

SUPERCONDUCTING DETECTOR FABRICATION CAPABILITIES AT ARGONNE



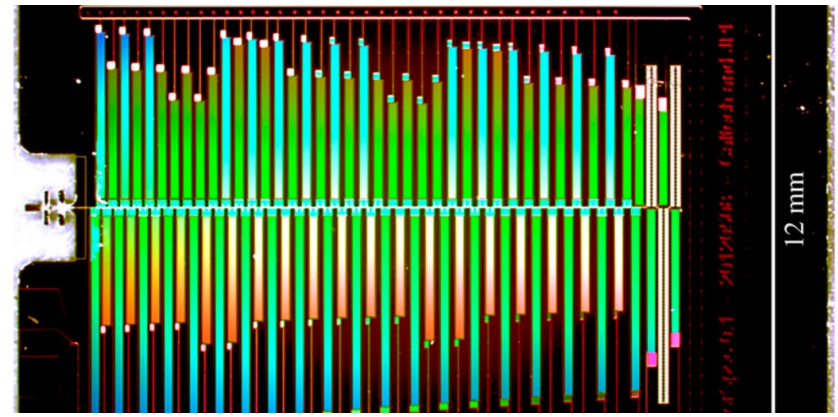
TOM CECIL

SUPERCONDUCTING DETECTORS

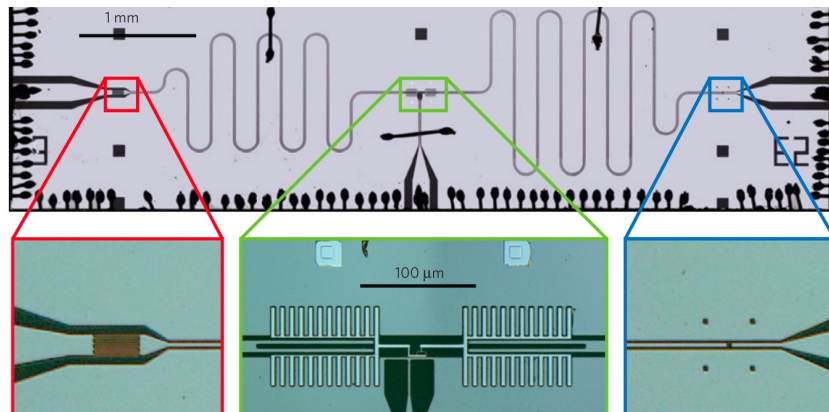
Lots of different types and applications



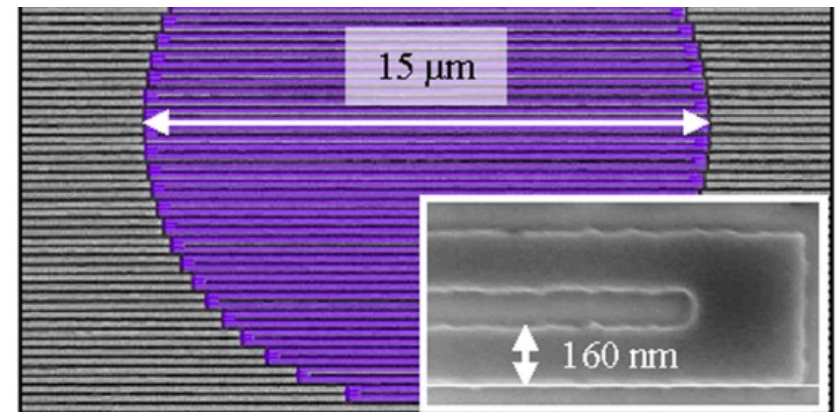
TES – CMB / XRAY / Gamma Ray



Resonator¹ – KID / Qubit readout / TES readout



Josephson Junction² – Qubit / SQUID / Mixer / Para-amp



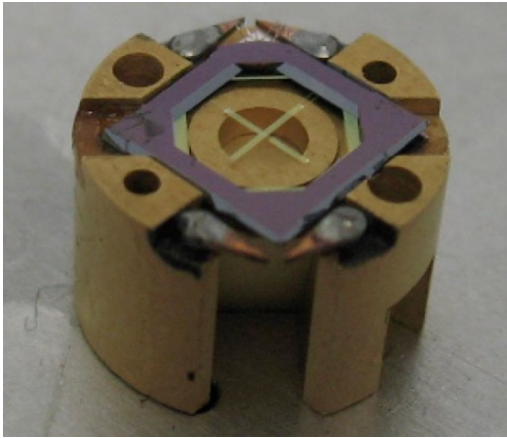
Nanowire³ – Single Photon Detection / LIDAR / Space communication

1: *J. Low Temp. Phys.*, vol. 176, no. 5–6, pp. 657–662, 2014.

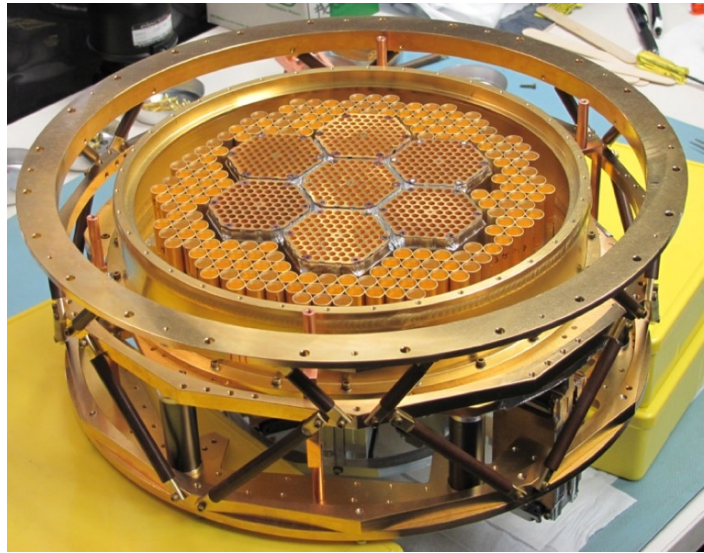
2: *Nat. Phys.*, vol. 6, no. 9, pp. 663–667, Sep. 2010.

3: *Opt. Eng.*, vol. 53, no. 8, p. 081907, Jun. 2014.

ARGONNE DETECTOR EXPERTISE MATURED THROUGH SOUTH POLE TELESCOPE PROGRAM



SPTpol camera
(2012-2017)



Physics World Breakthrough of the Year 2013

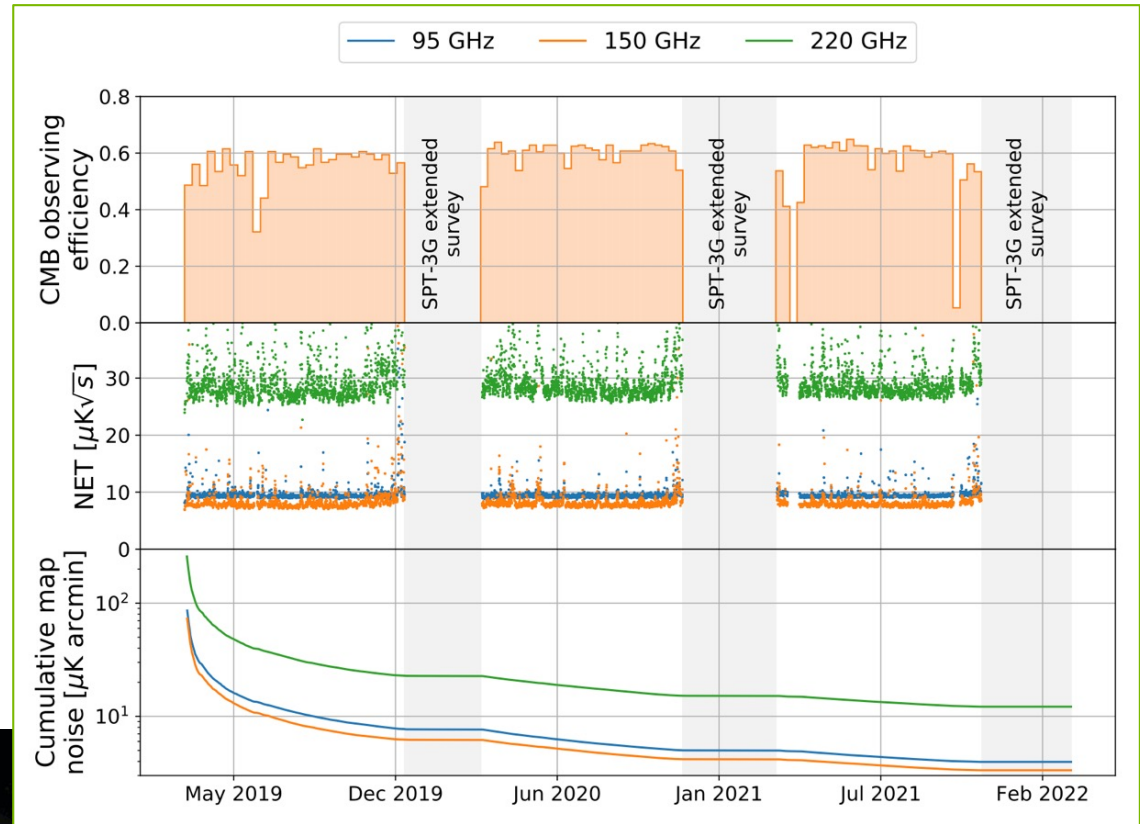
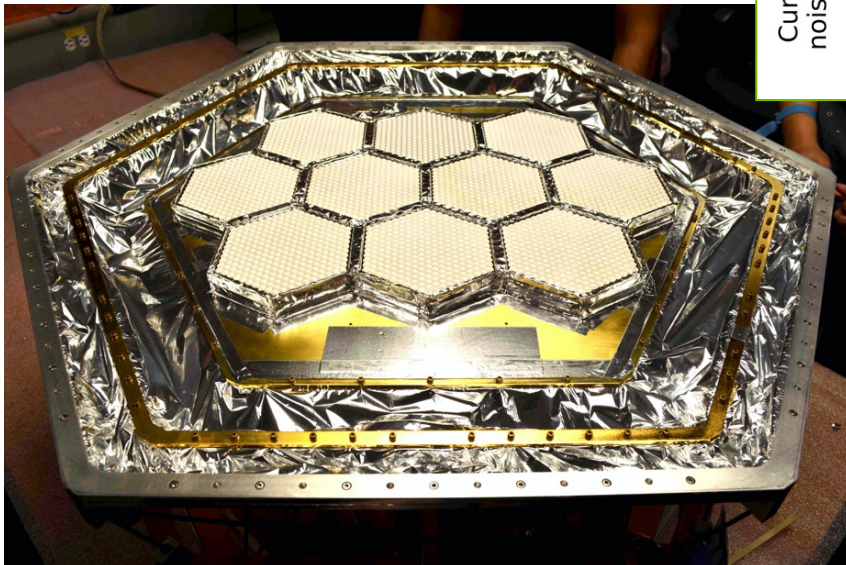
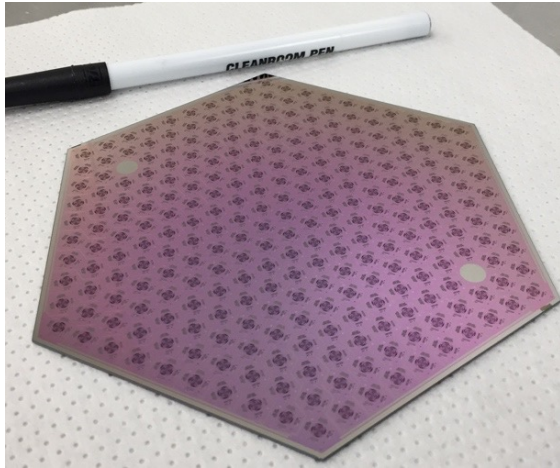
A *Physics World* Top 10 Breakthrough of the Year is awarded for physics research published in 2013 and the decision is based on the following criteria:

- Fundamental importance of research
- Significant advance in knowledge
- Strong connection between theory and experiment
- General interest to all physicists

This is to certify that a *Physics World* Top 10 Breakthrough of the Year has been given to

The astronomers working on the South Pole Telescope
for being the first to measure B-mode polarization in the cosmic microwave background radiation.

SPT-3G (2017+)



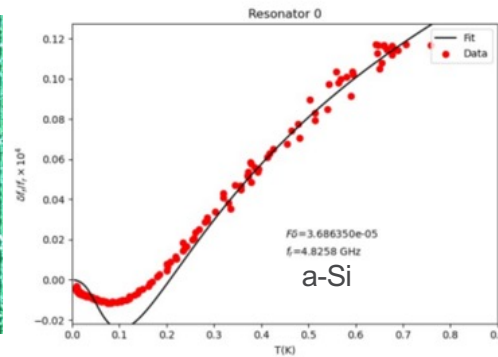
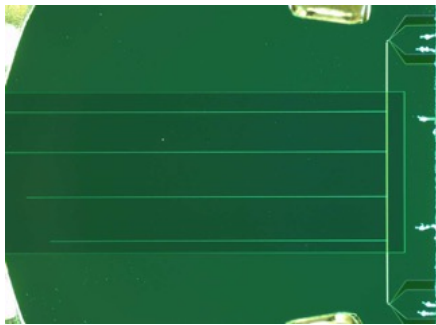
SPT-3G is a currently observing Stage-3 CMB camera.

- Performance is excellent and on-track to meet 5-year survey sensitivity goal

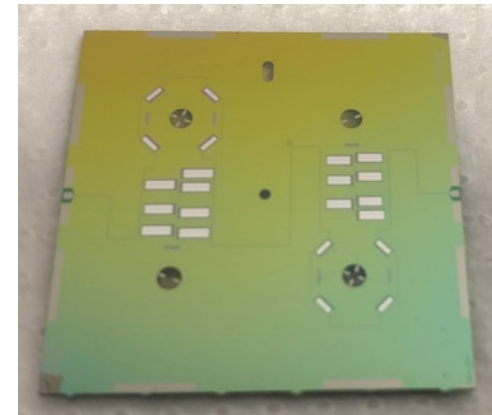
SPLAT forecasting for CMB-S4 is based off its performance.

SUPERCONDUCTING DETECTOR DEVELOPMENT AT CNM/ACR

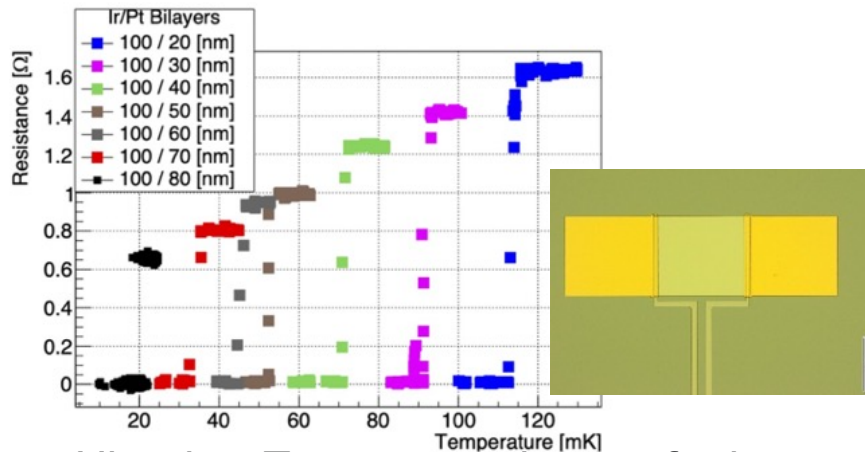
From basic materials research to full-scale detector arrays



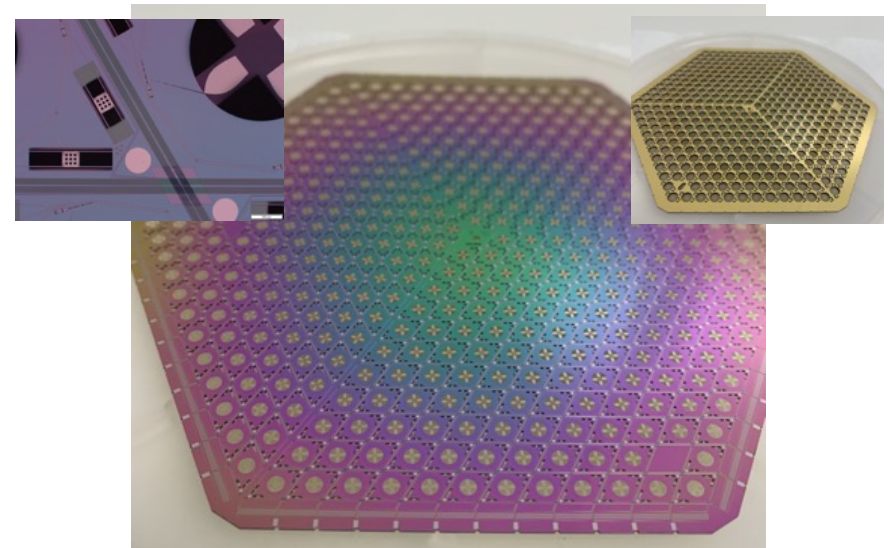
Low-loss dielectrics for microwave / mm-wave circuitry



Superconducting spectrometer prototype



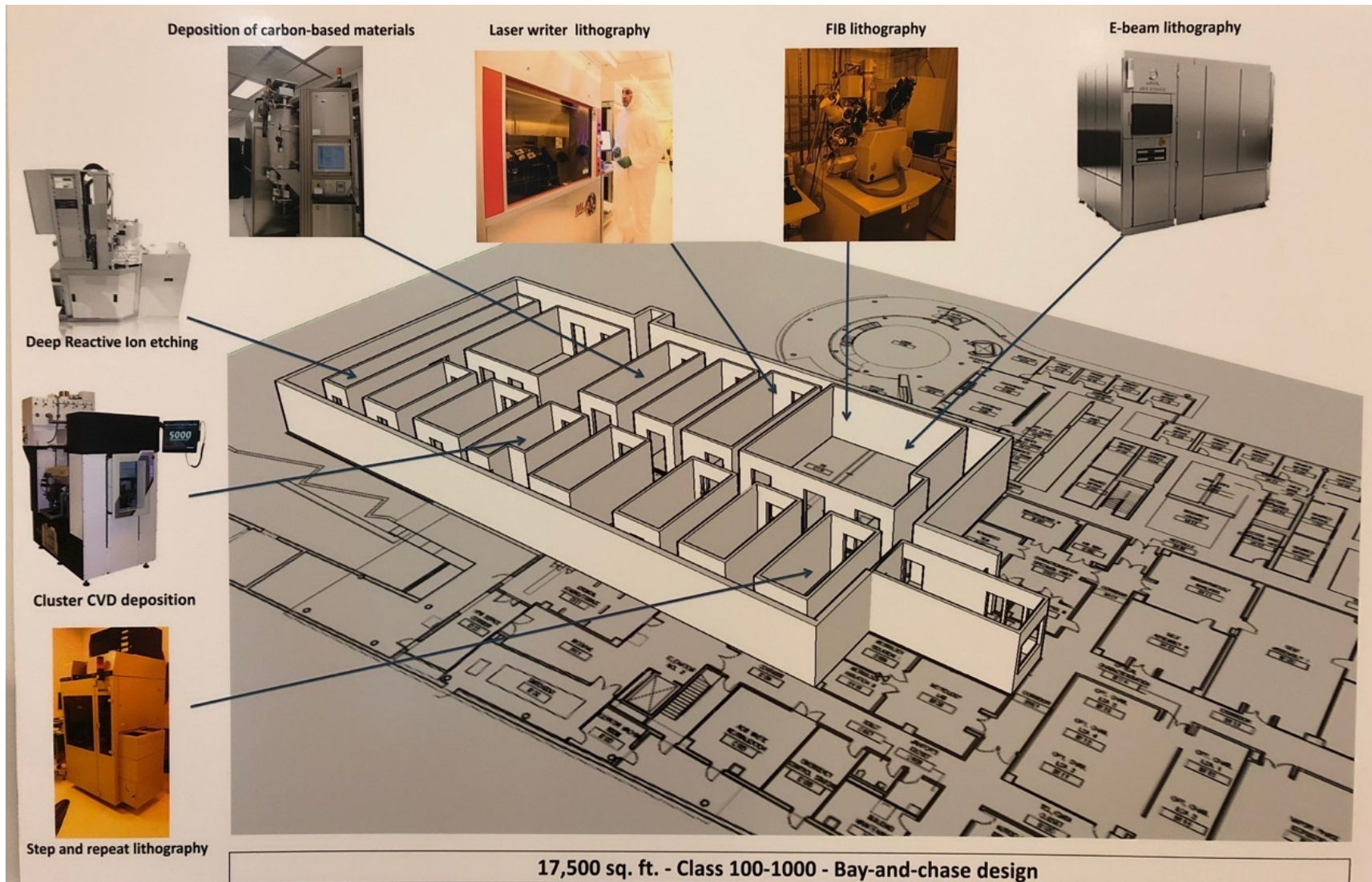
Ultra-low T_c superconductors for low-threshold detectors



CMB-S4 array

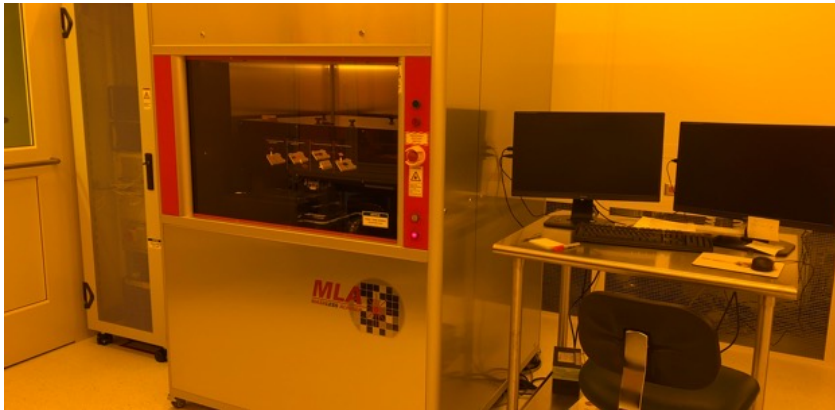
CLEANROOM FACILITIES

Specialized facility to meet equipment and cleanliness standards

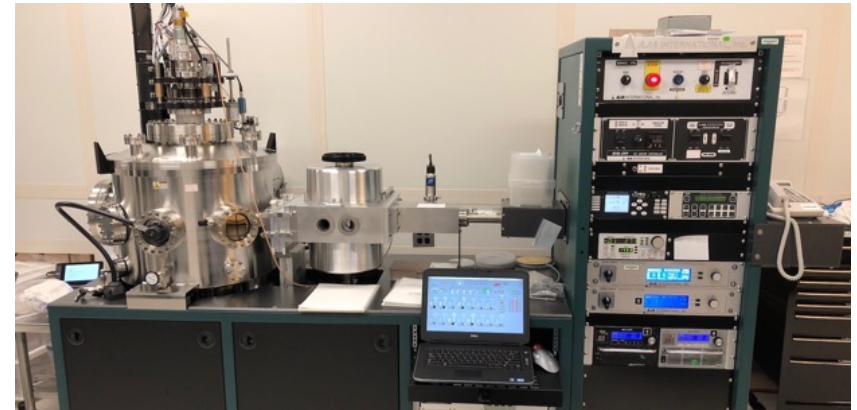


SPECIALIZED FABRICATION EQUIPMENT

Common processes enable fabrication of wide range of detectors



Photolithography



Material Deposition



Materials Patterning

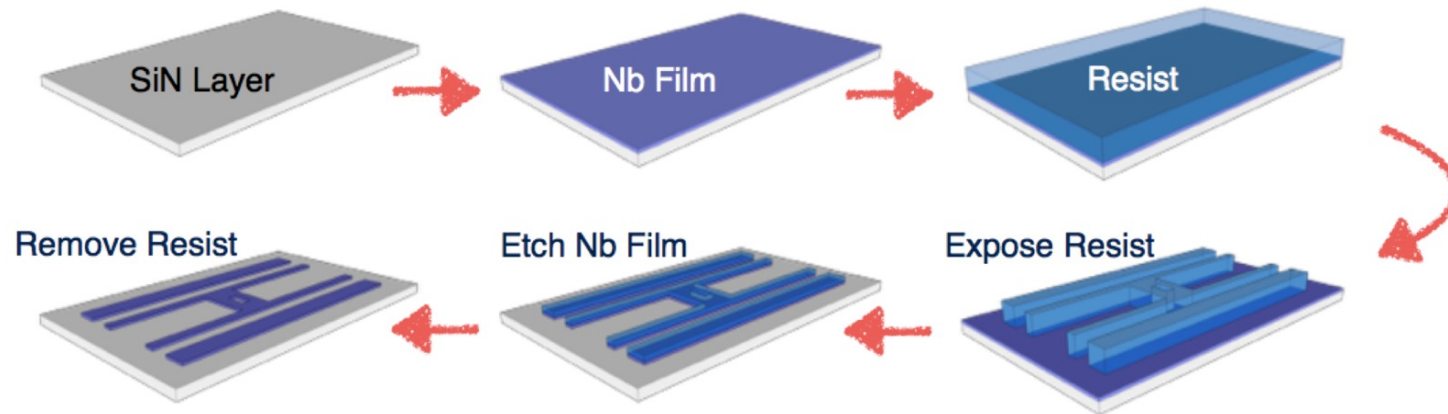


Characterization

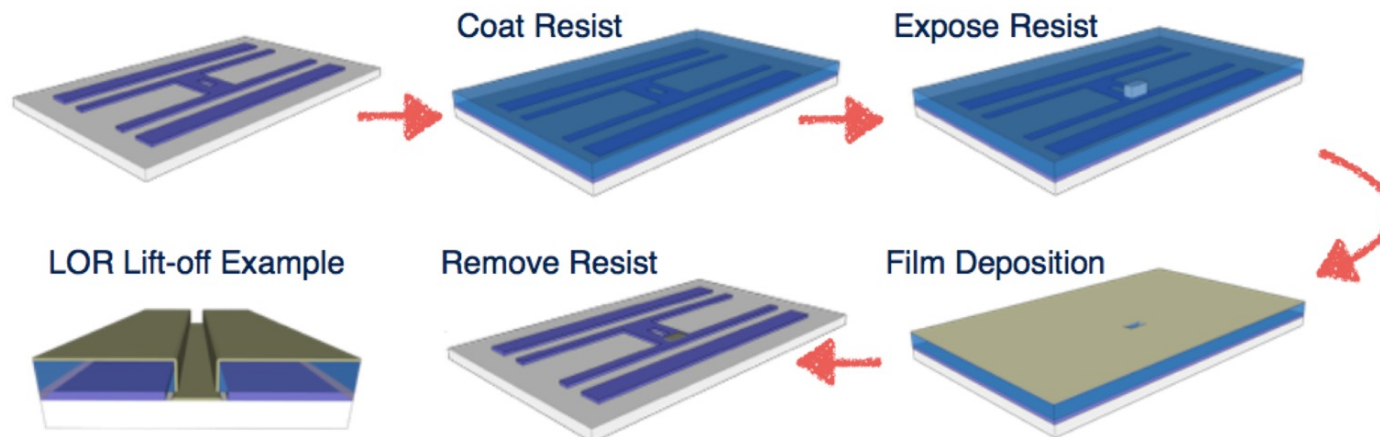
BASIC FABRICATION PROCESSES

Layers consist of patterned thin films. Two techniques.

Etch

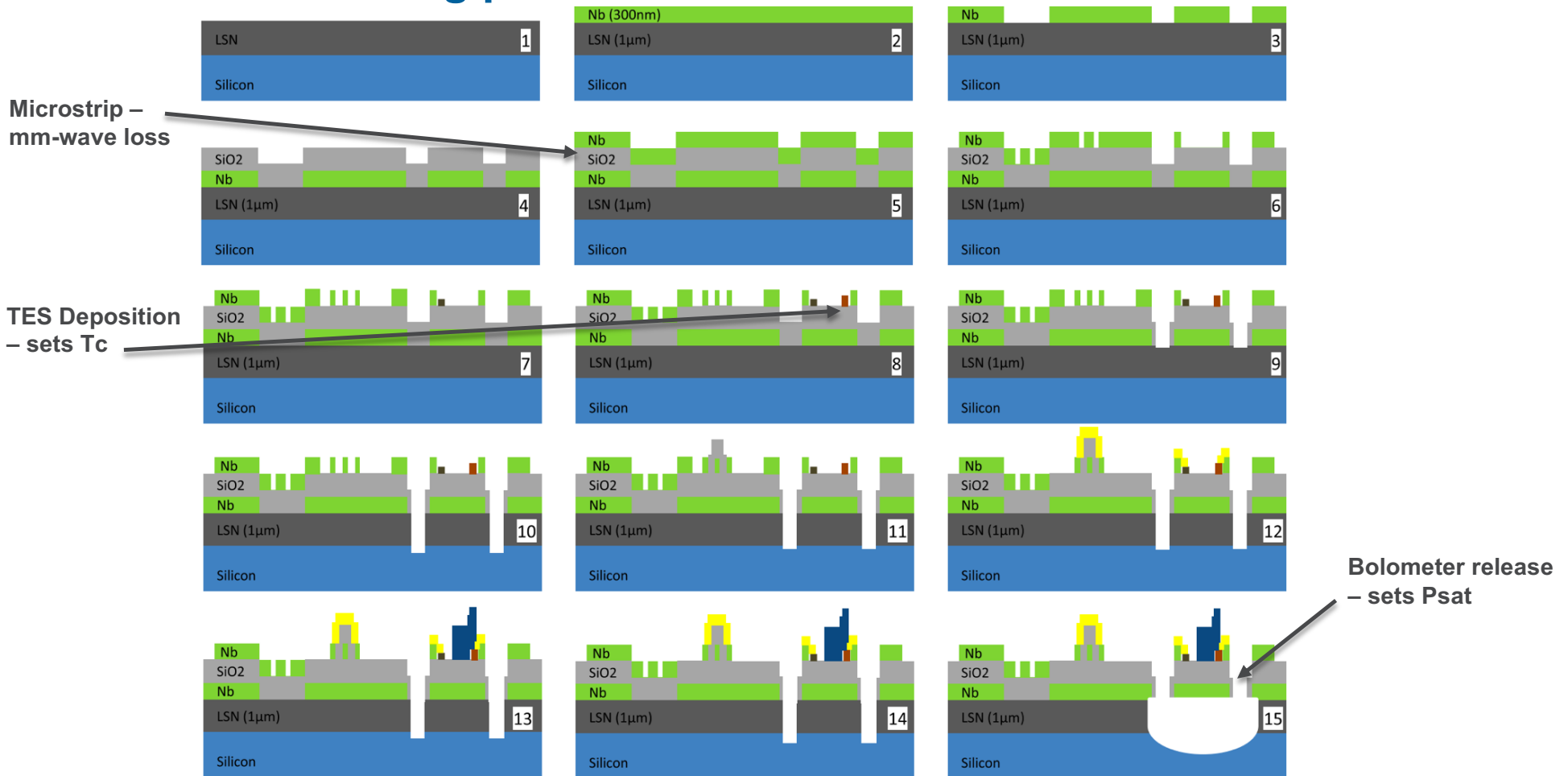


Lift-off



BUILD ARRAY THROUGH LAYERING

For SPT-3G full process has 15 steps requiring 18 stepper masks and direct write of wiring pattern. CMB-S4 is similar.



KEY TAKEAWAYS

- Superconducting detector array processing requires many process layers
- Direct connections between component performance and materials properties and fabrication processing
- Argonne has the facilities and staff to develop superconducting detector arrays that enable cutting edge science

