Silicon and Carbon Foam Low Mass Interposer

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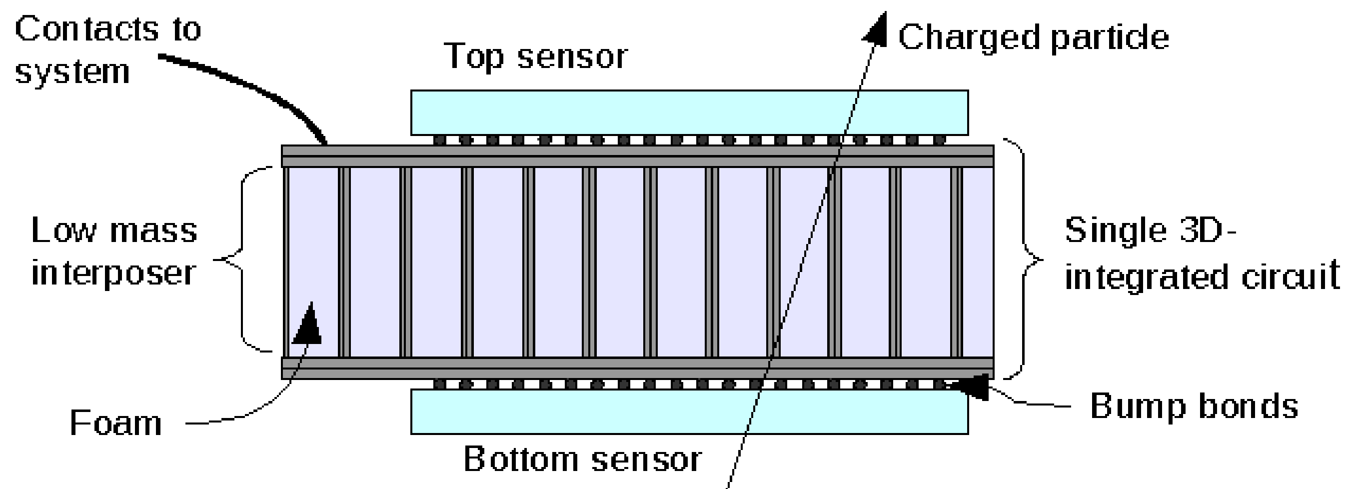
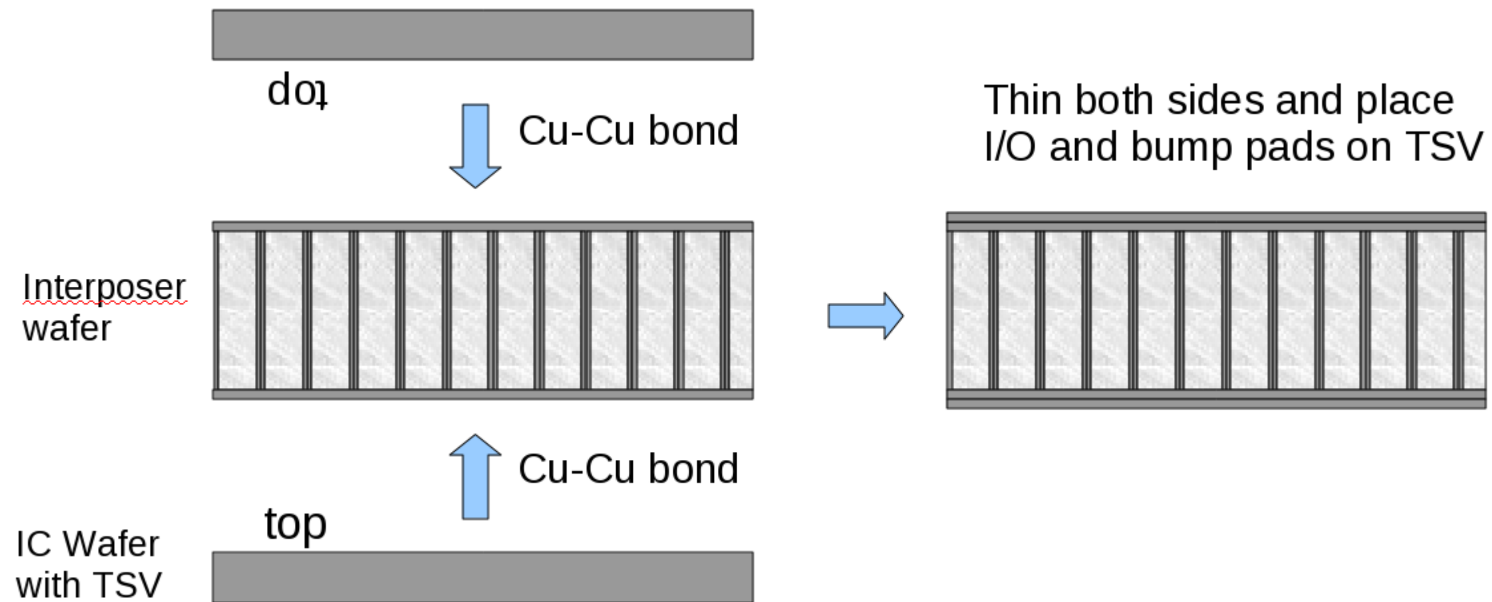
Initial Concept

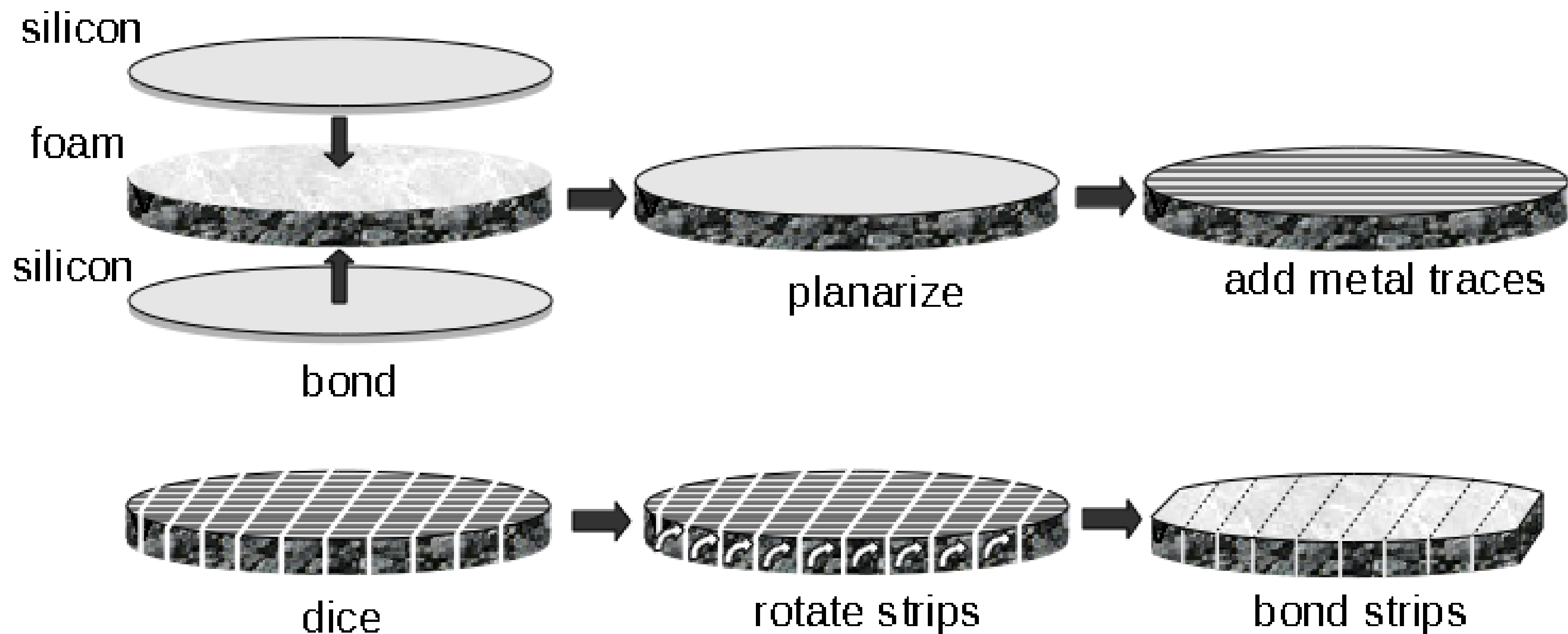
- Slightly different approach
- Make a very thick, 2-sided IC, then bump bond sensors on both sides, using flip chip same as now.



3D-Integration



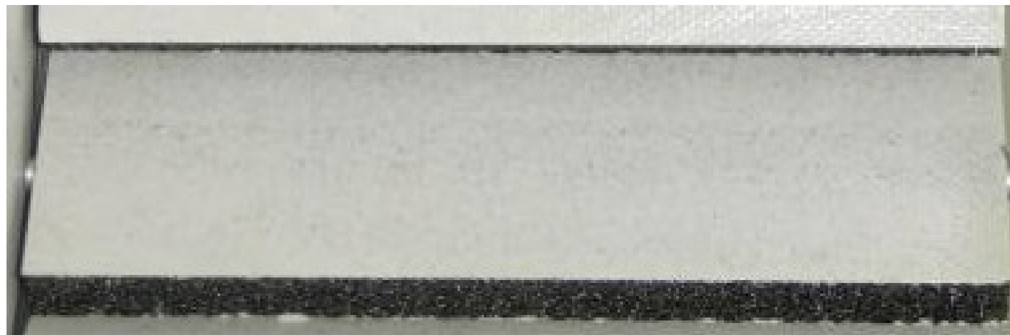
Construction Method 1



- Take advantage of carbon composite construction expertise
- Use copper traces to have part compatible with 3-D integration.

Method 1 Characteristics and Issues

- 4mm foam and 10um traces and spaces => 12.5 contacts/mm^2
  - Up to 50/mm^2 seems reasonable for this technique
- Use high temperature epoxy for assembly. Good to 350°C.
- For 0.1g/cc foam density and 50um thick silicon “lids”, 4mm thick interposer radiation length is equivalent to ~300um of silicon.
- Issue: would need to make 8” wafers to match electronics. Prototyping in 4”.
- Issue: surfaces of interposer are porous (exposed foam)
  - Can possibly fix with glue and another grinding step.

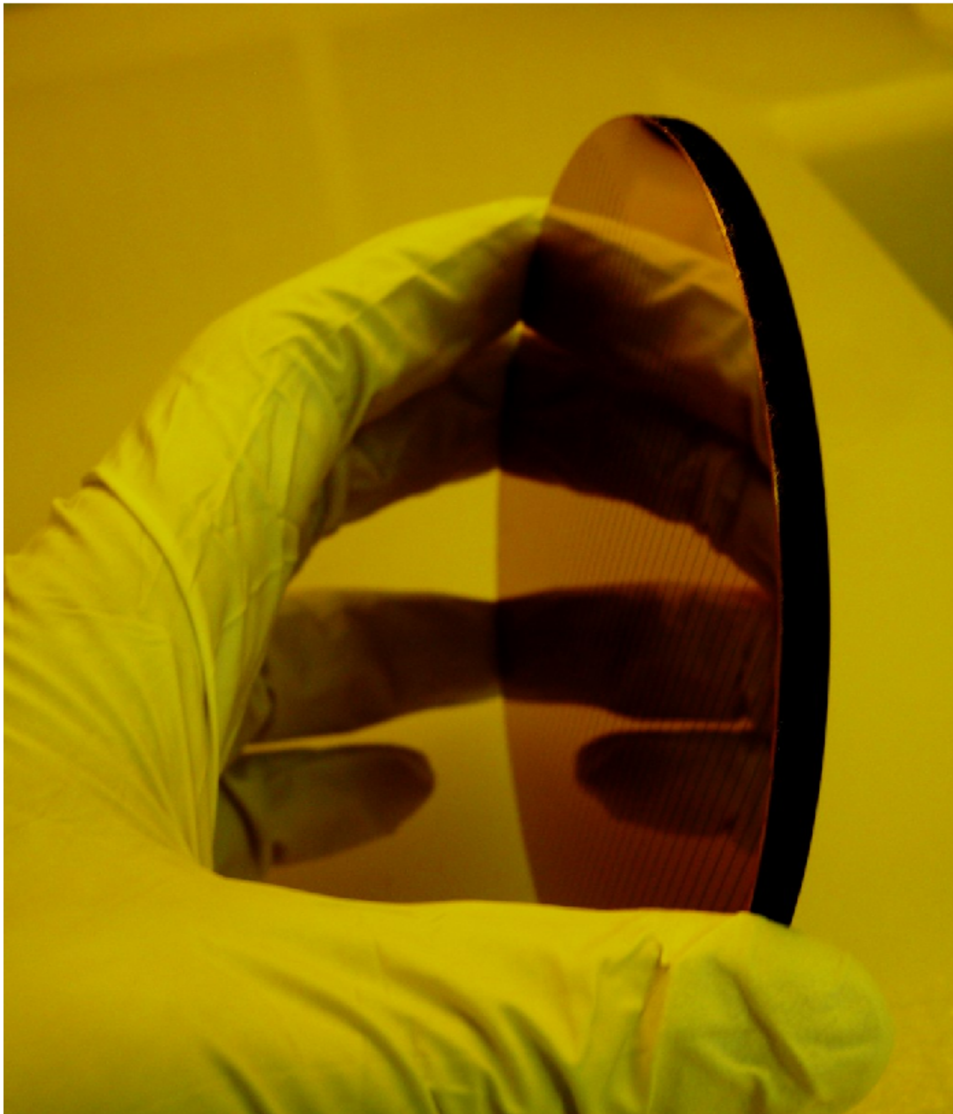


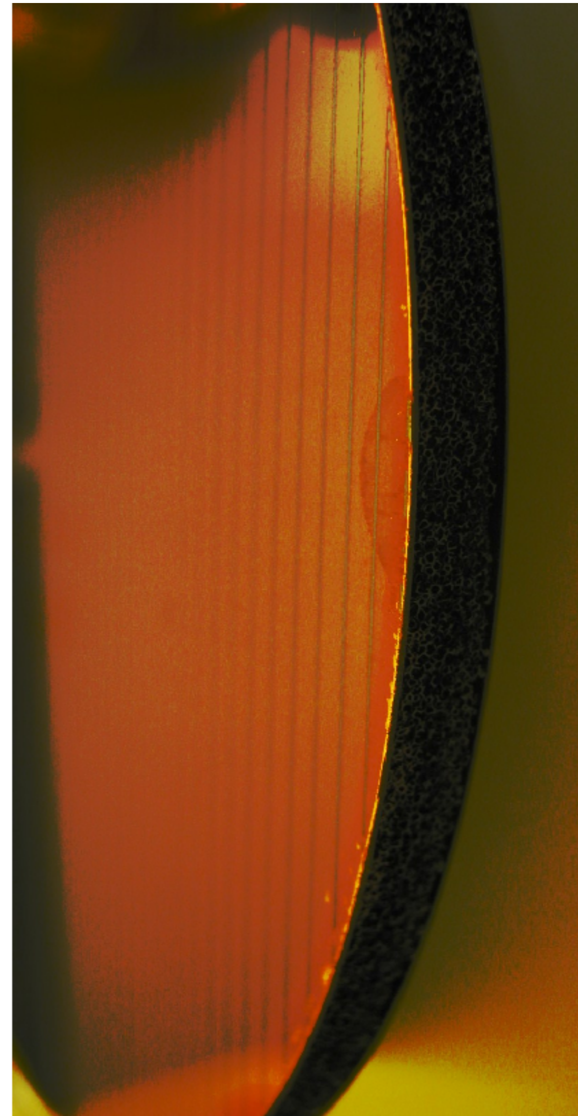
Foam coated with Thin layer of epoxy

Method 1 Prototyping Status

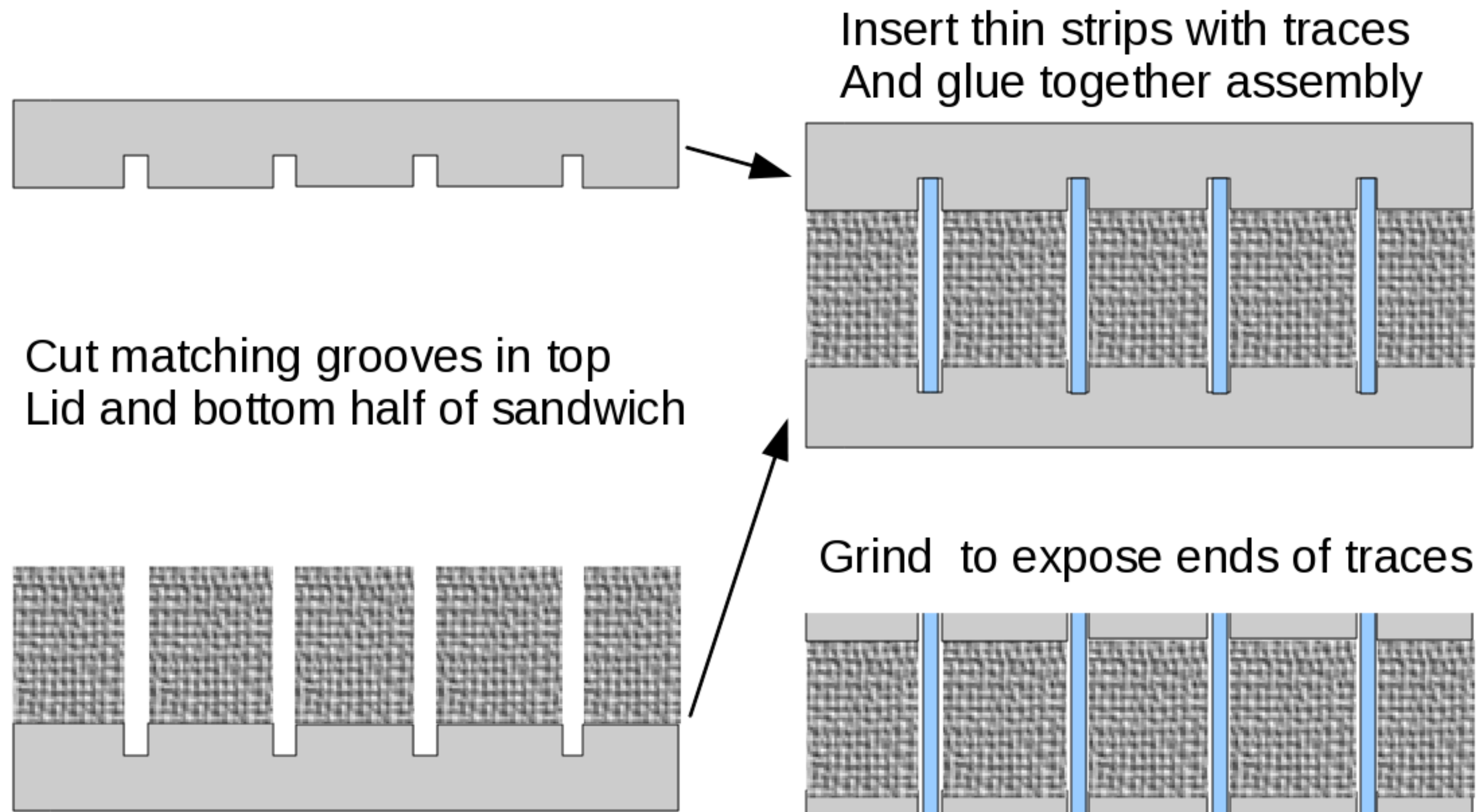
- Work in progress on mechanical prototype
- Fabrication of initial Si-foam-Si sandwich worked well. Planarity better than 25um over 4” wafer (4mm thick!) before any grinding.
- Did not grind. Used 250 um thick wafers and left them at that thickness.
- Successful sputtering of 2um Cu on sandwich assembly
- Etched very wide traces for this mechanical prototype. Would need to use lift-off, electroplating on a seed layer, or Damascene process to make thin traces on an electrical part.
- Demonstrated and tuned dicing of 4mm thick sandwich.
- Note yet done: gluing together of diced strips (wafer is now at dicing).

Method 1 Prototype (before dicing)





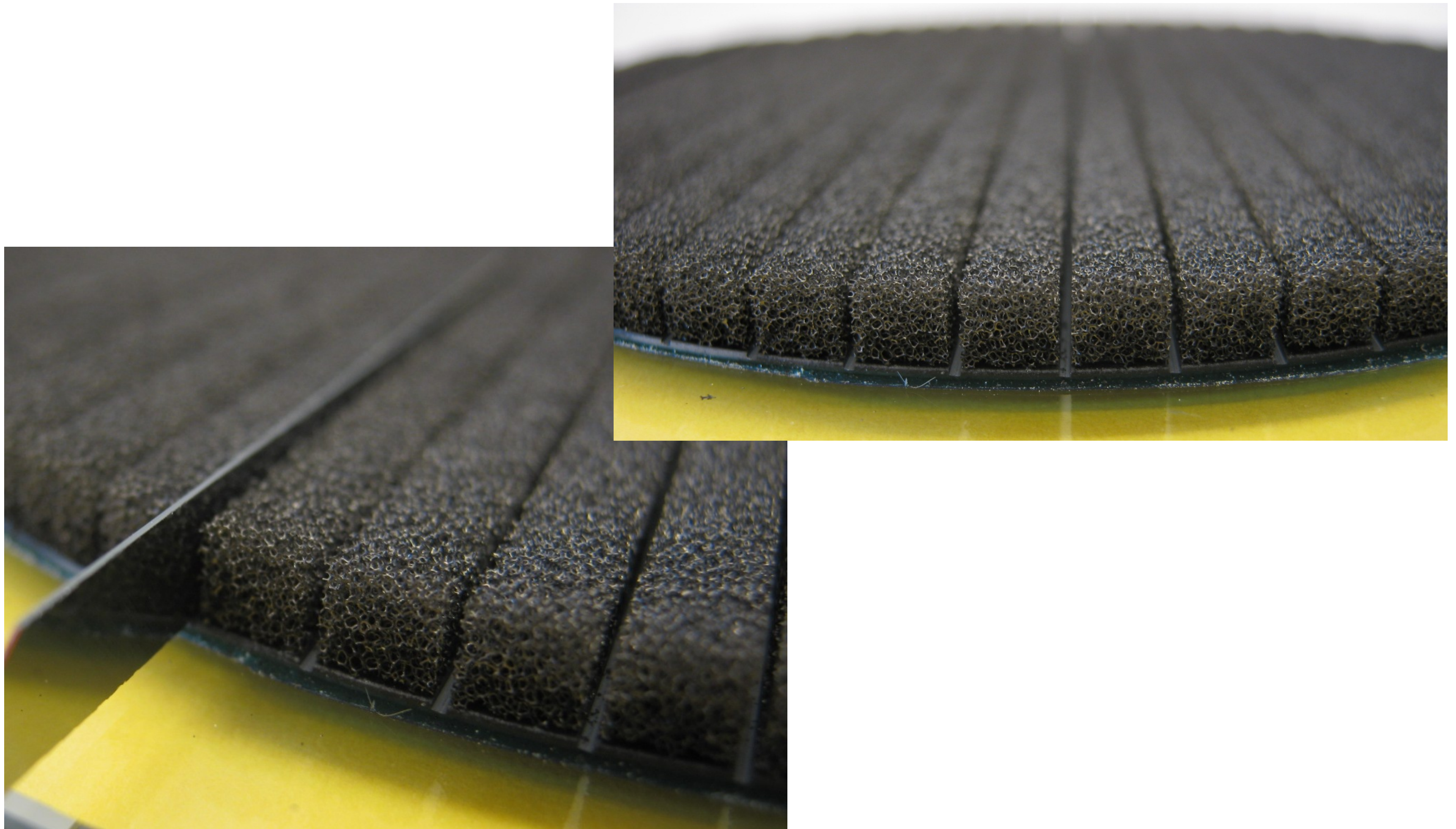
Fabrication Method 2



Method 2 Characteristics and Issues

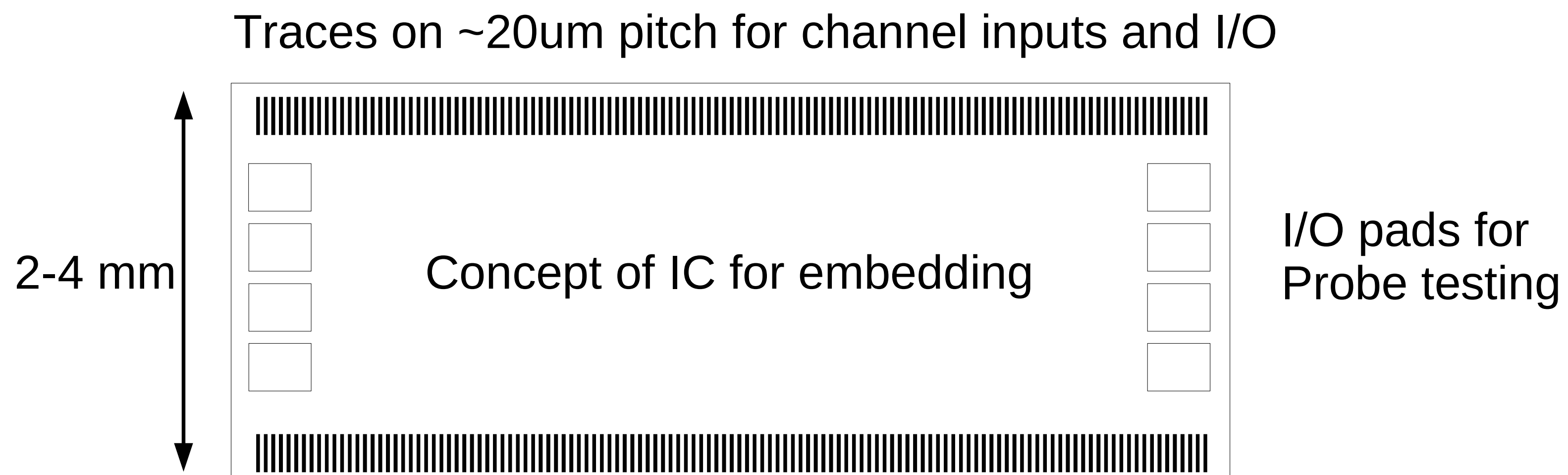
- Can achieve double 2x contact density as method 1 by having traces on both sides of inserts.
- Same high temperature epoxy for assembly. Good to 350°C.
- Higher mass because inserts cannot me made as thin as 50um and there are silicon lids in addition to the inserts
- Finished surfaces are silicon with embedded contacts looking similar to TSV.
- Issue: for use in 3D integration would need to make 8” wafers to match electronics. Prototyping in 4”.
- Issue: alignment of inserts is not as precise as Method 1 assembly. Variation in contact position must be managed.

Method 2 Prototype (before assembly)



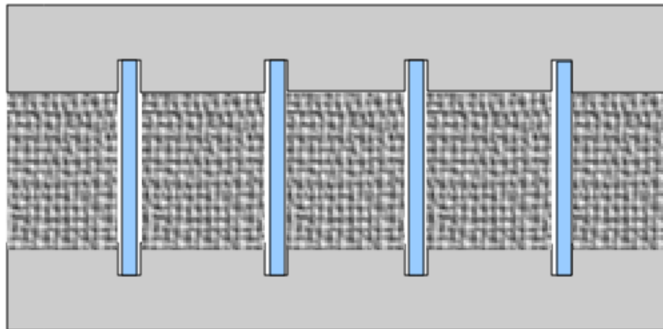
Method 2 Spin-off

- Instead of passive silicon strips with traces, insert active chips.
- After thinning to expose contacts, deposit and pattern metal layers to interconnect and service the embedded chips.
- Can create a large (4” wafer scale) silicon-foam hybrid ready to flip chip to “long pixel” sensors on both sides.
  - Eg. 50um x 2mm pixels.
  - Sensor area decoupled form electronic circuit area
- 2-sided with no need for wafer-wafer 3D circuit integration.

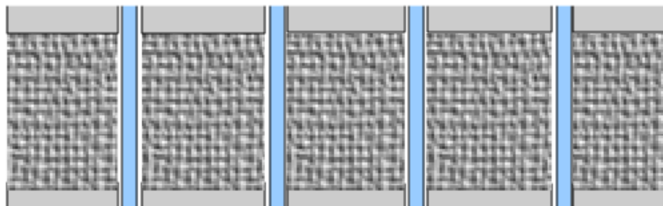


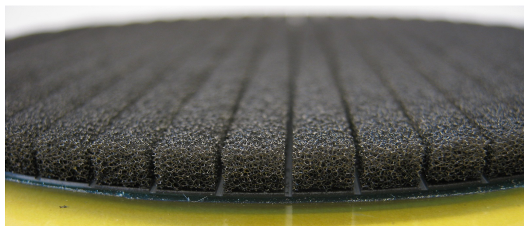
Si-Foam Hybrid (cont.)

Insert IC chips
And glue together assembly

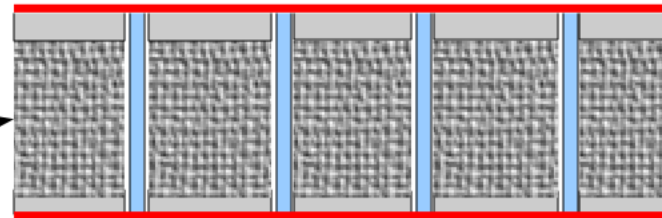


Grind to expose ends of I/O traces
Of active chips

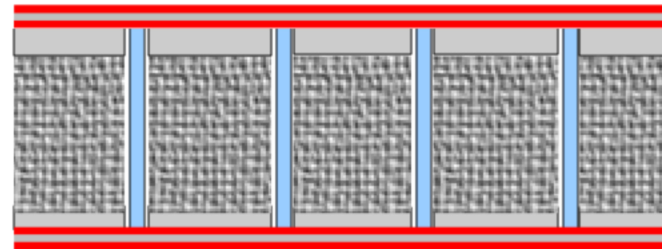




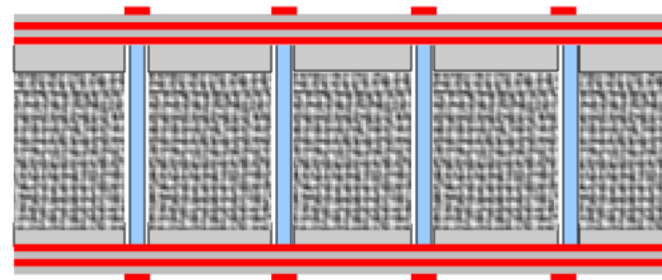
Add and pattern metal to interconnect
And power chips



Add dielectric, fill vias, and add
a shield metal layer

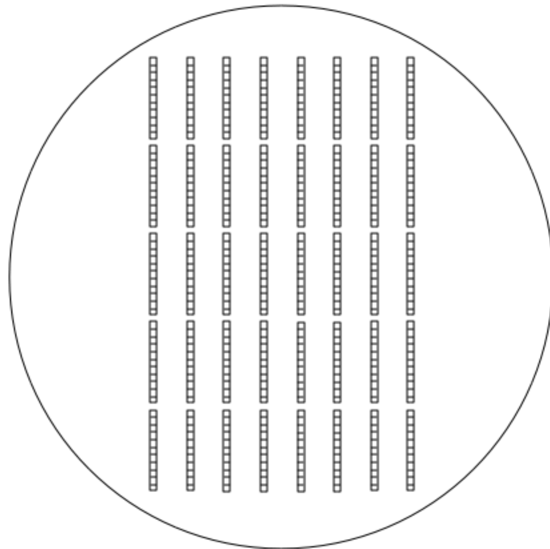


Add dielectric, vias, bump bond pads

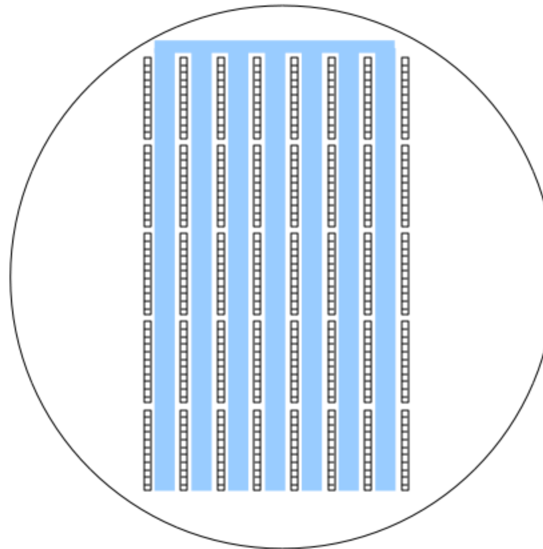


Top View

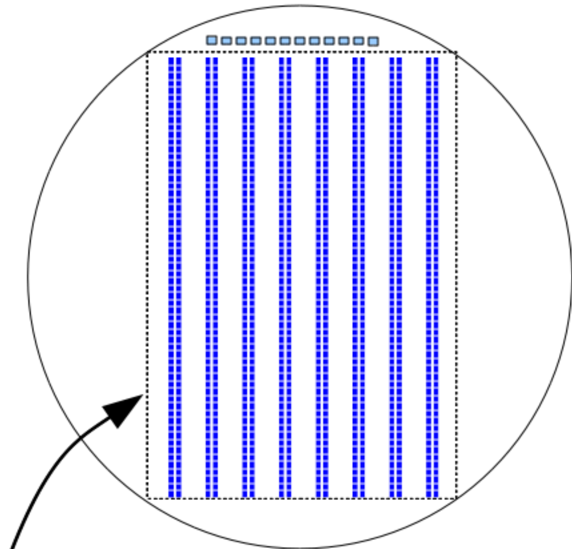
Si-Foam assembly with embedded ICs



Interconnect metal layer added



Final metal layer with bump and w-bond pads



Outline of sensor to flip-chip

Conclusion

- Composite wafers of silicon and foam (using C, but could also be SiC) offer interesting possibilities for building thick, low mass interposers.
- Contact density could be as high as 100/mm^2
- 2 fabrication methods are being prototyped.
- An interesting possibility is the production of Si-Foam hybrids with embedded IC chips for large area long pixel systems without the need for wafer-scale 3-D integration.