The Silicon Electron Multiplier Sensor

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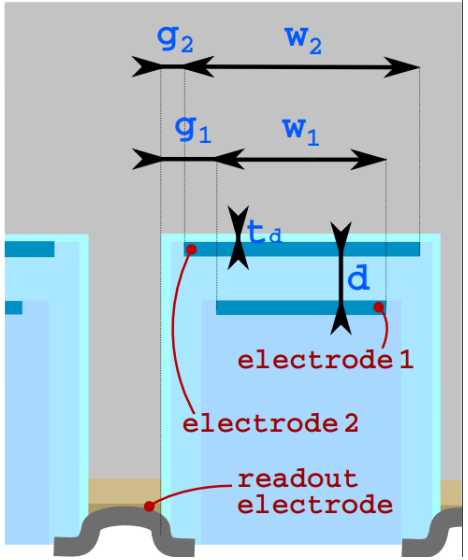
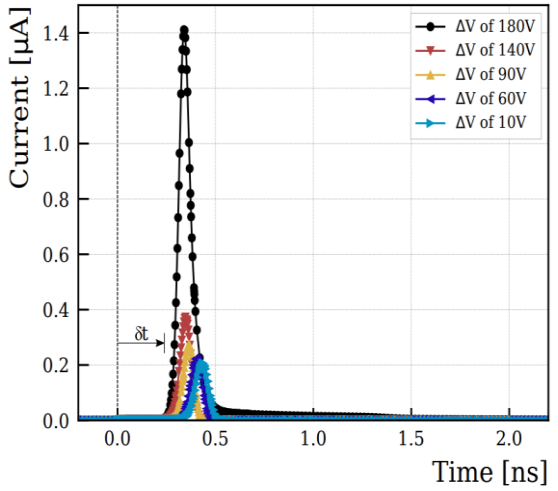
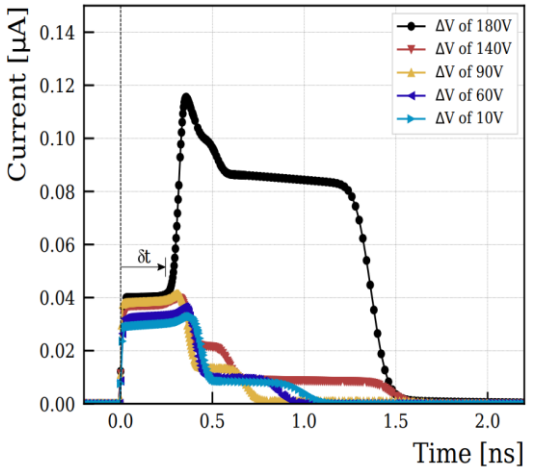
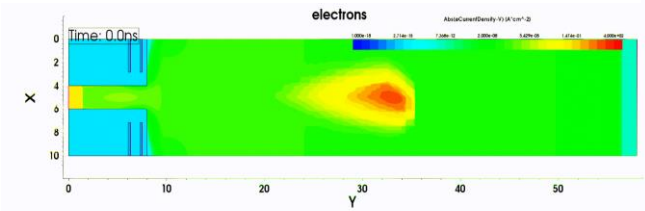
The Silicon Electron Multiplier Sensor

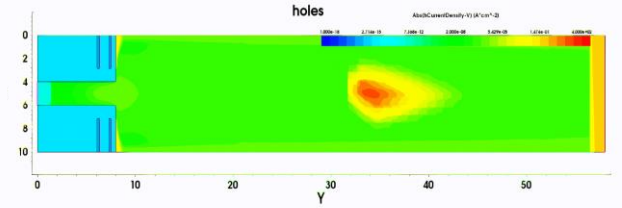
- **Make a radiation hard sensor with good timing capabilities**
  - Avoid doping dependent gain regions
- **Approach:**
  - Implement additional electrodes in sensor substrate to create high electric field regions to promote charge multiplication
- **Paper in review with NIM-A**
  - preprint on Arxiv: https://arxiv.org/abs/2203.01036
- **Demonstrator productions**
  - Metal assisted chemical etching
    - With PSI
  - Deep reactive ion etching
    - With CNM











Fabrication: Metal Assisted Chemical Etching

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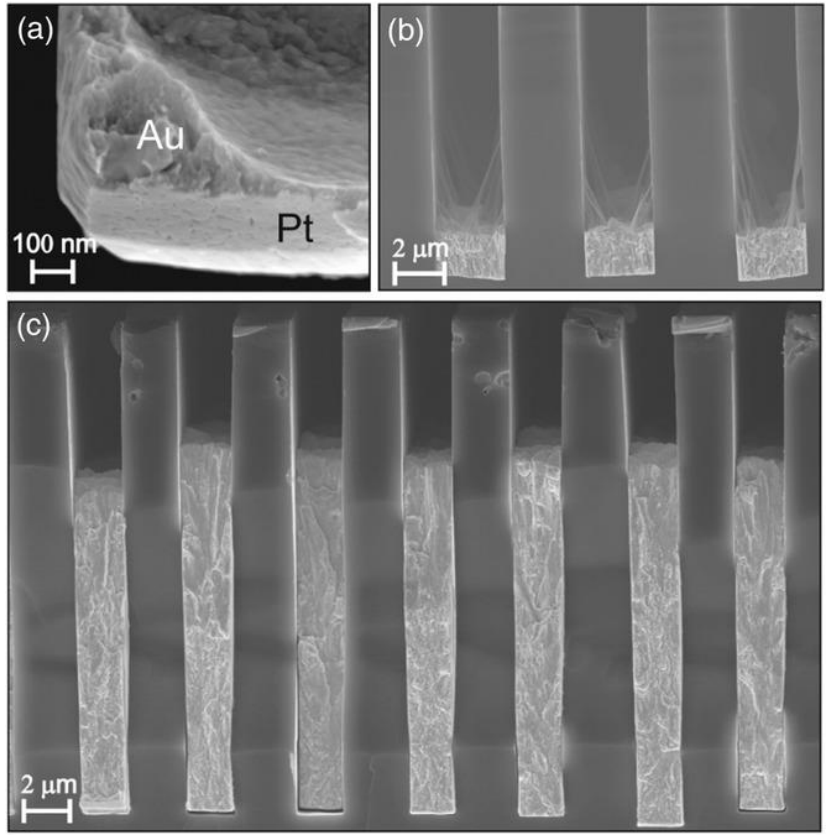
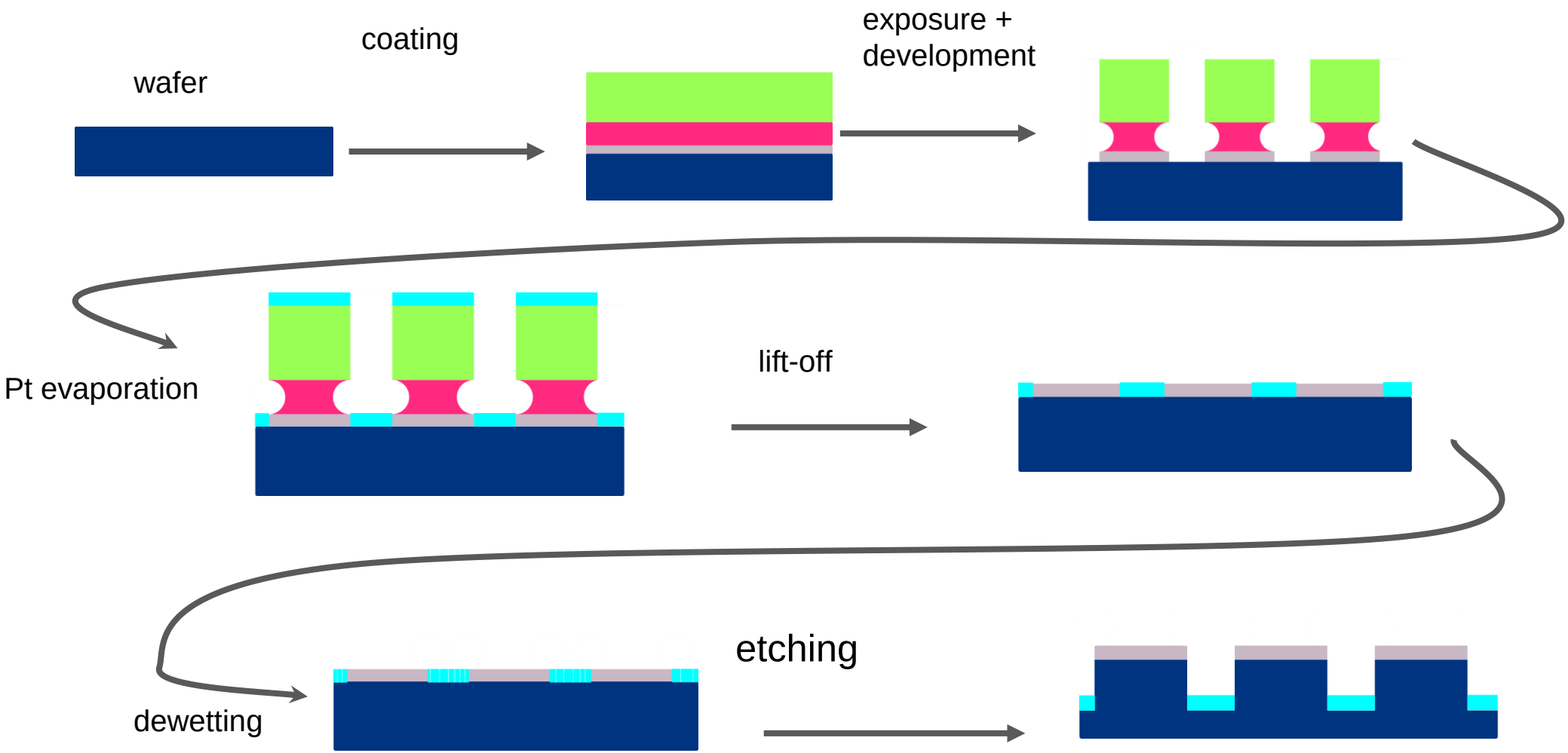
- **On-going fabrication at PSI**
- **Process developed at PSI by L. Romano[1,2].**
  - High aspect ratio grating fabrication for X-ray optics
  - [L. Romano et al; Nanoscale Horizons 5(5) (2020) 869-879]
- **Metallic pattern used as etching catalyst for HF vapor.**
- **Etching catalyst is also used as a multiplication electrode**
  - Suitable for single electrode geometries
- **Process not yet applied on active media**



[L. Romano *et al*; AdEM 22 (2020) 2000258]

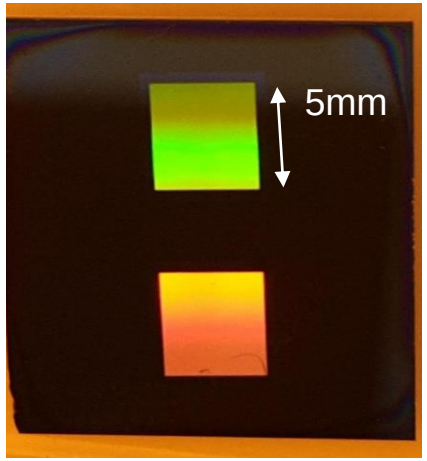
[1]ETH Zurich, [2]Paul Scherrer Institute

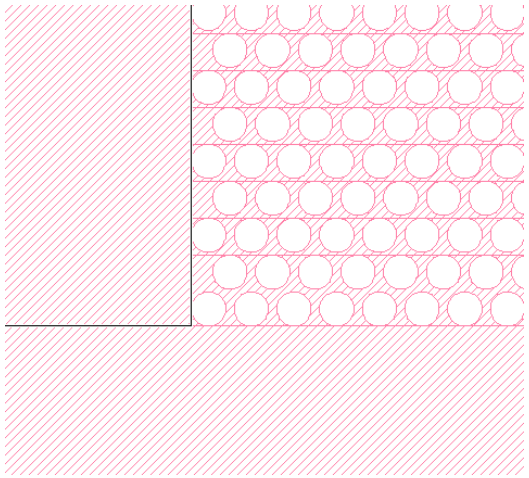
Process flow overview

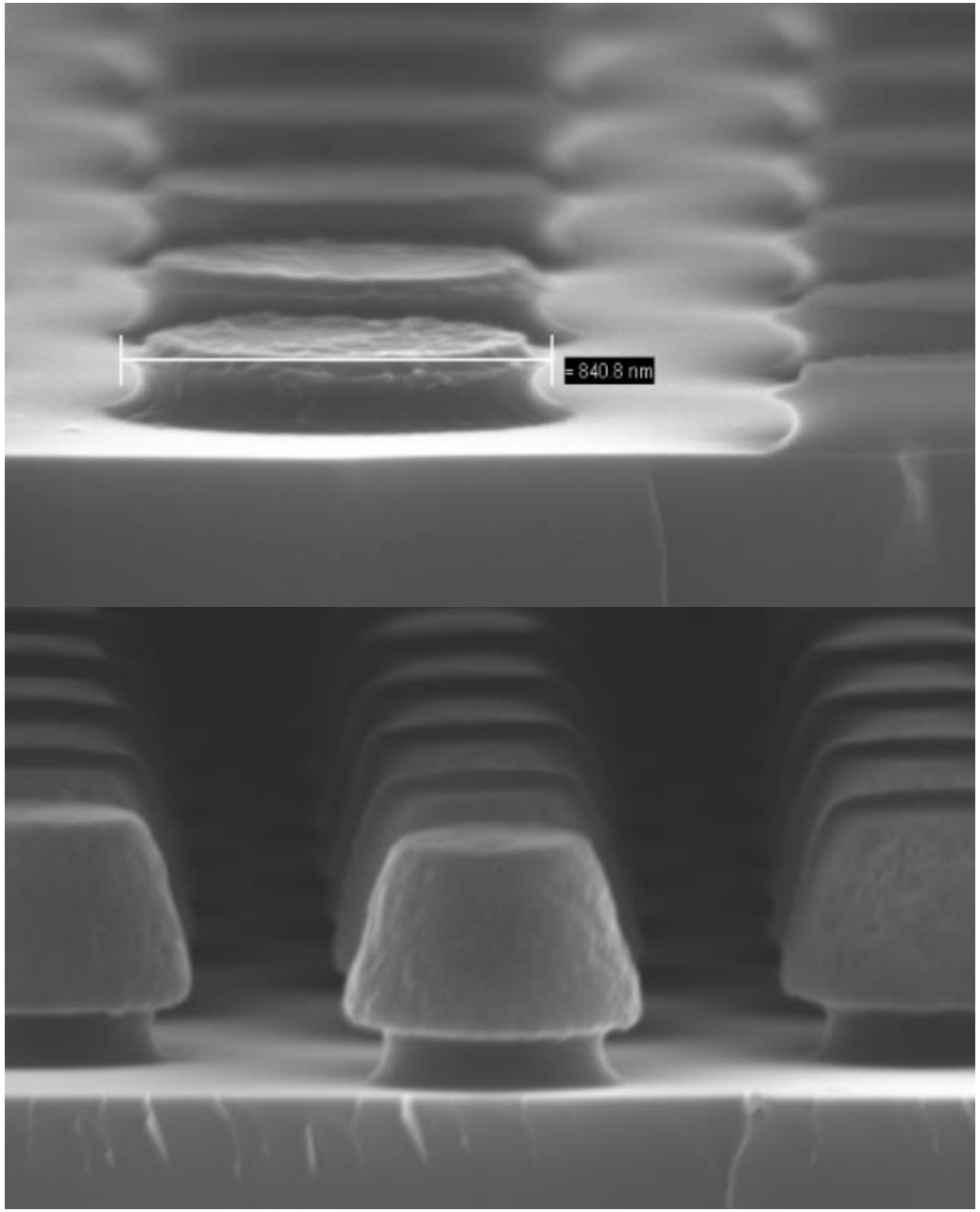


Process optimisation, Coating and exposure

- **Optimise different photoresists**
- **Pattern**
  - Hexagonal grid, circle radius of 500–600nm, pitch of 1.5µm,
- **Direct Write Laser system**
  - DWL66+ from Heidelberg Instruments
  - HiRes Write mode, can write features >0.3µm

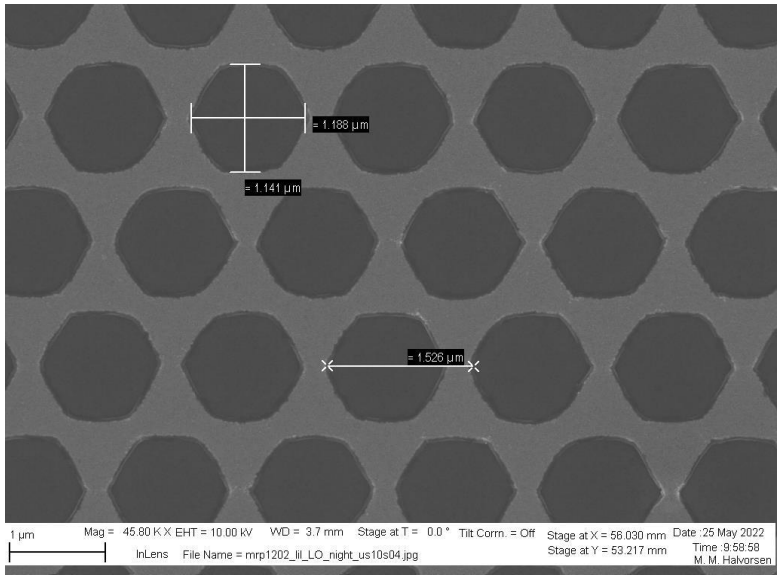


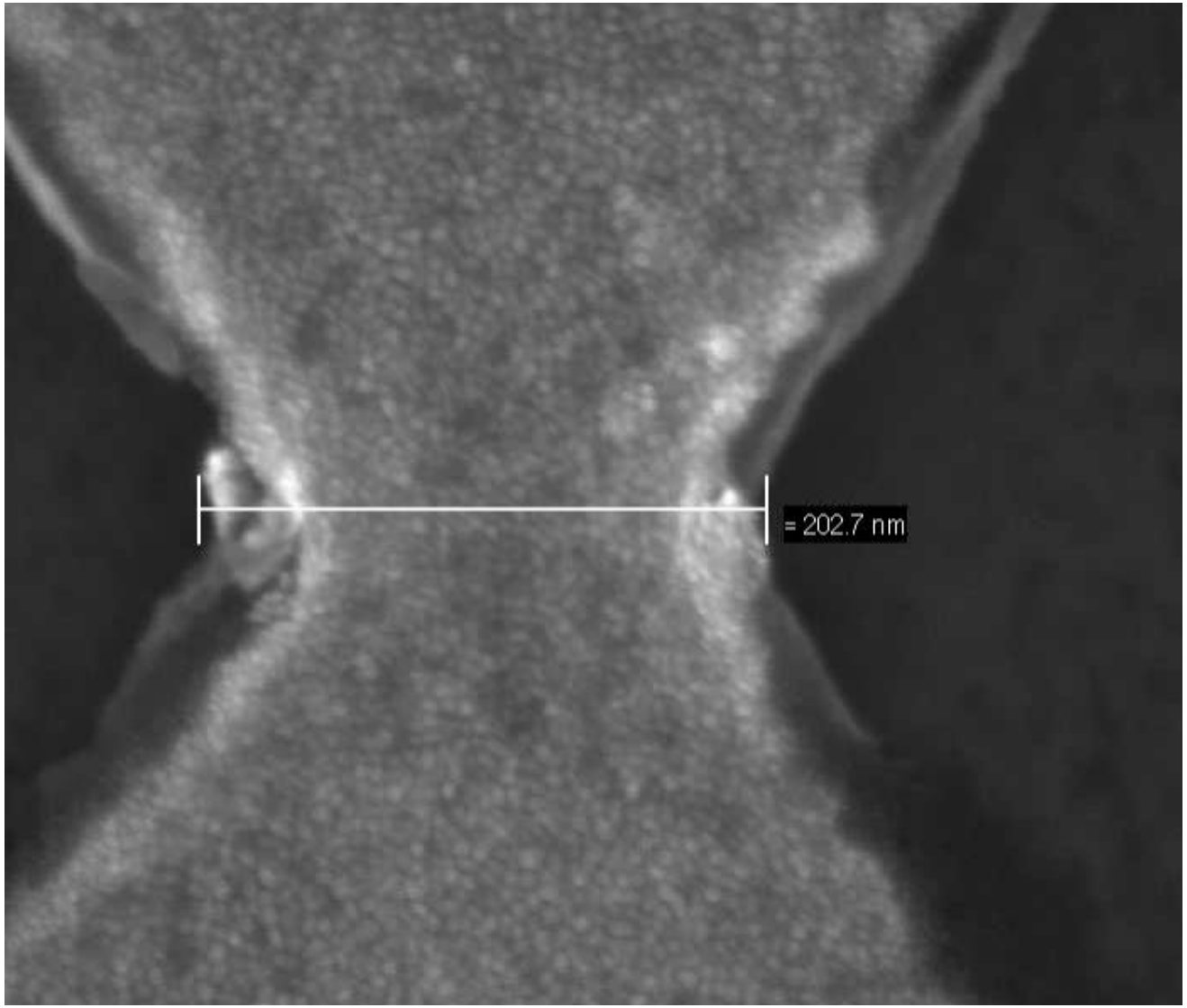




Platinum evaporation and lift-off

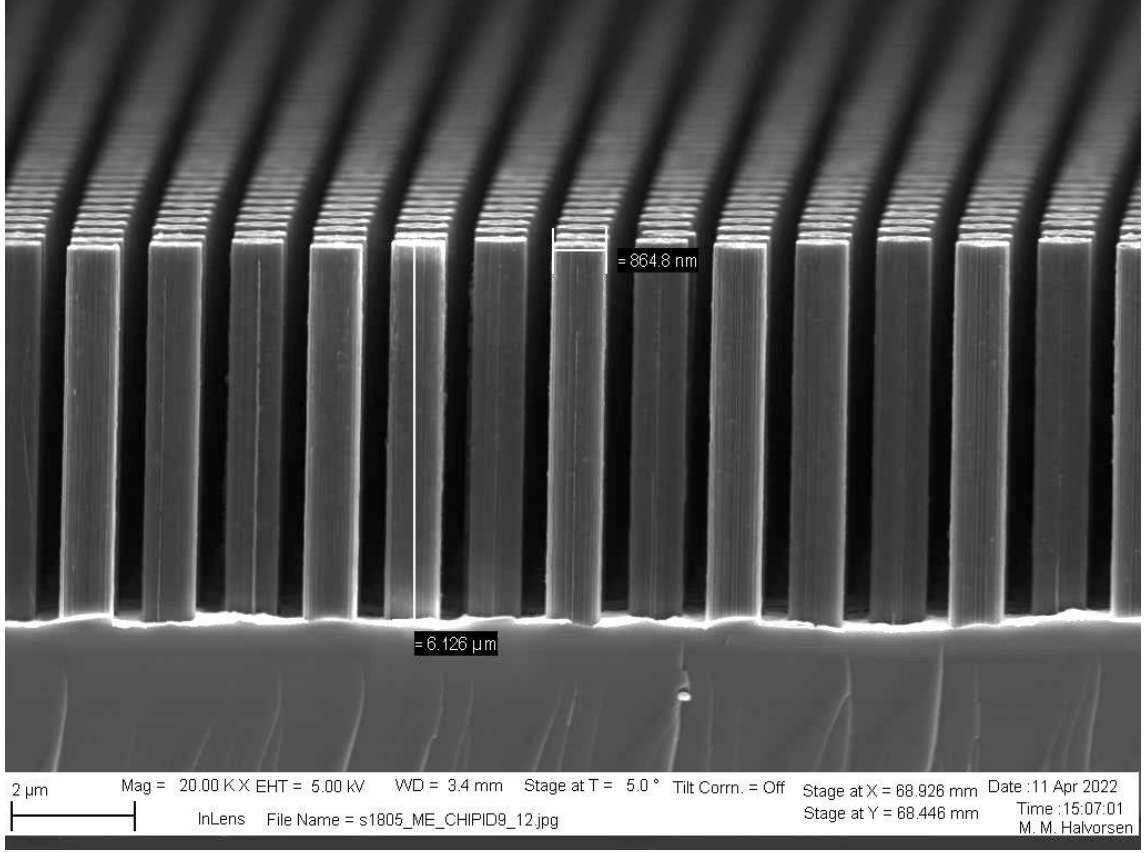
- **E-beam evaporator**
  - Pt deposition
- **Lift-off to remove excess photoresist and metal**
- **Dewetting to create nano pores**





Etching

- On-going optimisation of etching parameters
  - Temperature
  - Time
  - Distance from HF-liquid interface



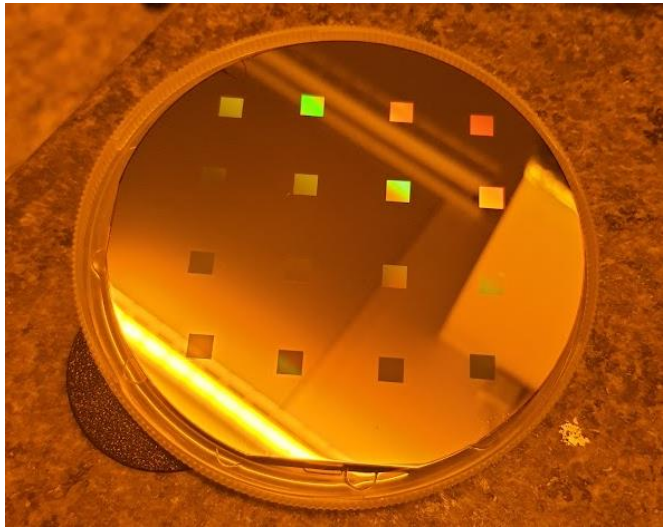
Remaining processing steps

- Trench filling
- Contact mentalisation

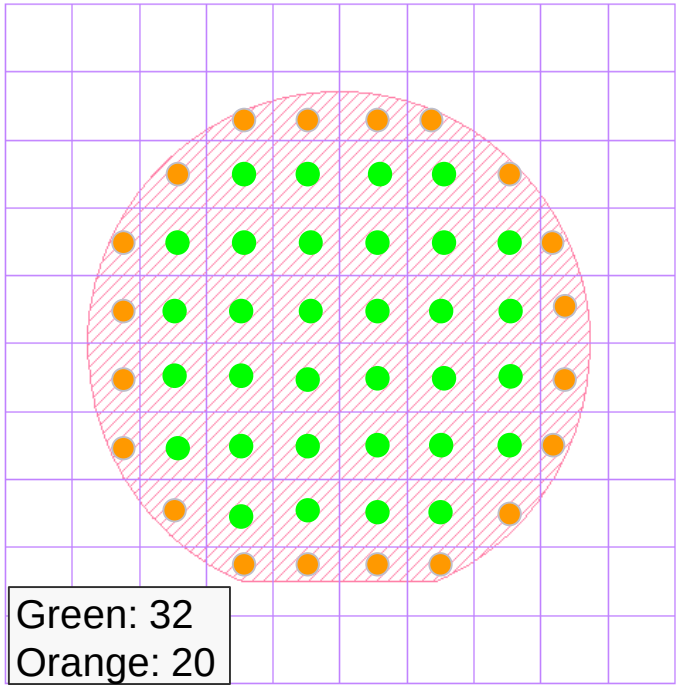
Upcoming steps

- **High resistivity wafer procured from CNM**
- **Process optimisation**
  - Etch rate comparison
- **Test several patterns**
  - Pad-, pixel- and strip-like geometries
- **First production to be completed after summer**

4” test wafer



6” high resistivity wafer



Fabrication using deep reactive ion etching

- **Project in cooperation with CNM.**
- **Awarded AIDA innova blue sky R&D grant for a demonstrator production**
- **Project has started**
  - First design proposal beginning of July
  - Refining of simulations
  - Post-doc starts this summer
  - Production starts this autumn 2022
- **DRIE etching of pillars**
  - Deposit oxide and metal afterwards
- **Metal not in direct contact with the semiconductor**
  - Milder operation conditions for silicon
- **Process related constraints**
  - Scalloping

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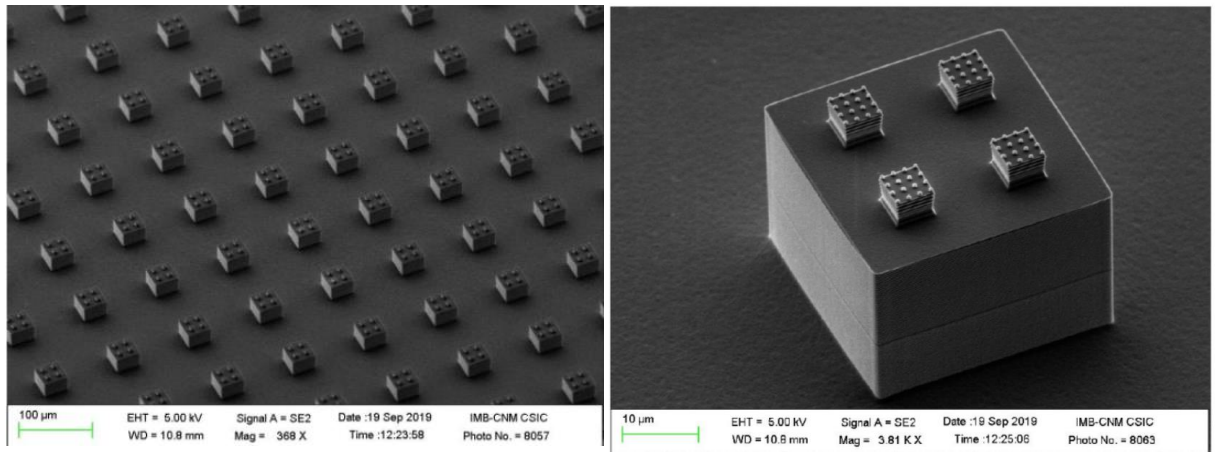
AIDA innova

[courtesy of CNM]



Conclusion

- **Two demonstrator productions are initiated**
- **MacEtch fabrication is well advanced**
  - Last process optimisation steps remains
- **Fabrication using DRIE is progressing**
- **After productions:**
  - Electrical characterisation