Metal Micromachining Team

SAND2019-3583PE

EPICs

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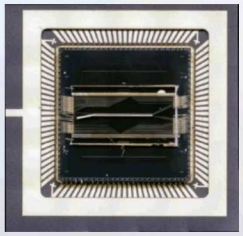
Metal Micromachining Team

MMT - MESA Light Labs

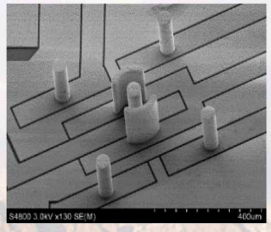
Lab #1 – Lithography



Lithography

- EPICS Ion Trap (Lithography on optical coatings)
- mm thickness range
- Can be electrofilled
- Micromolding or cast w/ PDMS
- Accommodates topography
- Polymer or glass

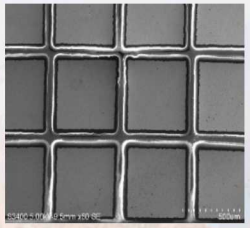
Lab #2 – Electroplating



Electroplating

- LIGA Stylus Ion Trap
- 2.5D structures
- Precision coatings
- Magnetic materials
- Insulating materials
- Conductive polymers
- >10:1 aspect ratio
- Multi-layer

Lab #Planarization



Planarization

- Improved R_a 1.46 → 0.07 µm
- R_a as low as 50nm
- Wafer/die thinning
- Provide flat/parallel surface for processing
- Beveled edges
- Vacuum, pad, wax mount

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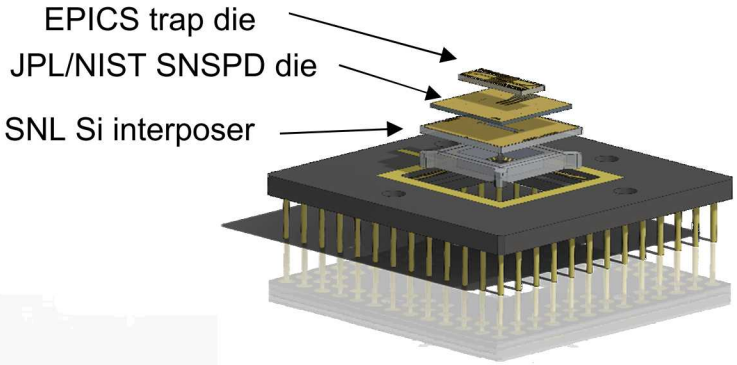
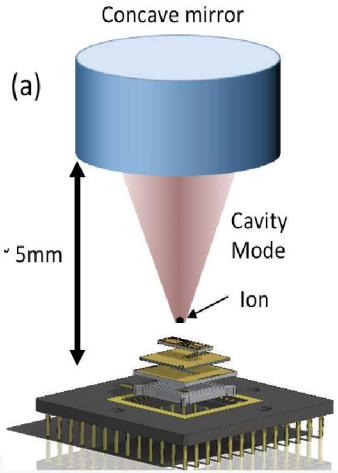
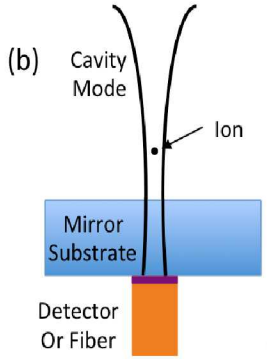
Generation 3 integration

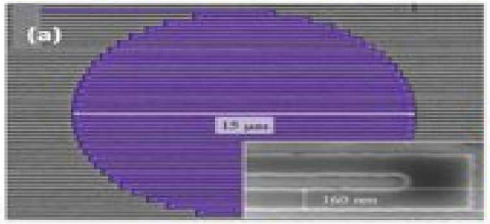
Ion Trap Fabrication (Duke/SNL)

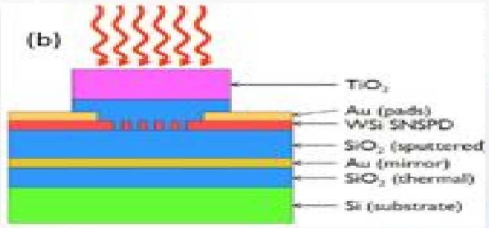




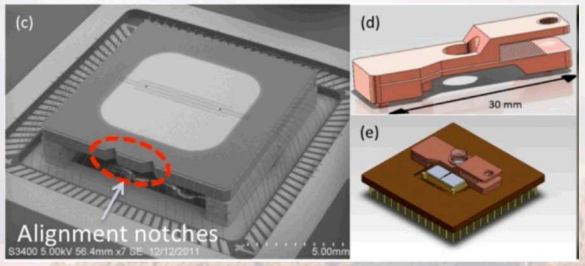


SNSPD Detector Development & Integration (NIST/JPL)





Optomechanical Integration (Duke/SNL)



EPICS goal for generation 3 fabrication

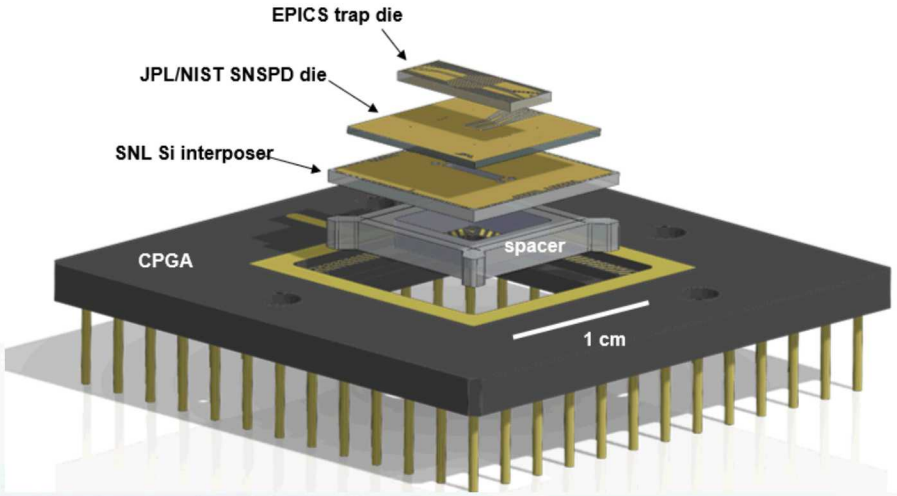


Figure 3: EPICs Ion trap integration model showing EPICs ion trap die, SNSPD dectector, interposer, spacer, and CPGA.

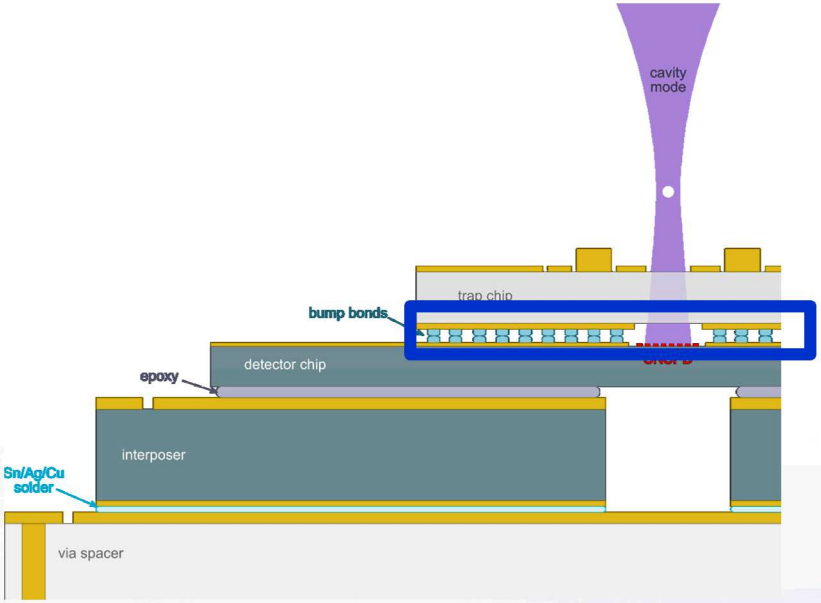
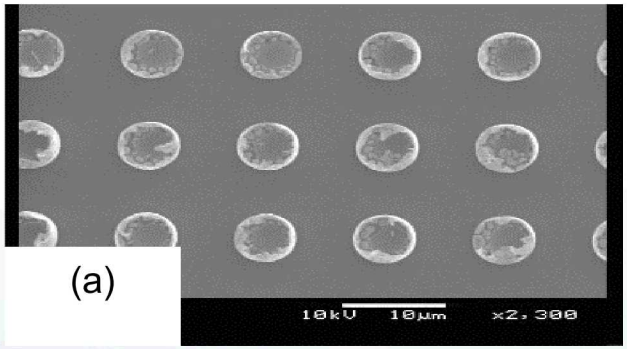
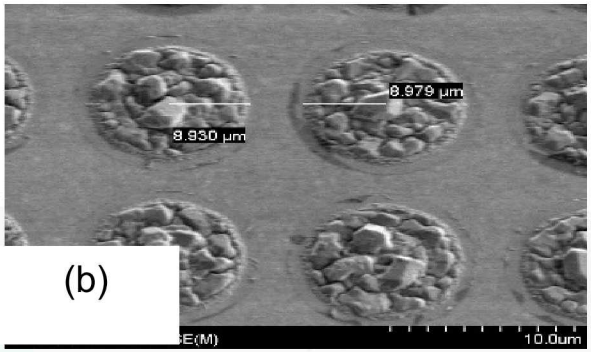


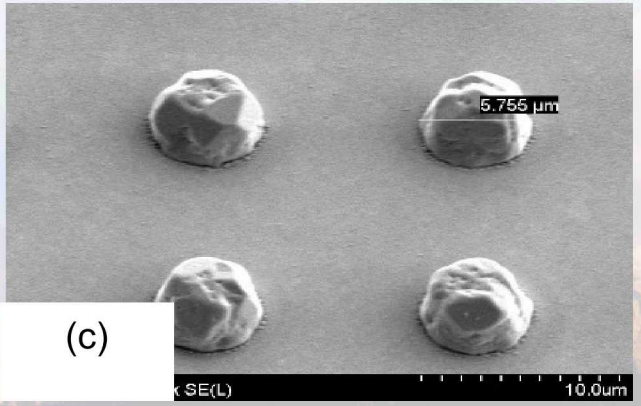
Figure 4: Generation 3 EPICs cross section view showing full integration of cavity mode, ion trap location, Sandia Trap chip, JPL/NIST SNSPD, interposer, and spacer.

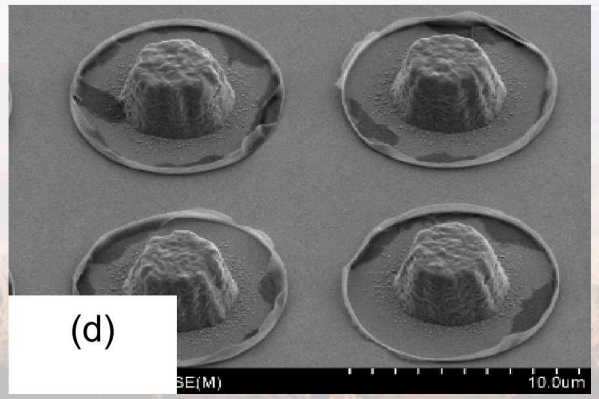
Indium bump progression

(a) Poor lithography
(b) Thin indium
(c) Sandia Indium in CHA tool
(d) Jet processing indium









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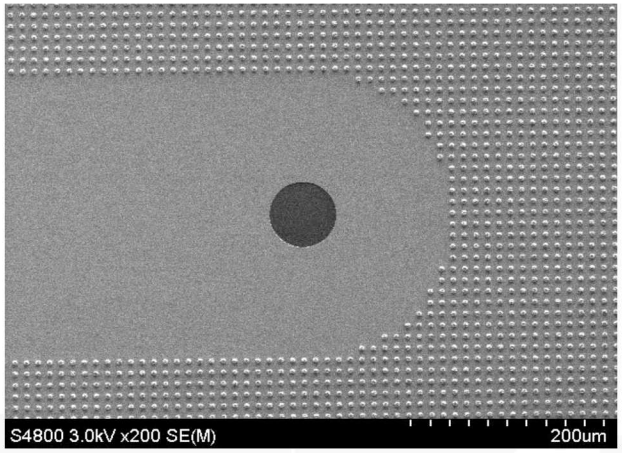
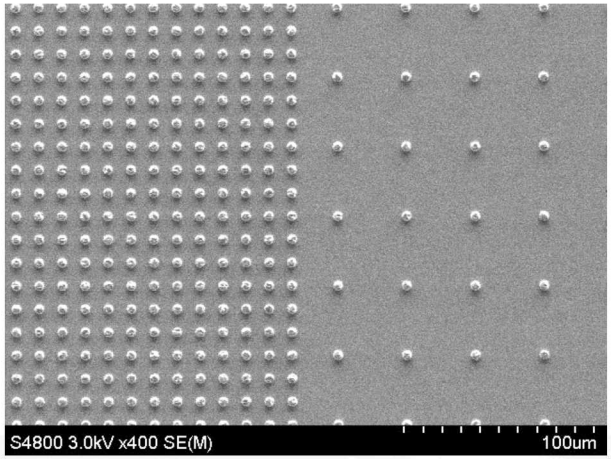
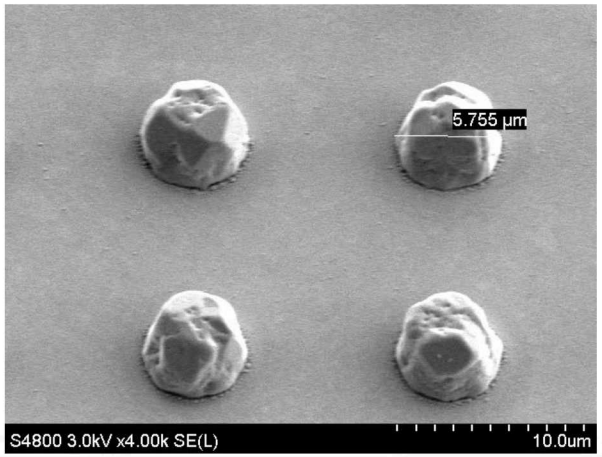
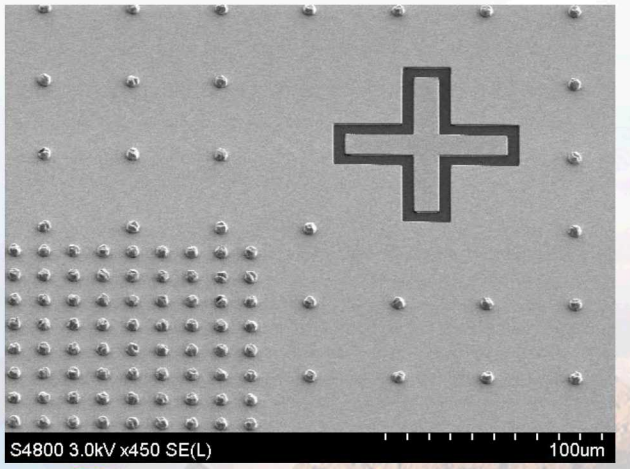
SNL CHA Indium bump deposition

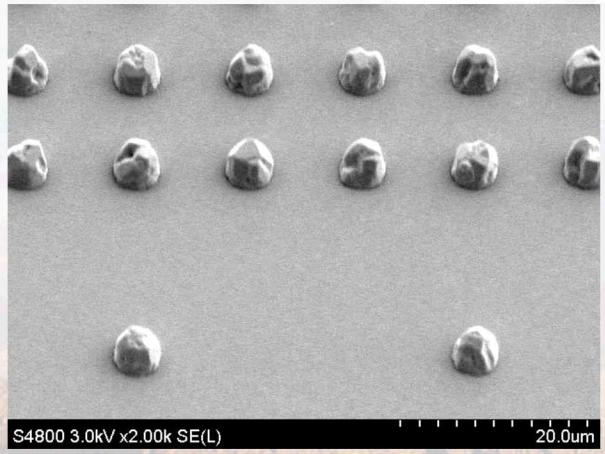
- CHA tool in Microfab
  - Processed only backside: layer 1 Ti/Au (100/5000 A°), layer 2 Ti/Ni/In (100/100/30,500 A°)

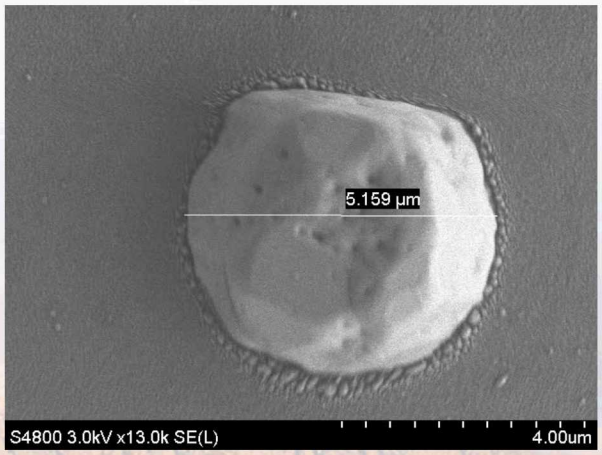












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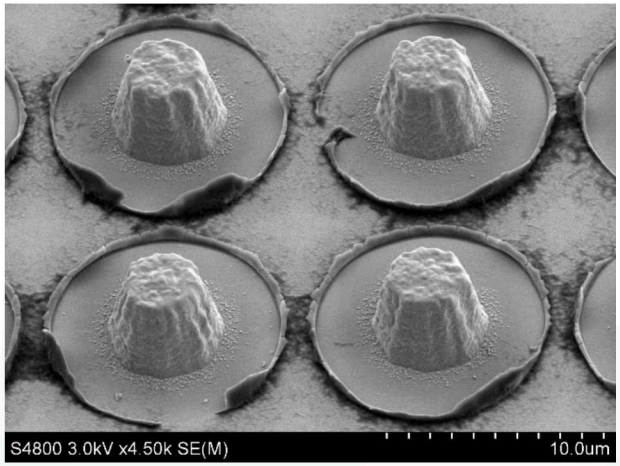
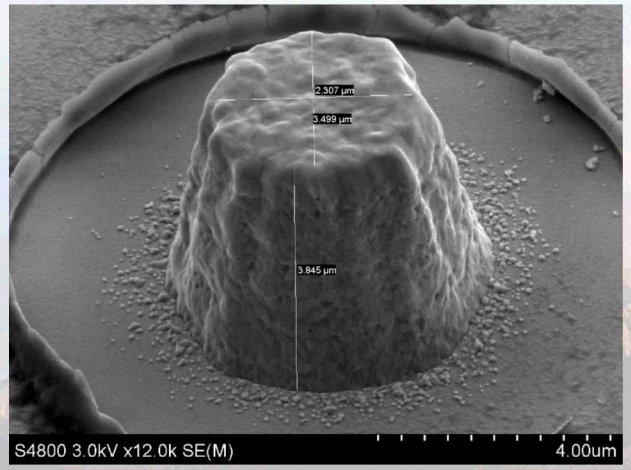
Jet Processing Indium in 2035 & 2070

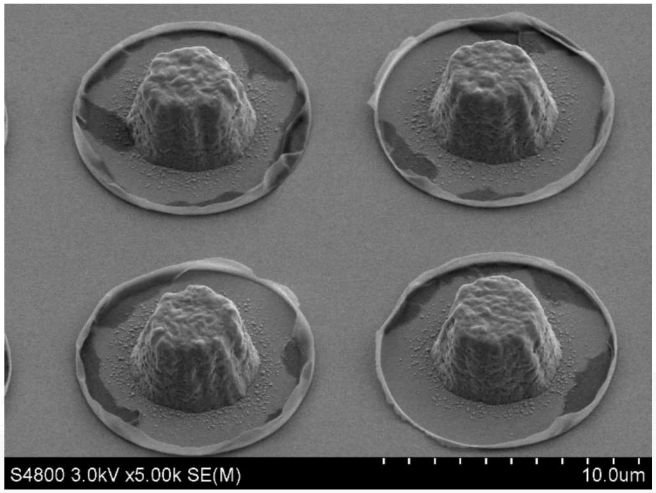
- 2035 and 2070 lift off requesting Ti/Ni/In 200/1000/30,000 A°

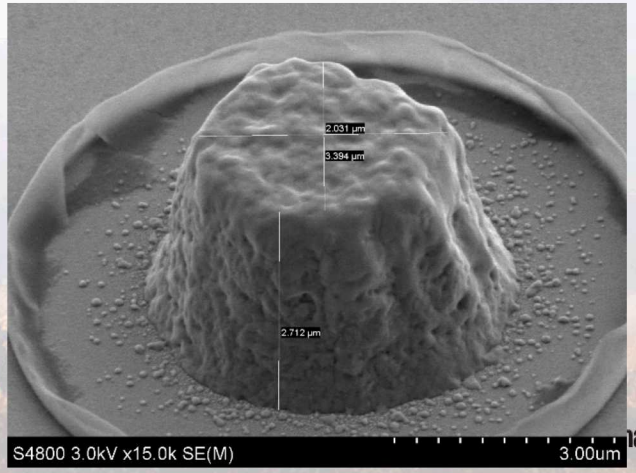
nLOF 2035





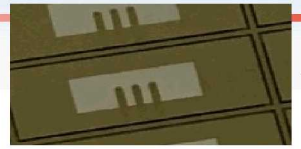
nLOF 2070

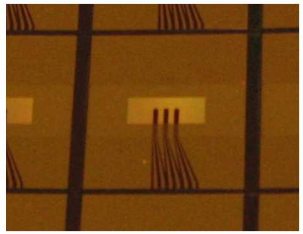


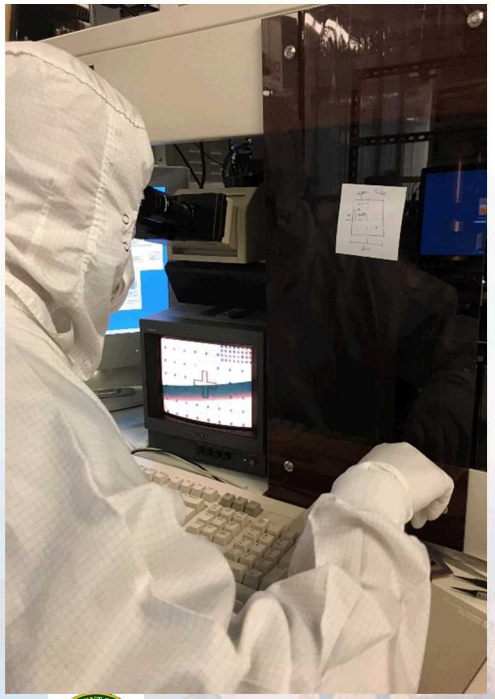


Indium bond testing

- Acetone, isopropanol clean
- Formic acid clean at Bond 135°C
- Bond 100°C and 10 kg force







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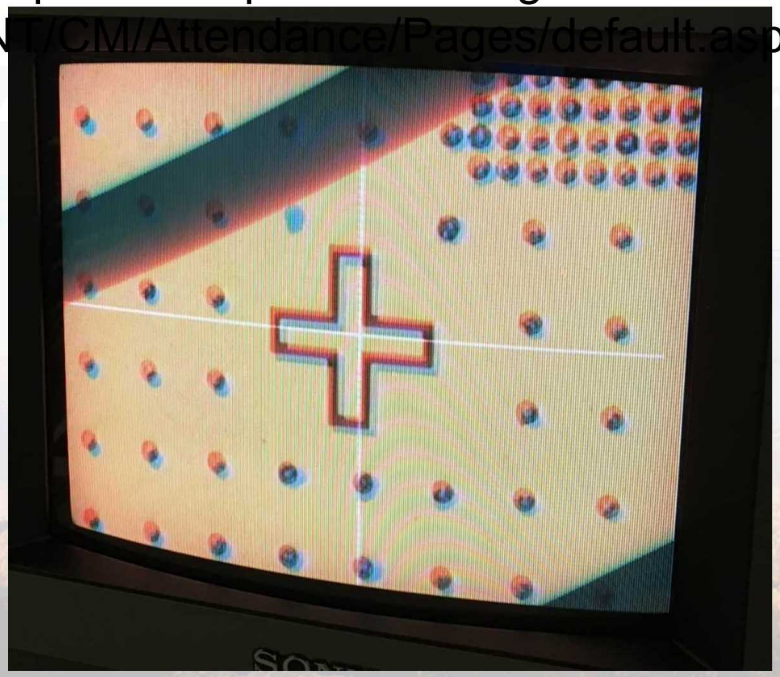
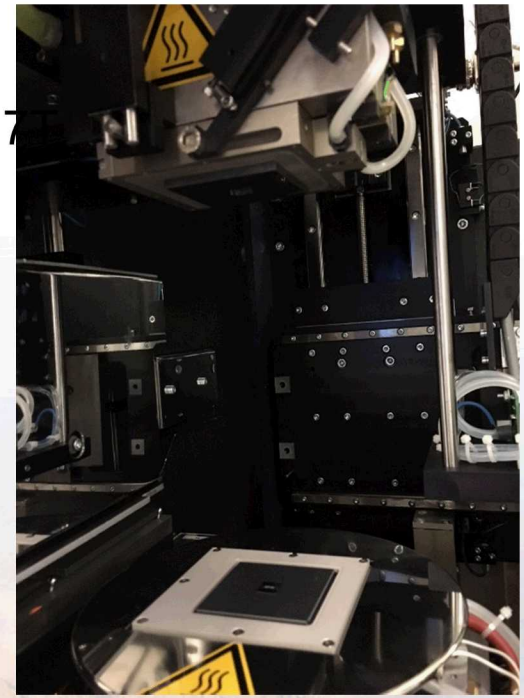
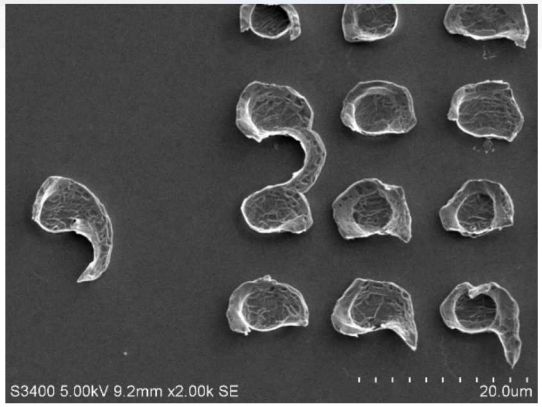
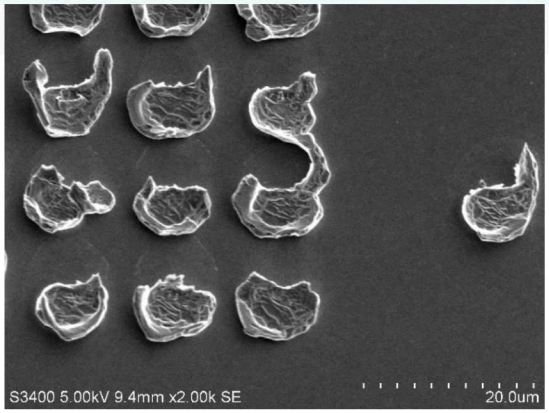
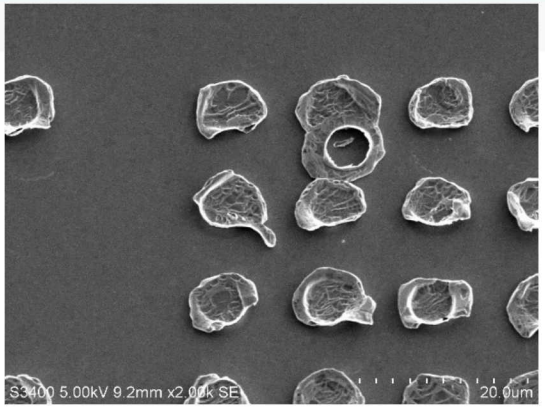




Indium bump bonding

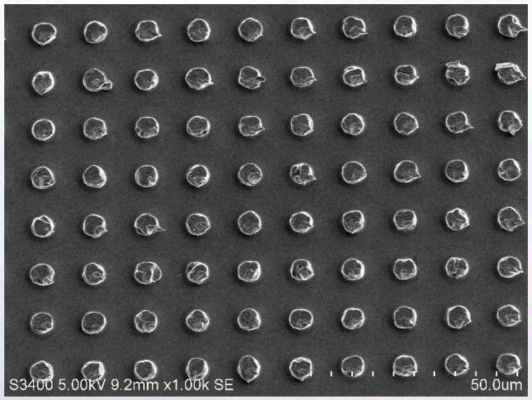


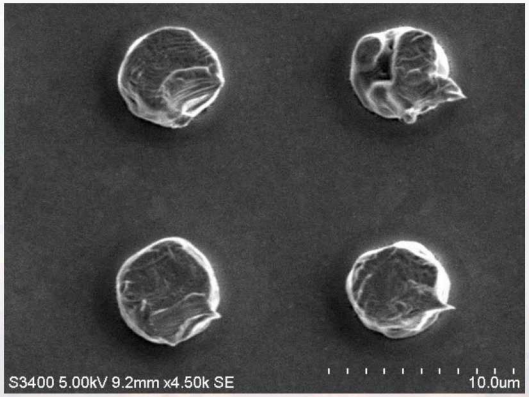




Corresponding sites of bonded die

Corresponding si





Uniform deformation observed on all or the majority of indium bumps

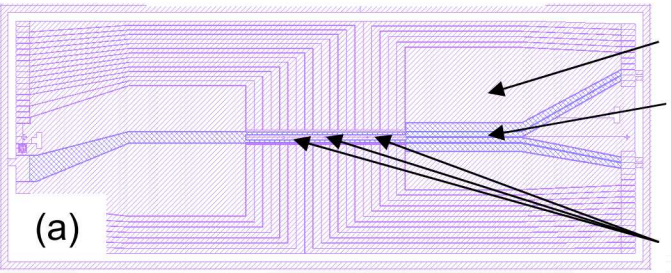
- **Uniform bumping obser**
- **Further uniformity and b evaluation in progress**
- **Taffy pull characteristic debonding the two piece**

*** SNL die 6 bonded to 9 at 100C and 10kg-force after a formic acid reflow at 130C**

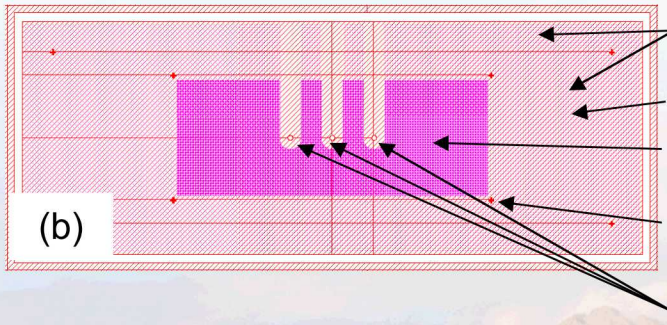
Generation 3 EPICs fabrication

CAD Layout

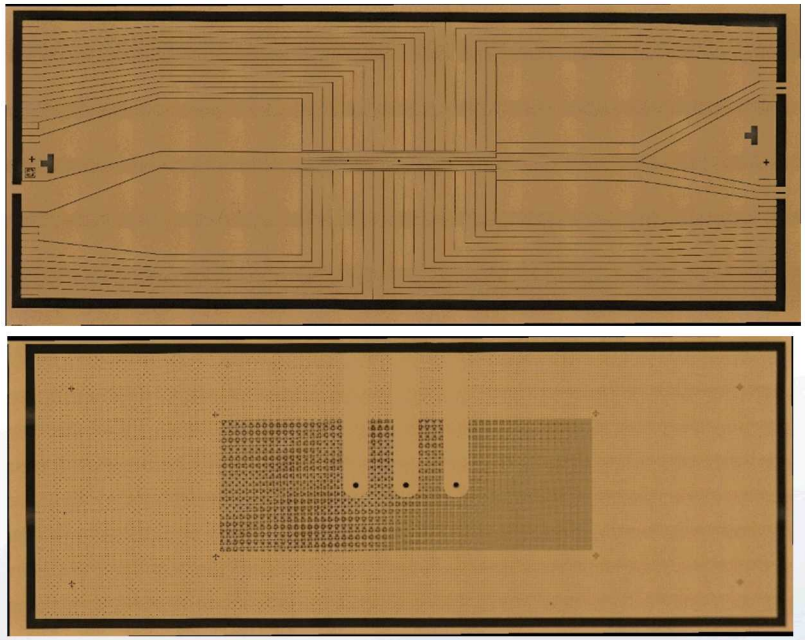
Top of Sandia Trap



Bottom of Sandia Trap



Microscopy image



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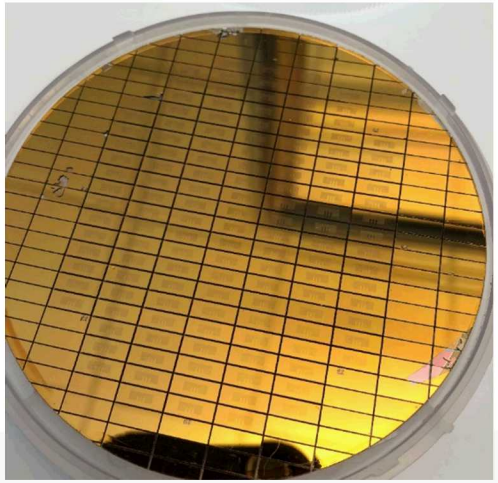
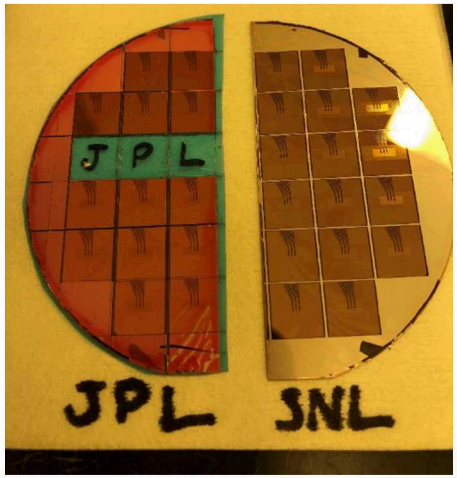
7000 ppm wafer and SNSPD JPL/SNL indium ½ wafer

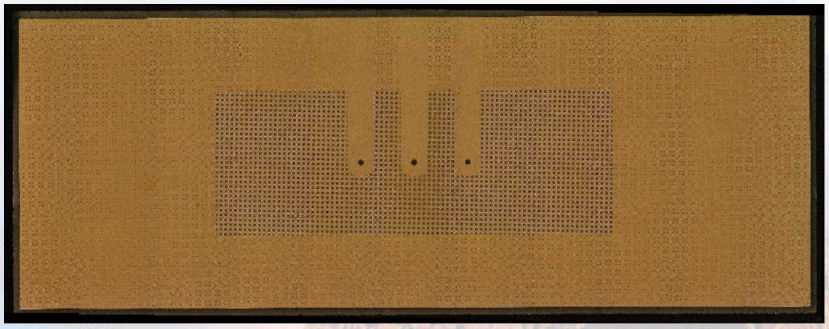
Front side SNL trap fabrication



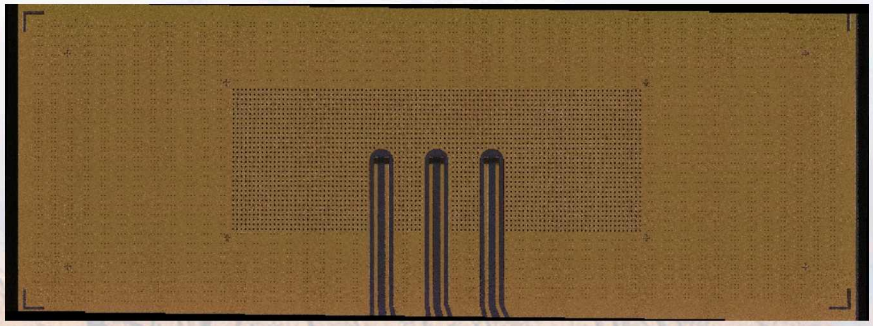
SNSPD JPL & SNL Indium



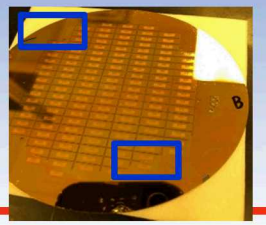
SNL device die



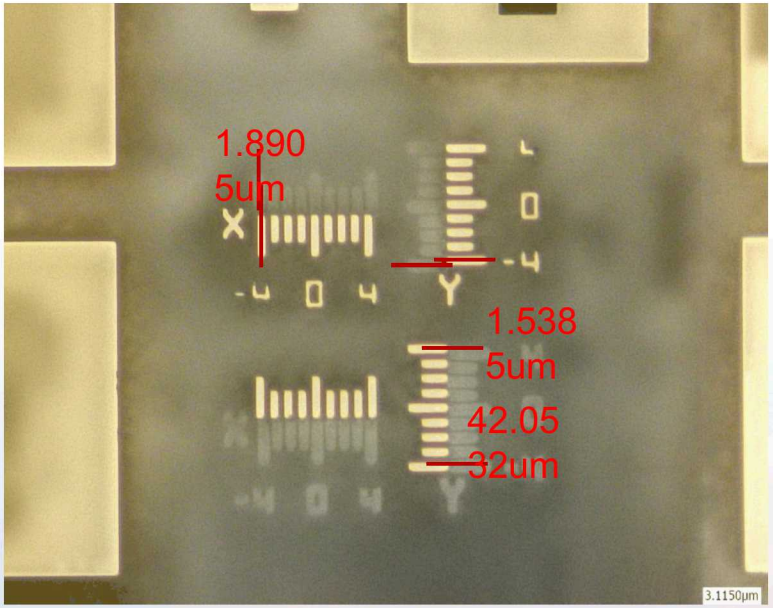
JPL device die



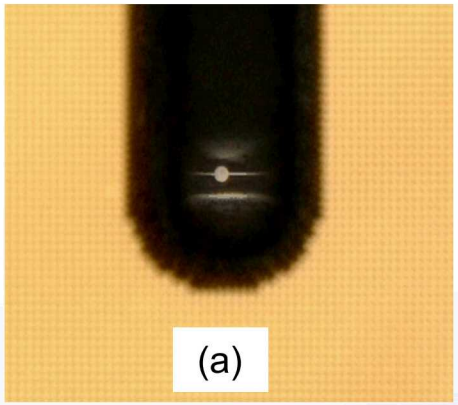
Alignment

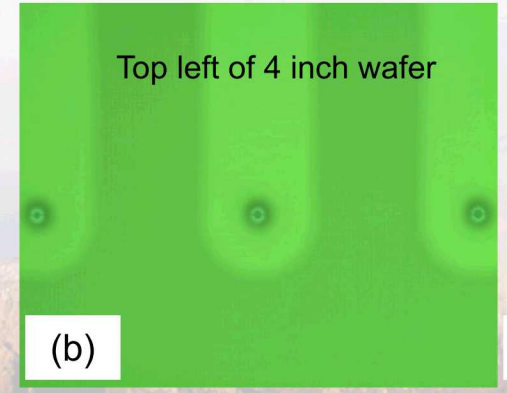


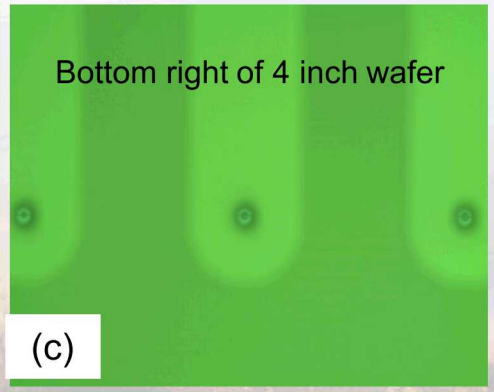
- Tested alignment on test substrates
- Confirmed ability to align +/- 2 micron



- 7000 ppm device substrate after full fabrication







SEM Images SNL trap chip

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SNL Deliveries

- Delivered 4 detector die packaged without trap for testing
- Delivered 4 generation 2 devices fully packaged

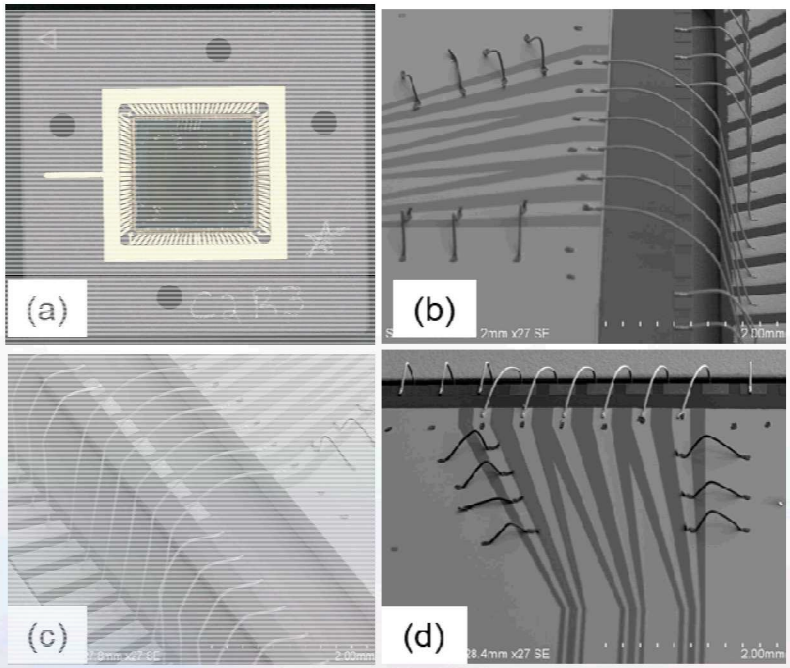

Figure 1: (a) top view of a packaged SNSPD delivery to Duke (b,c,d) SEM side profile view showing wire bonding done to CPGA and to ground plan of chip

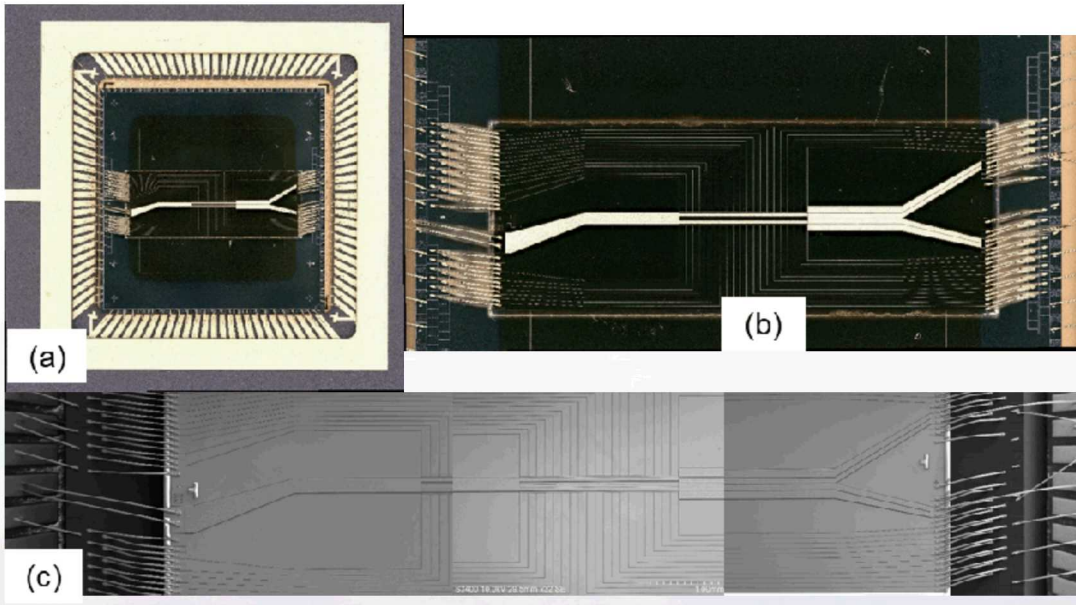

Figure 2: (a) top view of gen 2 packaged trap (b) magnified view of trap die (c) top SEM view of gen 2 trap