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3D Printed Space Transformers

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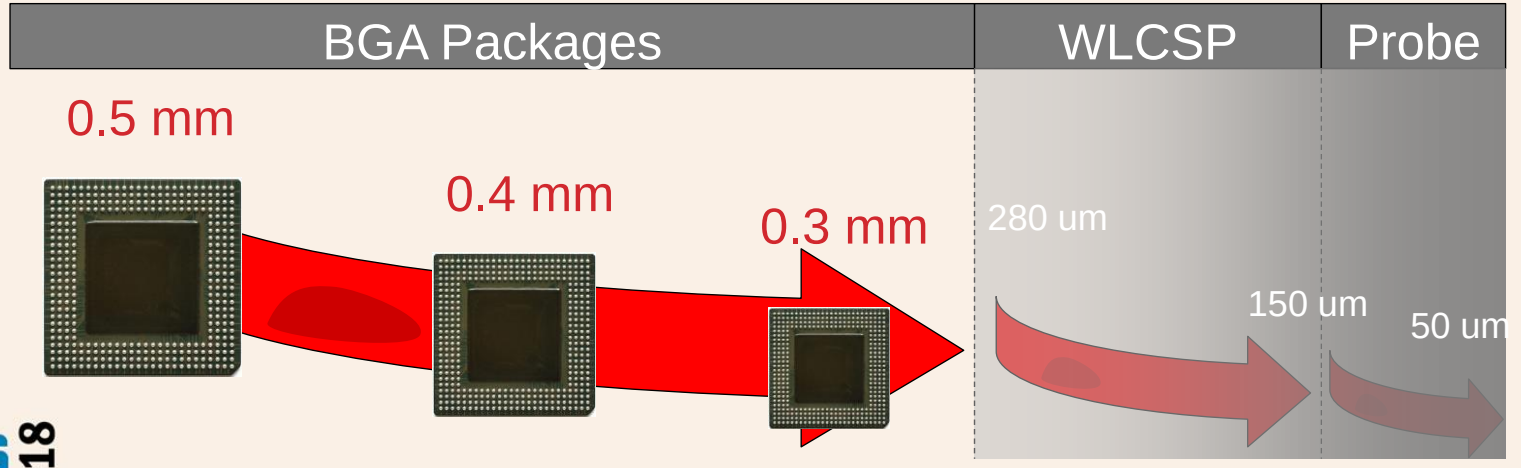
The World is Shrinking

- Mobile devices are leading the charge for smaller packages
- Current standards are 0.4 mm pitch and 0.35 mm pitch
- Future standards are 0.3 mm and smaller
- In ATE, we are running into a wall on testing mobile parts



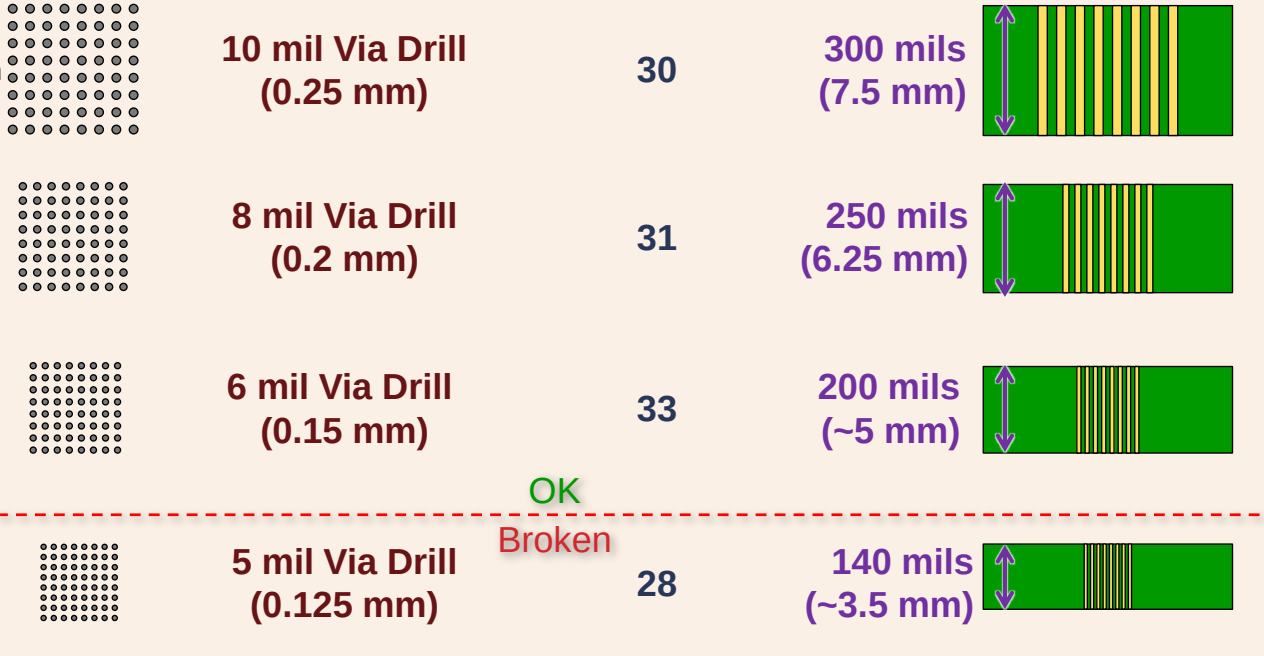
3D Printed Space Transformers

The Impact of Aspect Ratios

Device Pitch	Via Diameter	Aspect Ratio	Board Thickness
0.65mm	10 mil Via Drill (0.25 mm)	30	300 mils (7.5 mm)
0.5mm	8 mil Via Drill (0.2 mm)	31	250 mils (6.25 mm)
0.4mm 0.35mm	6 mil Via Drill (0.15 mm)	33	200 mils (~5 mm)
		OK	
		Broken	
0.3mm	5 mil Via Drill (0.125 mm)	28	140 mils (~3.5 mm)

As pitch Shrinks

Your Board Must Get Thinner



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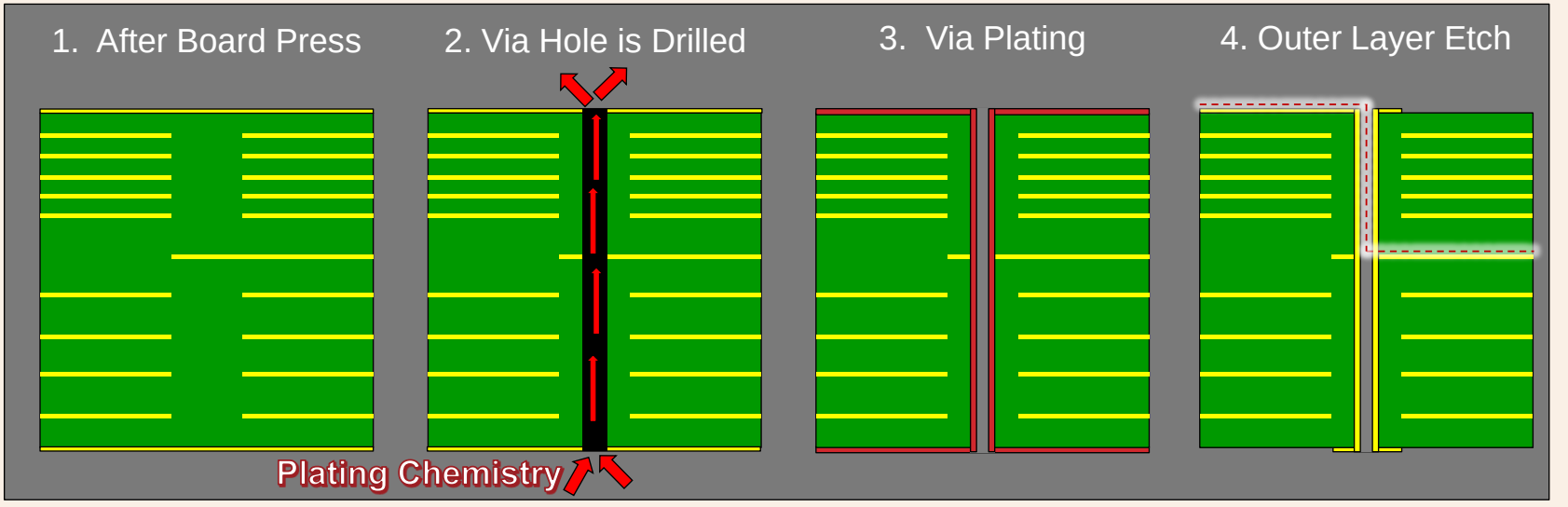
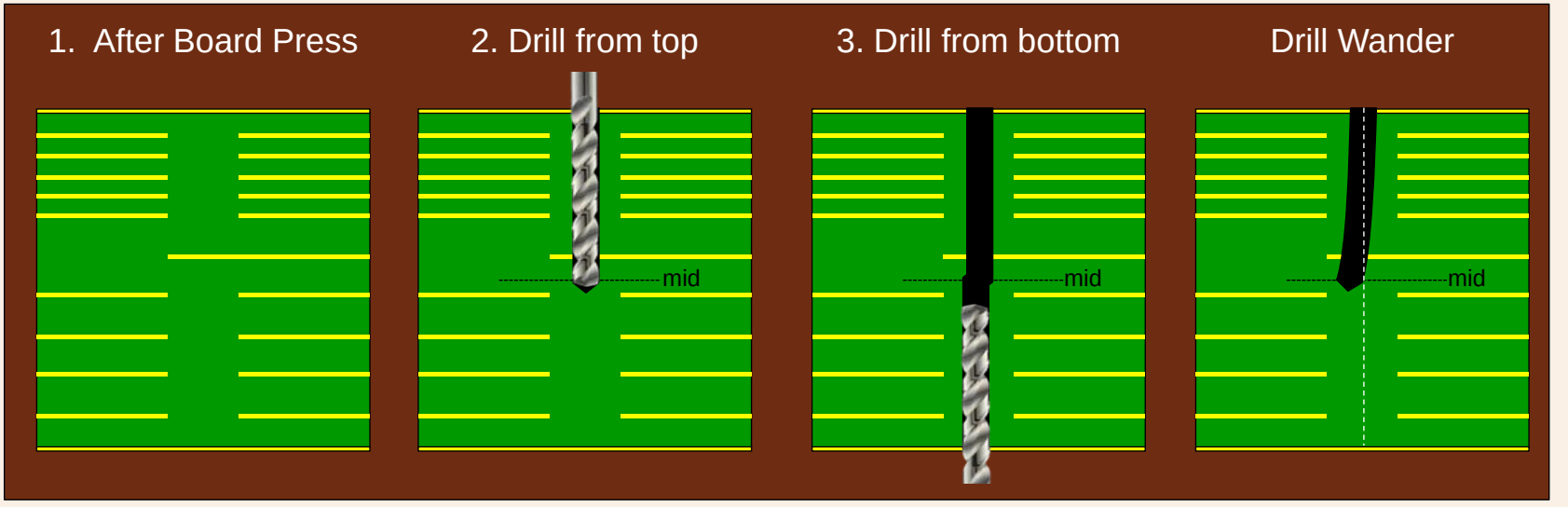
Via Construction Basics



Via plating is limited by fluid dynamics

Therefore… physics limits aspect ratios

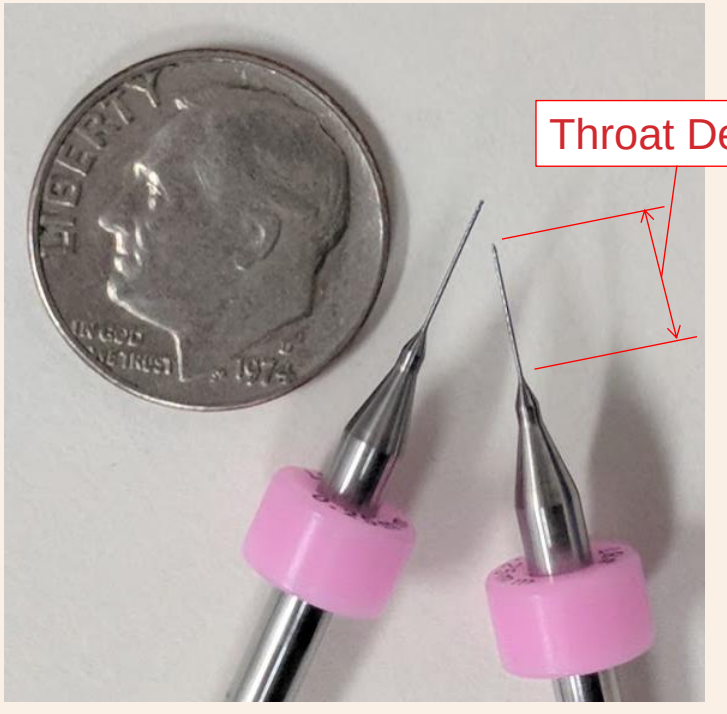
Flip Drilling



- All high aspect ratio vias are done with flip drilling
- The longer the drills, the lower the board yield

PCB Drill Bits

- PCB drill bits
  - 0.25 mm drill shown
- There is a trade off between throat depth and drill wander



PCB Manufacturing Challenges

- Via plating
- Via drilling accuracy
- Alignment between layers

The PCB industry has worked very hard to improve these tolerances and there isn't much room for improvement

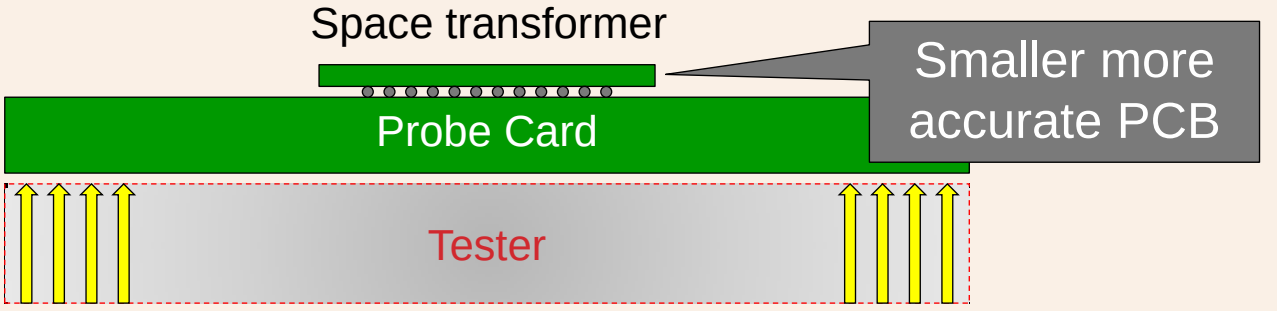
What is the Industry Solution for 0.3 mm pitch?

The market uses one of two different solutions:

1. Dual lamination (Same as 2 but built into the same board)

or

2. Space transformer (also known as Multi Layer Organic - MLO, Multi Layer Ceramic - MLC, or substrate)
   - Space transformers are made using a more accurate fabrication process

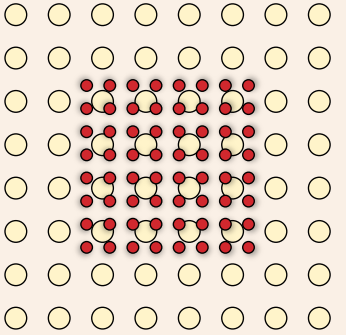


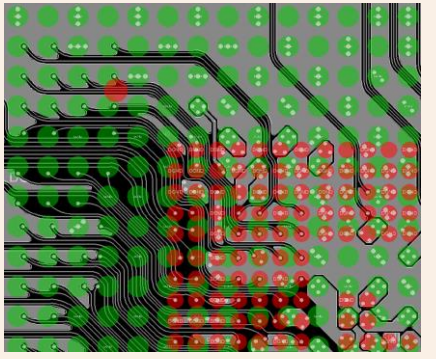
Space Transformer Challenges

- Expensive build process
  - Require build up layers
  - Buried vias
  - Very fine etch tolerances

  } Expensive & Long fab time

- Typically require narrow trace (~25 micron)
  - Increased losses
  - Poor impedance control
- High cross talk
- Two stage design process





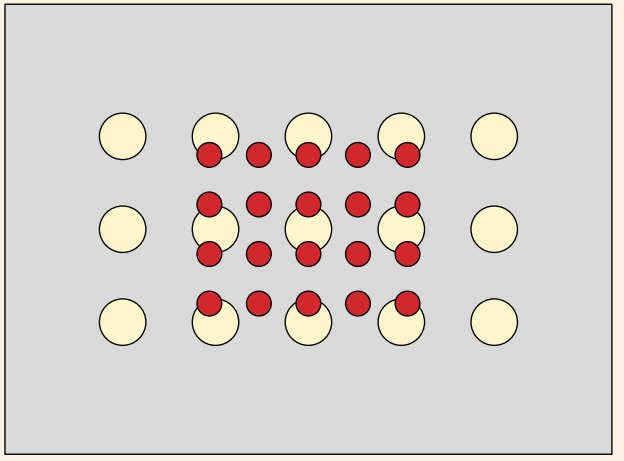
Yes But… What Choice Do We Have?

"The shortest path is the one you know."

The current method works, but it's

1. Expensive
2. Slow
3. Takes a lot of design resources

What If We Could Build Angled Vias?



- Space transformers are hard because the angled path must be routed on Cartesian lines
- If we can used angled lines, space transformers become trivial

3D Printed Space Transformers

- Developed a 3D printing process for space transformers
- Currently capability 0.3 mm pitch
  - Future technology will allow us to go smaller!
- Custom software driven design

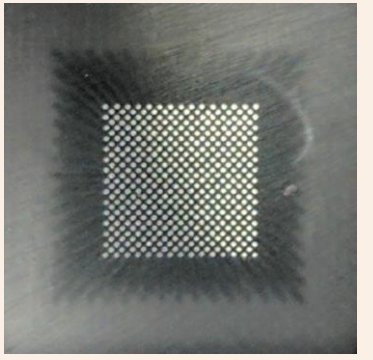
3D Printing Flexibility

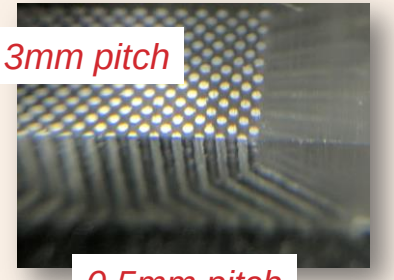
- Vias can be shapes, curves, or angled
- Signals can be routed like PCB traces in 3D space
- Signal nets can be coaxial or impedance tuned
- Power nets can be merged together, made thicker, or designed for low inductance
- Printed blocks can be as tall as 4” high
- This technology is young and will have a fast improvement curve, enabling smaller features and better tolerances

Prototype Shown Below

- 0.5 mm to 0.3 mm transform
- 15 x 15 staggered pitch
- 421 pins
- 0.100” tall
- Solder attachable

(Transparent dielectric used for demonstration purposes)



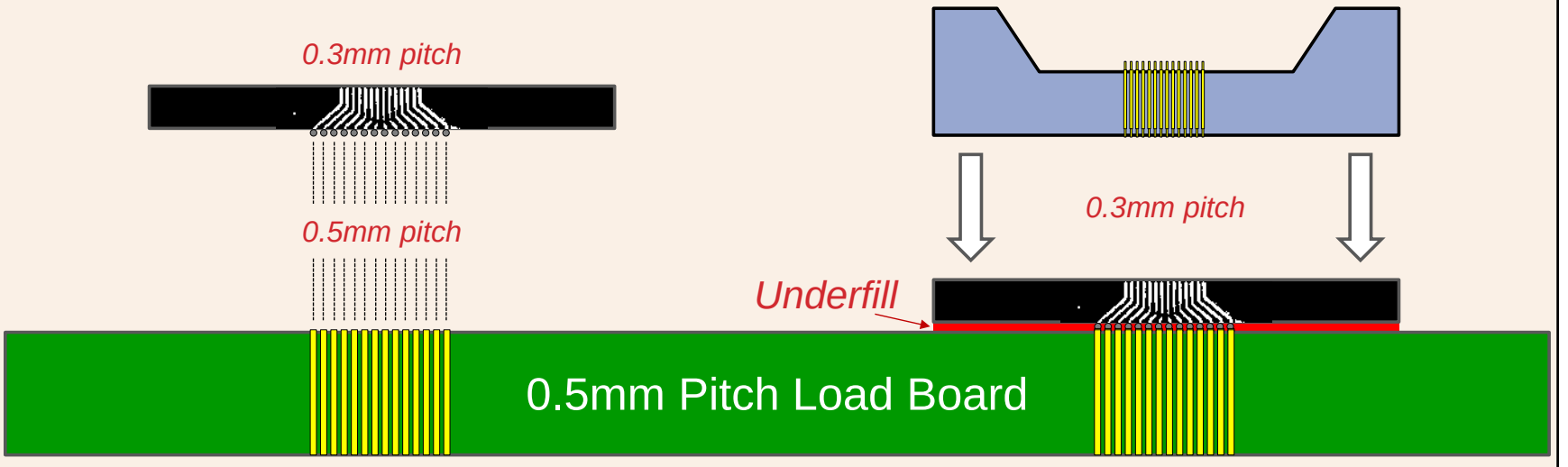


The Impact of Aspect Ratios

Standard Use Model: Reflow on ATE Board

1. Reflow Space Transformer

2. Attach Socket



Space Transformer is reflowed onto board and socket is assembled on top

Advantages for 0.3 mm Pitch

- Allows for a ≥ 0.250” thick main board
  - More PCB layers
  - Better signal integrity (SI), Better power integrity (PI)
  - Easier back drills
  - Better board yield
  - Higher site count (More routing resources & bigger “sweet spot”)
- Space Transformer
  - Easy design
  - Fast build time

Disadvantages

- PCBs scale better than 3D printing
  - Long individual build time, less parallel manufacturing benefits
- Edge tolerances are worse than PCB edge tolerances
- No power or ground planes

Conclusion

- Space transformers are a revolutionary solution for an emerging 0.3 mm pitch problem
  - This is only one application of this technology and we're investigating other uses
  - This has never been done before and this suggests possibilities as limitless as PCBs themselves