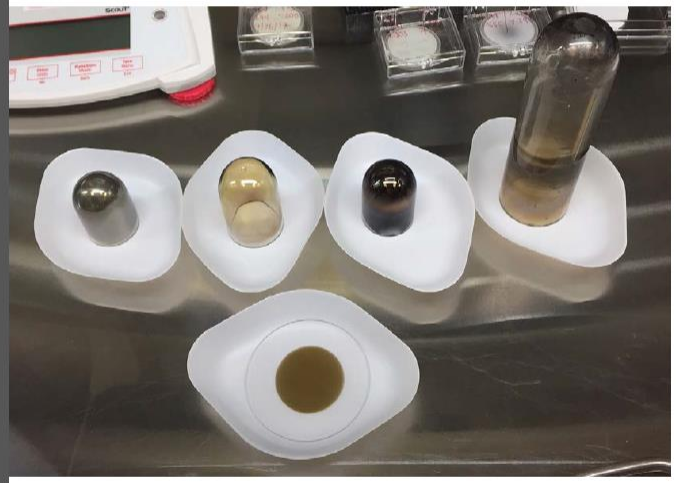


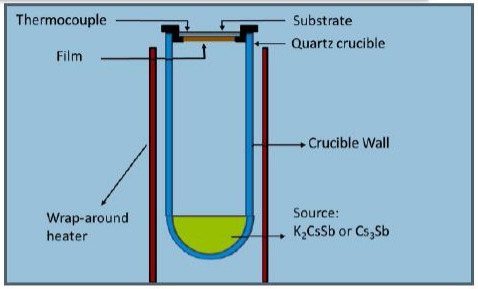
Challenge: The reaction chemistry is highly exothermic and the product is reactive to ambient moisture

Solution: Solid state synthesis performed in a controlled environment

RMD
A Dynasil Company

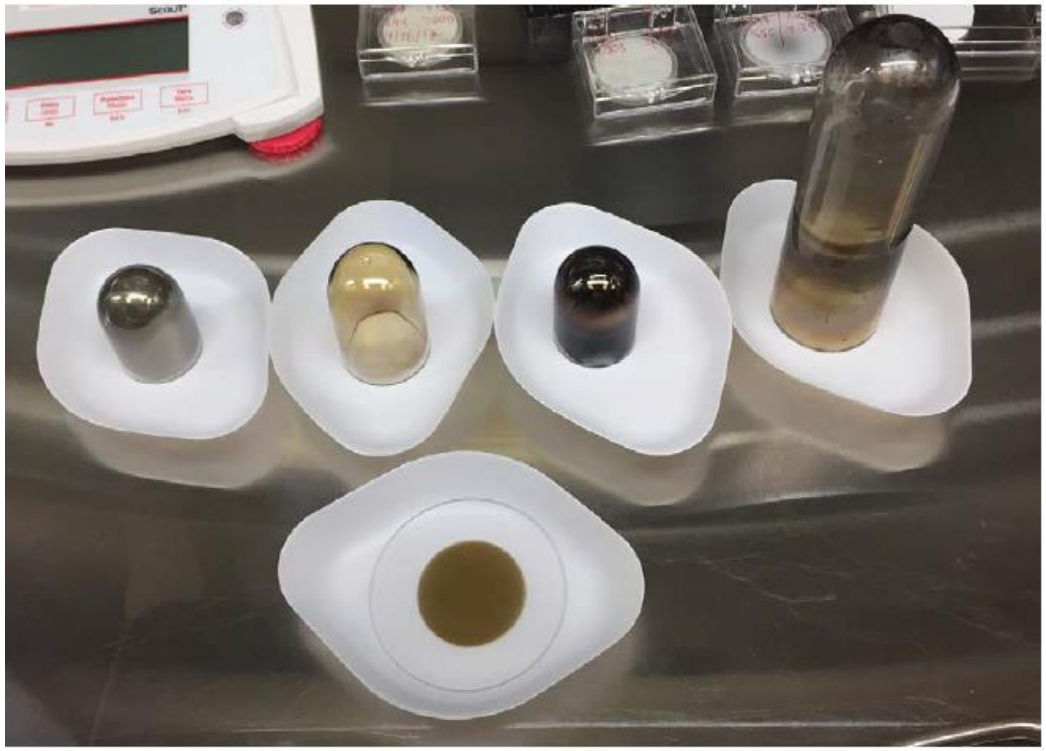
Evaporation Process

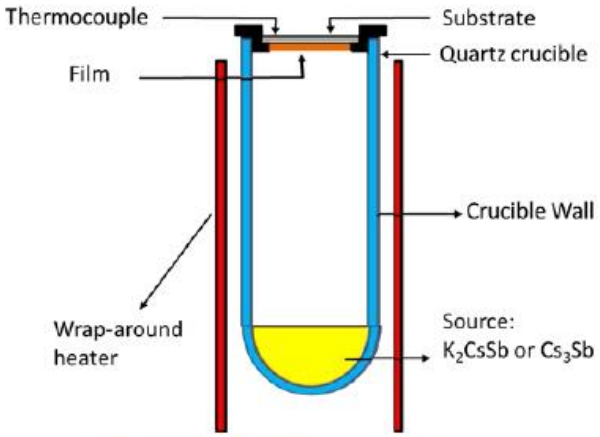




Hot Wall Evaporation

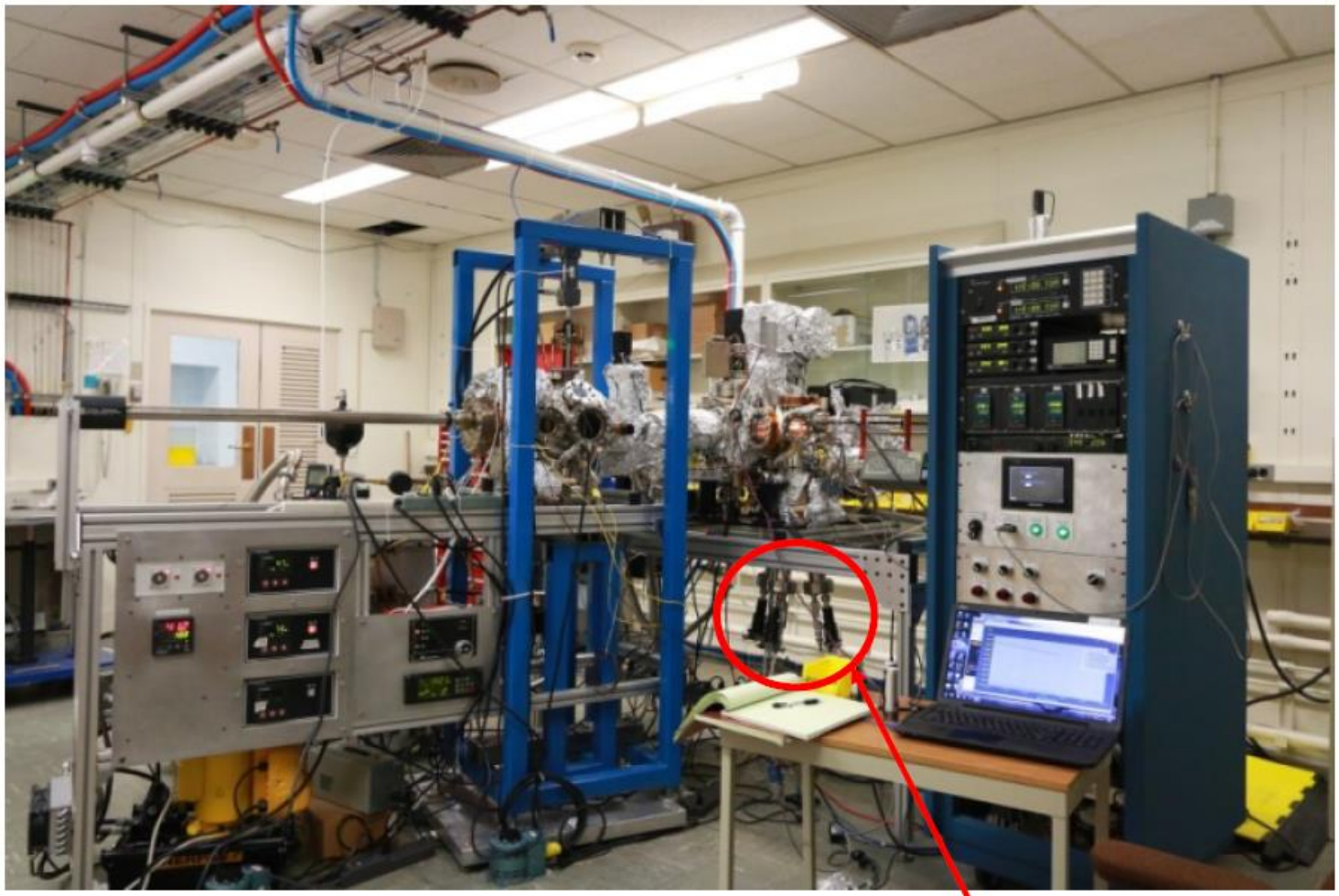
Evaporation Process





Hot Wall Evaporation

Photodetector fabrication facility



Modification is required here

Task: Modified design for sources

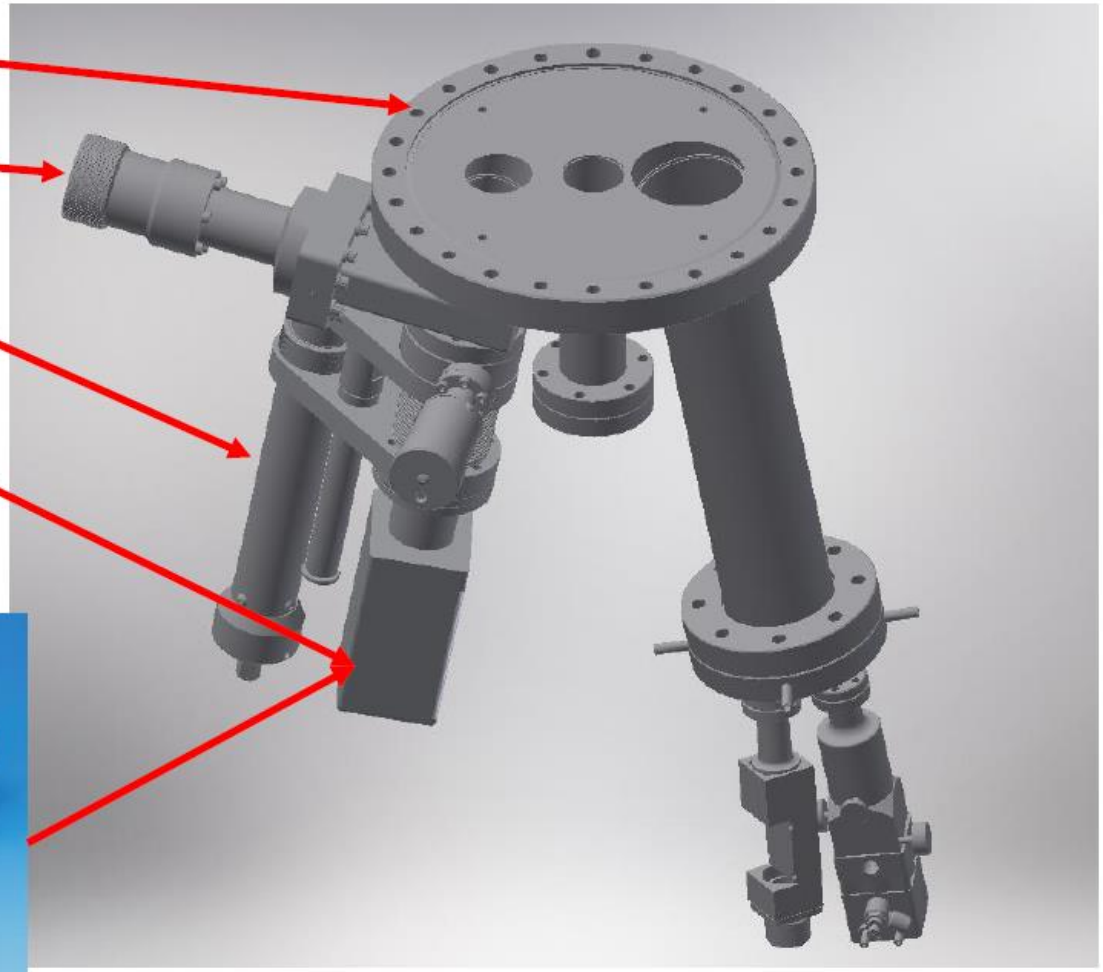
The new design does not use an effusion cell, use a direct thermal evaporation source to evaporate the bulk material, easier handling.

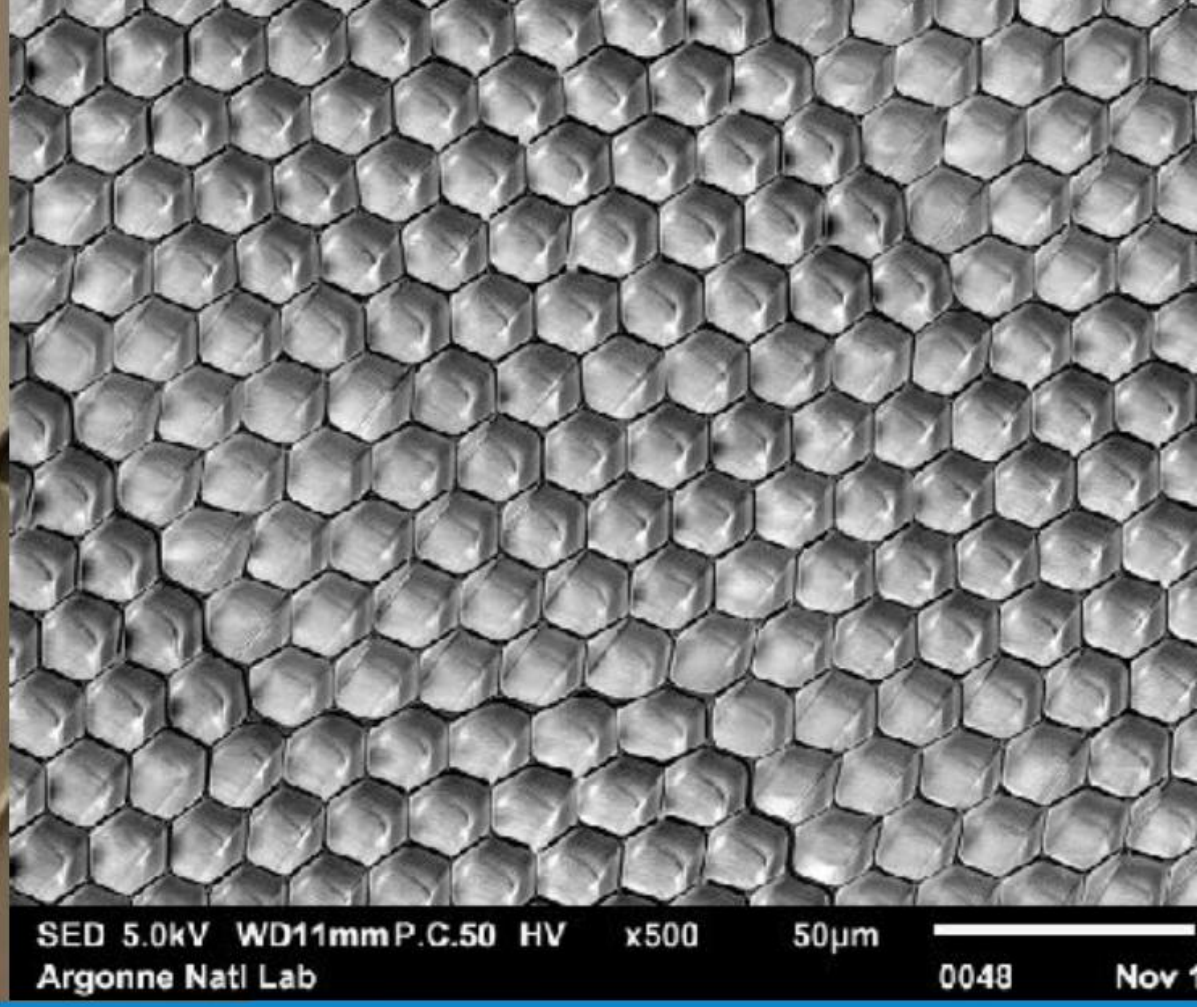
Source flange

Gate valve

Single axis stage

Evaporation source



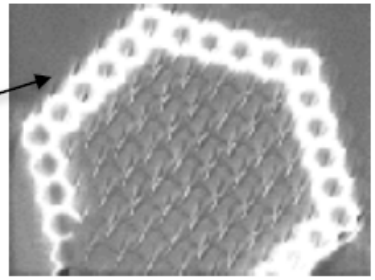


3D PRINTING OF CAPILLARY ARRAYS FOR MICROCHANNEL PLATES

SO, HOW DOES ONE PRINT AN MCP?

- Use Two Photon Polymerization (TPP) of photoresist to make structure
  - First shown by Maruo & Kawata “Two-photon absorbed near-infrared photopolymerization for three-dimensional microfabrication”, J. MEM. Sys **7**, 411 (1998).
  - Infrared laser (780nm) focused to small spot where power is sufficient to produce TPP. Resolution is ~0.1-1μm.
    - Varying laser power ranges effect from no polymerization, to useful polymerization, to blistering
  - Write the structure by moving laser from point-to-point

laser draw as shown by monitor camera



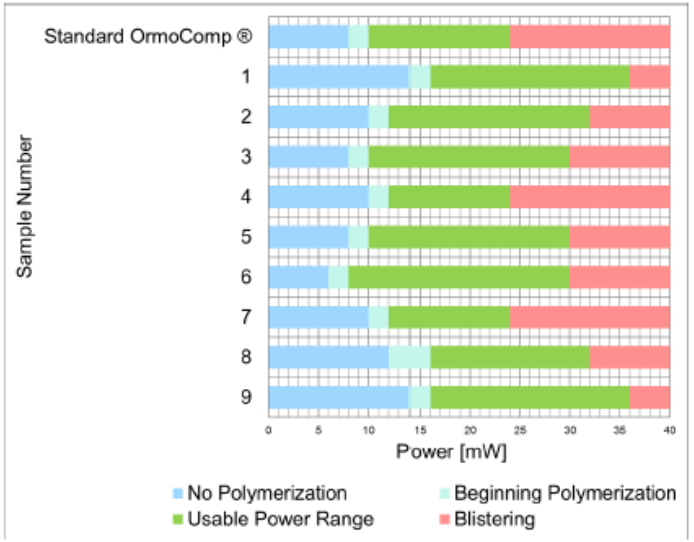
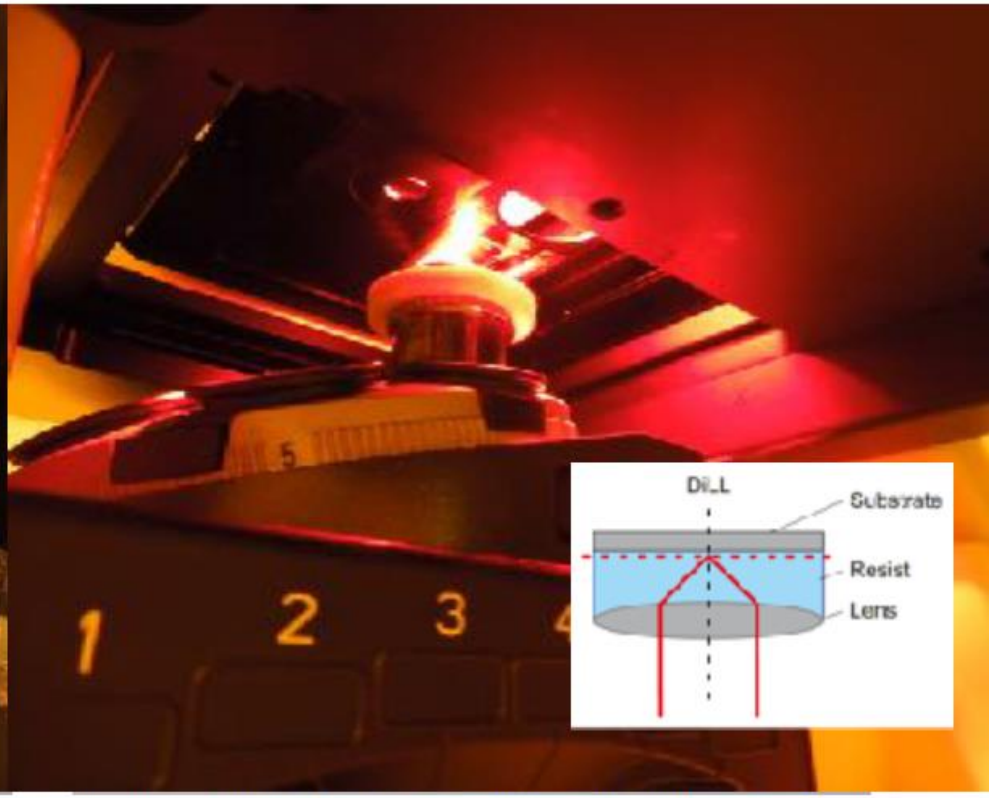


figure credit: Harnisch & Schmitt, SPIE (2017)

  - Complete process with developer and UV illumination
- 3D TPP printers commercially available
  - We use Nanoscribe Photonic Professional (GT)

NANOSCRIBE 3D PRINTER SPECIFICS



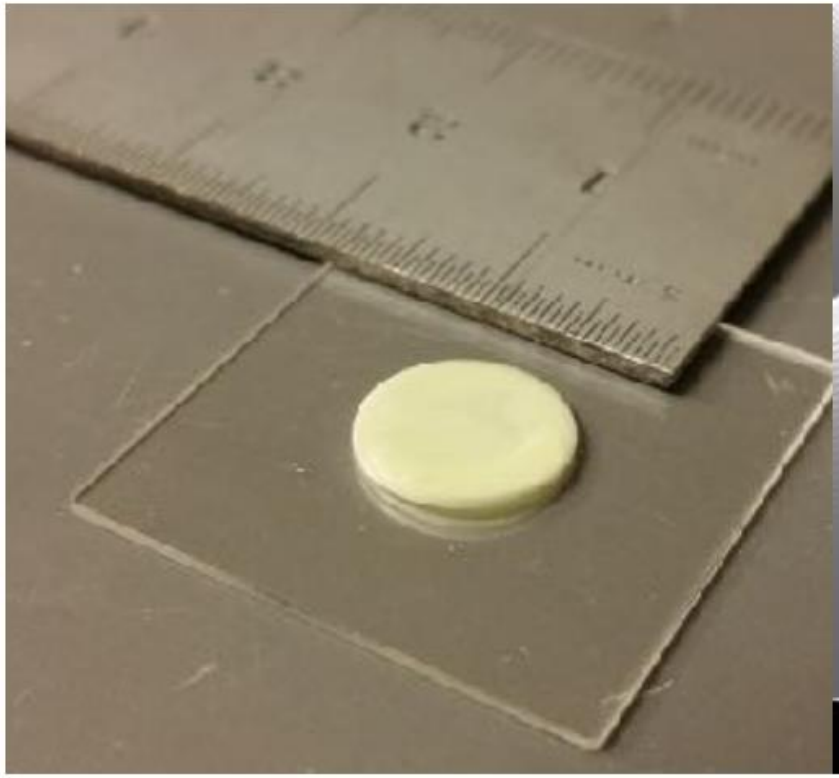
Printer is "table-top" device consisting of

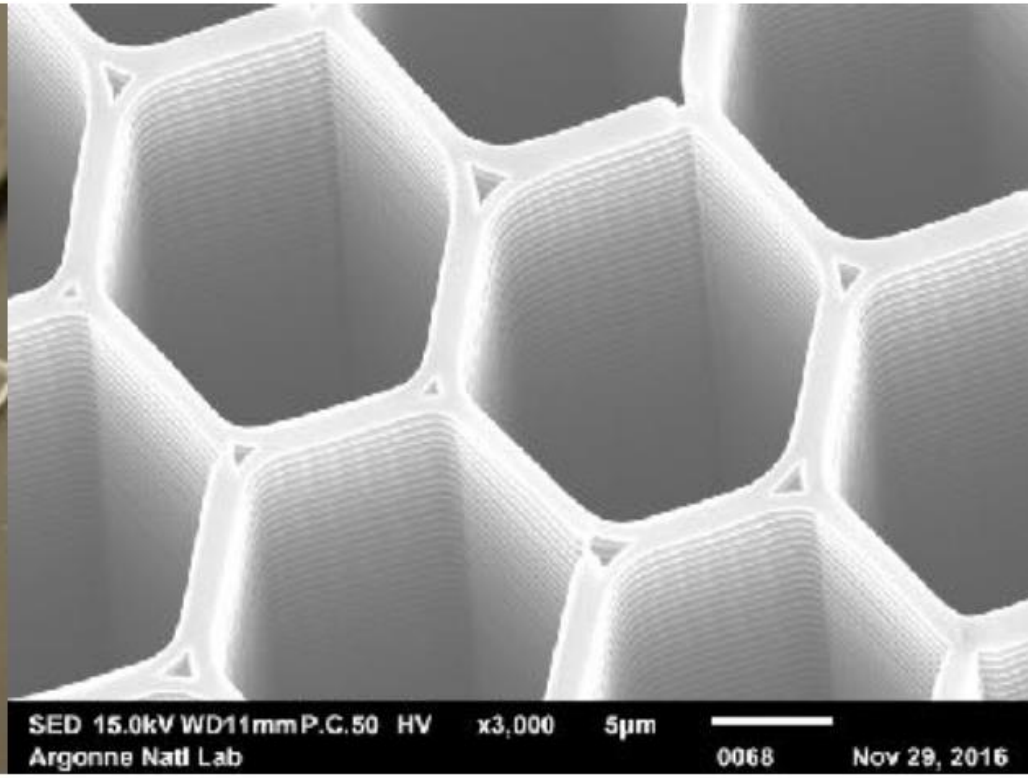
- Floating optical table
- Laser and focussing optics
- Microscope and autofocus system
- Motorized stage: stage (cm movement), piezo (300µm), galvo (100nm-400µm)

Photoresist applied to glass plate which is inverted and inserted into stage.

Microscope lens is dipped into photoresist to focus laser spot onto print voxel. Dip-In Laser Lithography (DiLL)
Printing starts at just inside glass/resist interface to adhere structure to glass

1CM CAPILLARY ARRAY WITH HEXAGONAL PORES





Completed capillary array

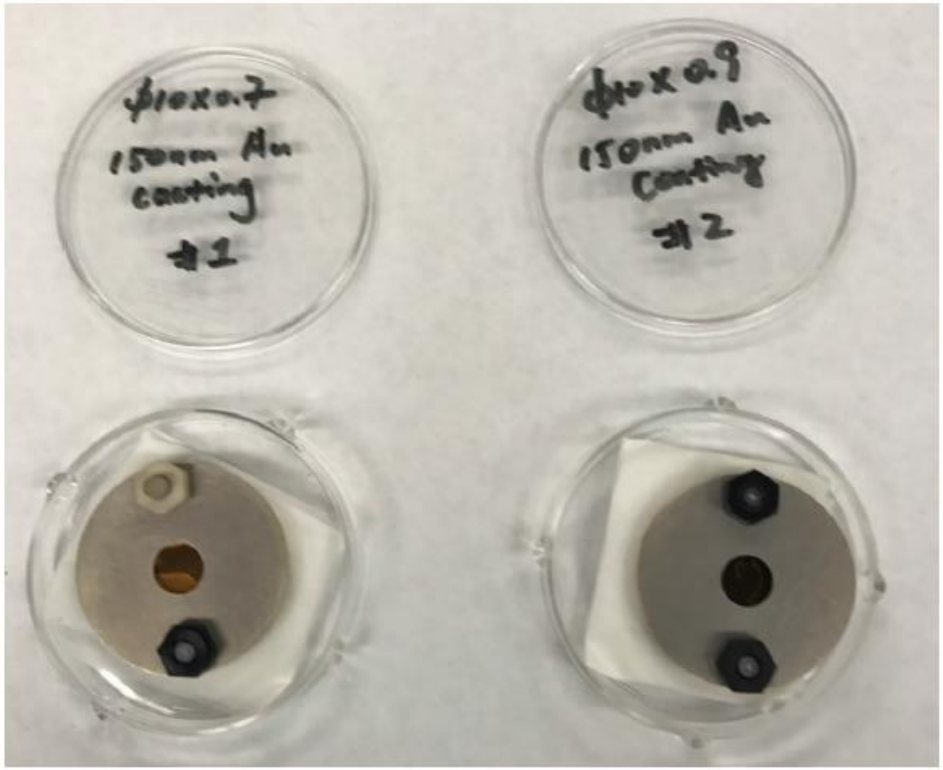
- Resist stabilized after print with developer
- Wash with isopropanol
- Exposure to UV lamp for 15 minutes completes any polymerization

SEM image of earlier capillary array

- Laser write speed too fast causes breaks in structure at vertices

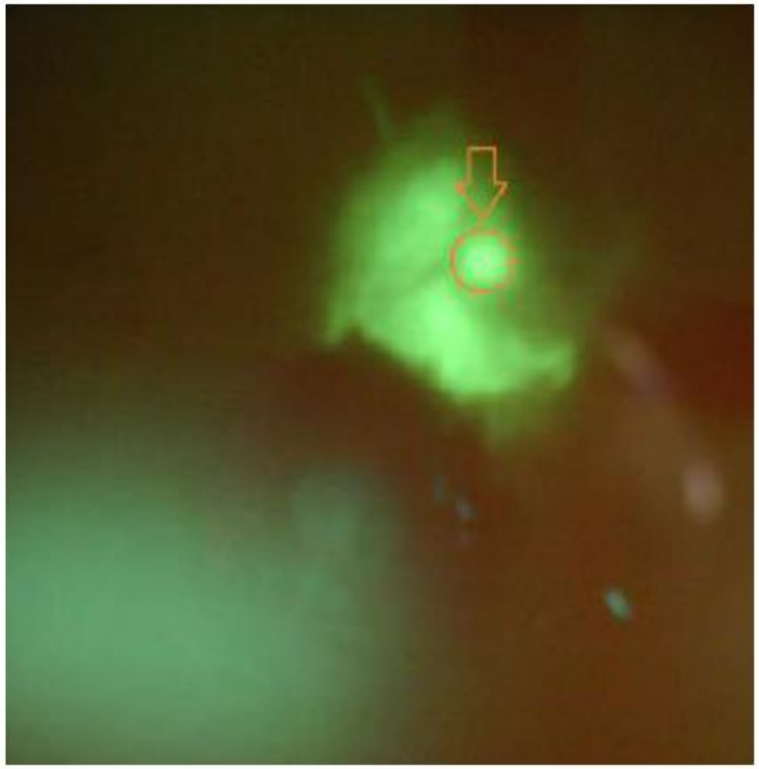
Overall size of capillary array that can be printed **currently** limited by writing speed: 1cm x 0.9mm array takes 39 hours

FUNCTIONALIZATION OF 3D PRINTED MCP VIA ALD AND DEMONSTRATION OF GAIN PRODUCTION



1cm MCP with 10μm pores after ALD coating

- Resistance ~2GΩ; high but usable
- SEE layer — Al_2O_3



1cm MCP image in phosphor chamber

- Illuminated with UV lamp to ionize electrode
- Gain produced in 1cm MCP further amplified by second 8” MCP