

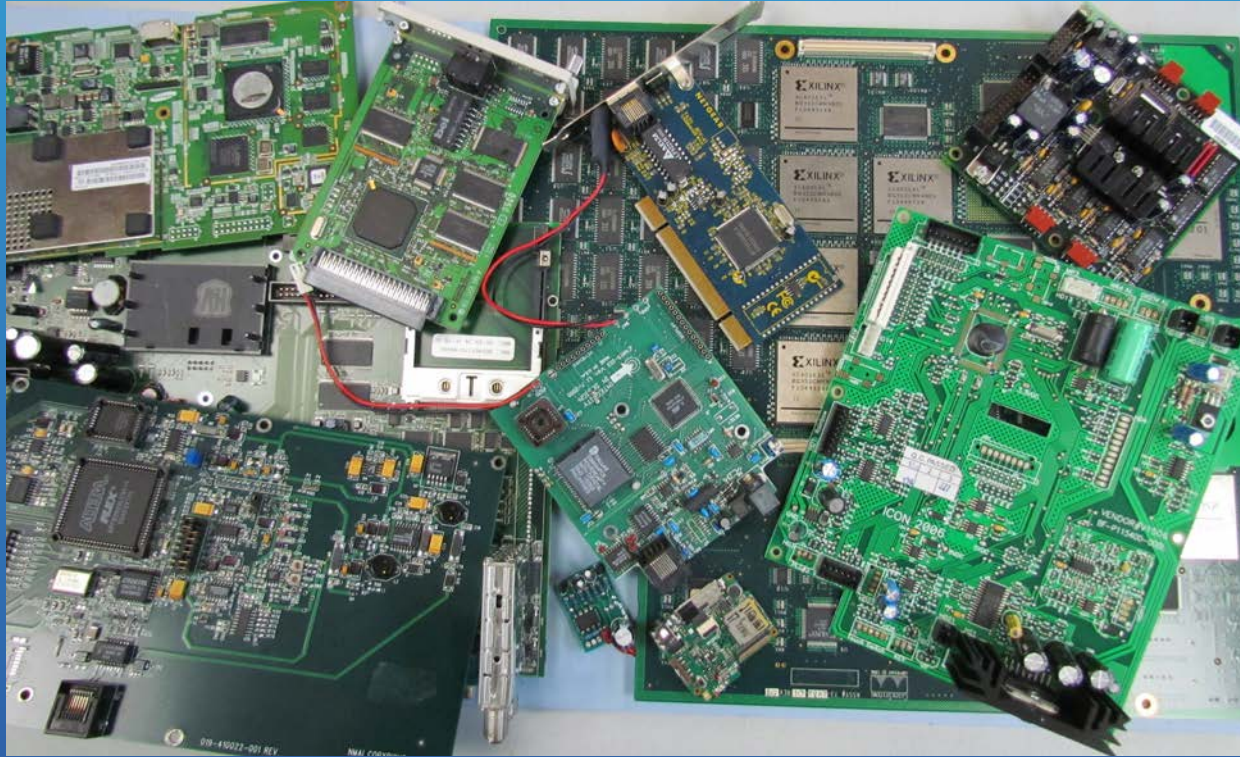
Reverse Engineering using X-Ray

George Tarnovsky

U.S.A

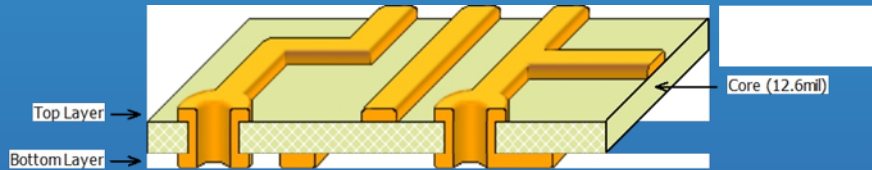
George@target-eng.com

Circuit boards come in various shapes and sizes.

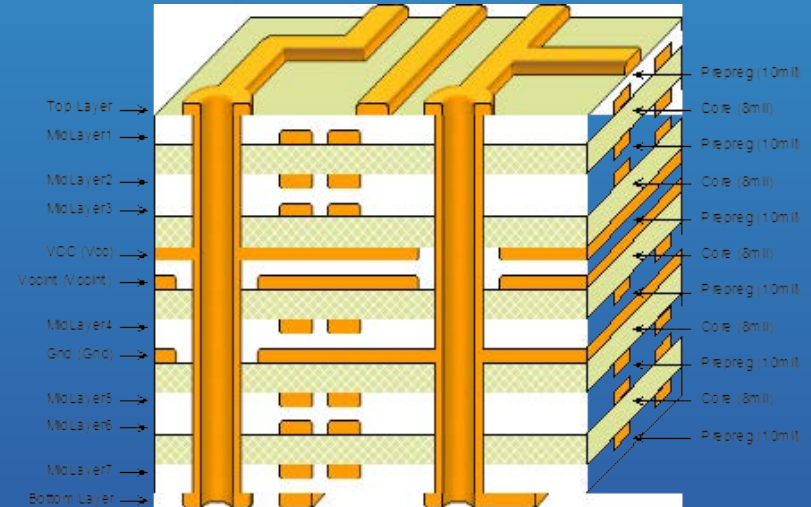


PCBs outward appearances, the internal complexity is not evident. Below are cross sectional views of circuit boards illustrating the unseen differences.

Simple 2 layer design



Complex 12 layer



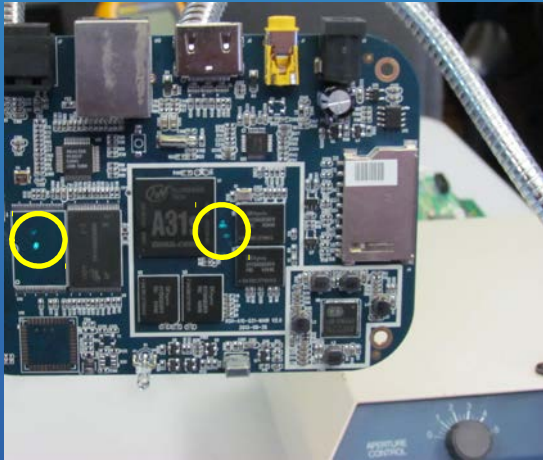
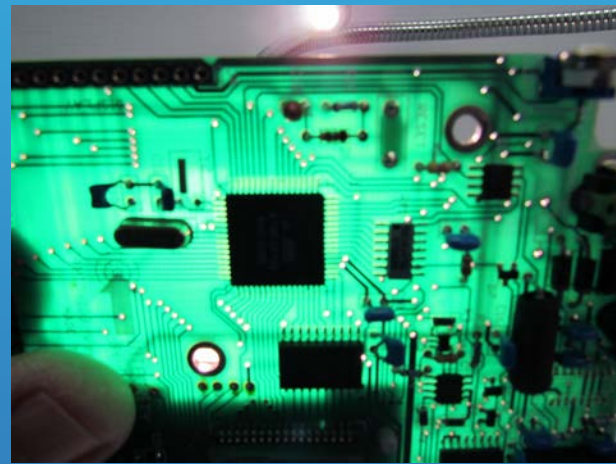
Both PCB's are the same thickness, the 12 layer is expanded to better illustrate the layer properties.

Common methods used for reverse engineering circuit board designs:

- Back lighting, to aid visual circuit tracing mostly effective on:
 - ✓ Single sided--mask or component placement can obscure view
 - ✓ Double sided
 - ✓ Few multilayer boards--multilayer boards without plane layers
- Conductive tracing, using a method such as an Ohm meter:
 - ✓ Effective on most single, double, and some multilayer boards
- Mechanical delayering:
 - ✓ Very destructive; populated boards very difficult

These methods are virtually ineffective with most BGA designs.

Back lighting aids in tracing
double-sided board.

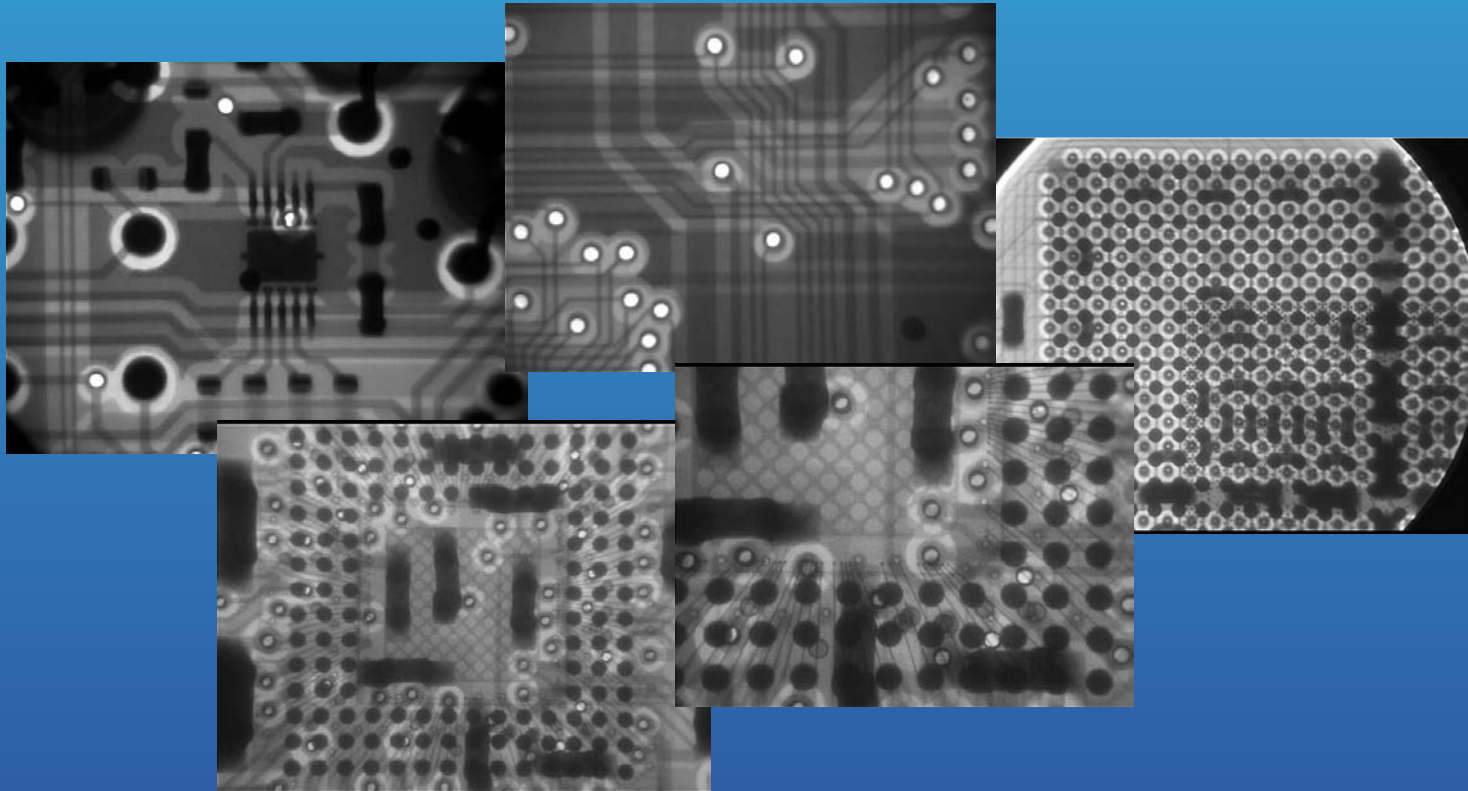


Back lighting is
ineffective on
multilayer with internal
planes.

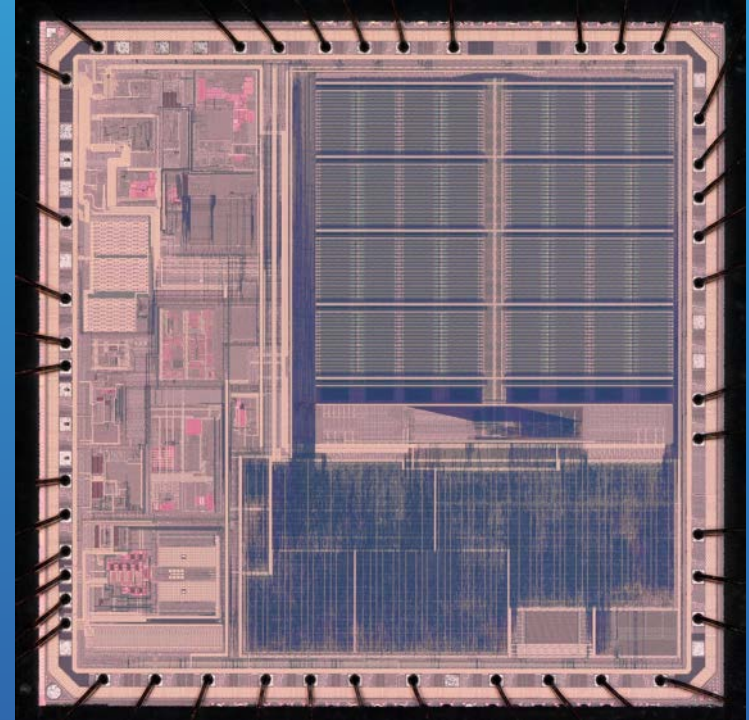
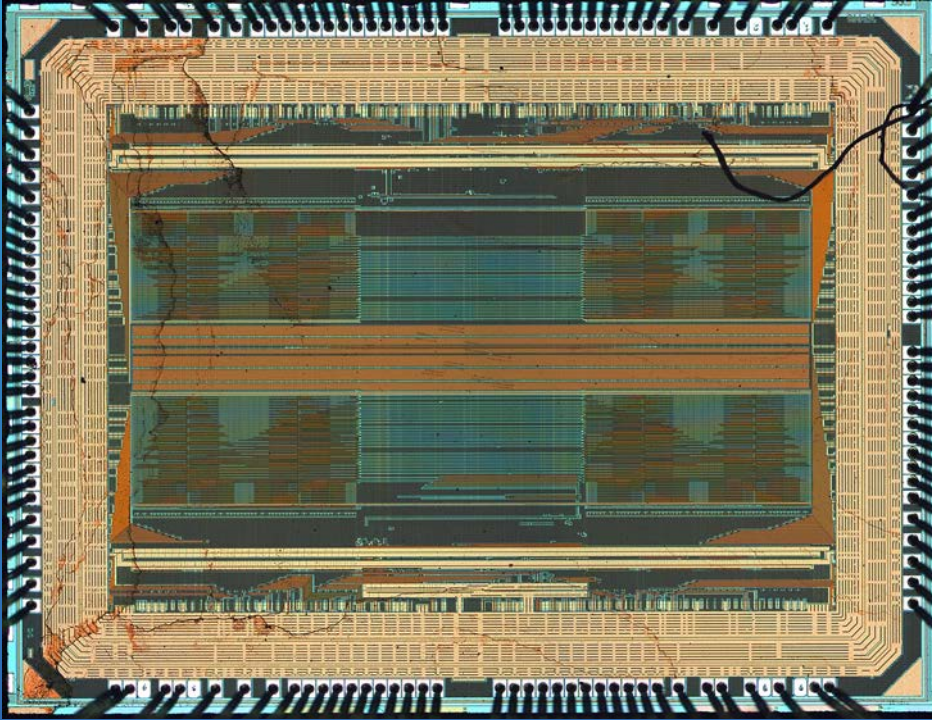
A Word of Caution!



**Using X-Ray everything can be seen.
Practically nothing can be hidden for view.**

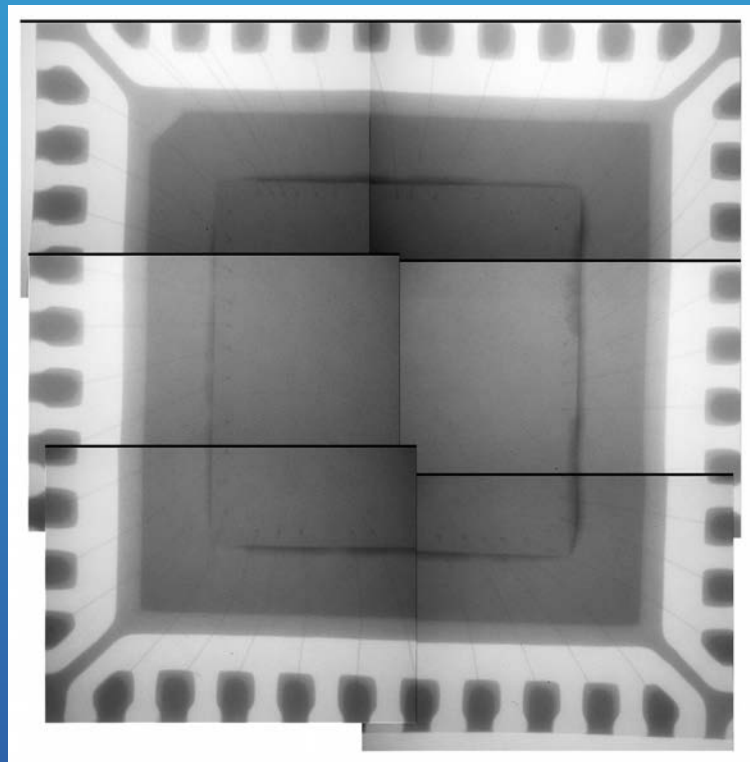


Decapsulated Dies

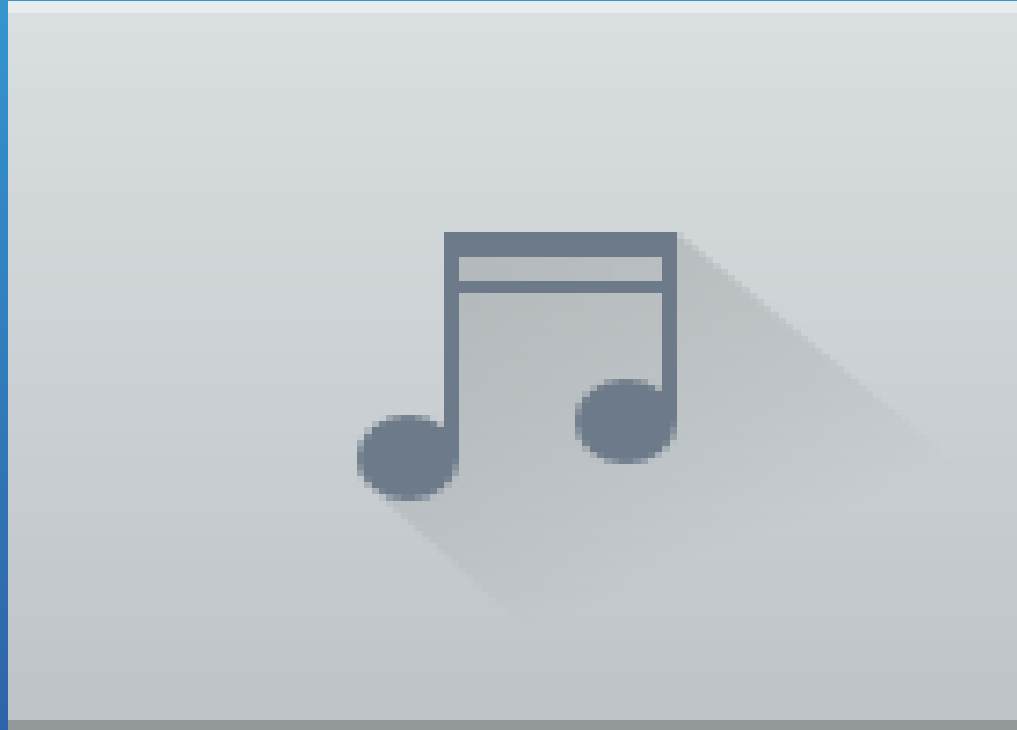


Compliments of Christopher Tarnovsky Semiconductor Guru's

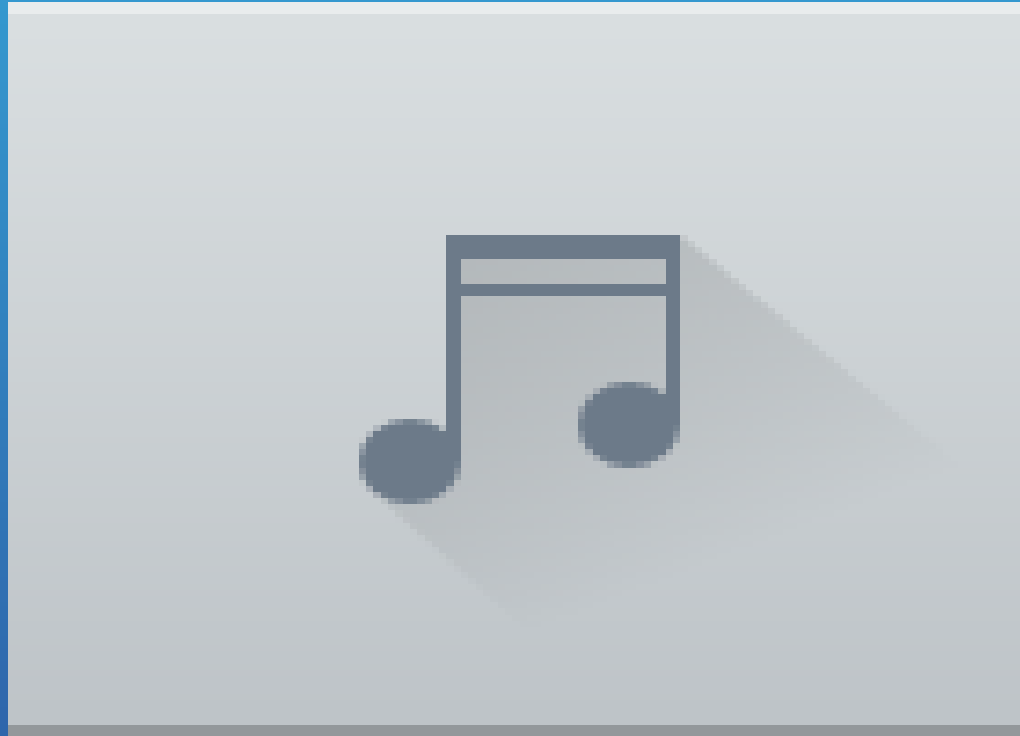
X-Ray view of the die area



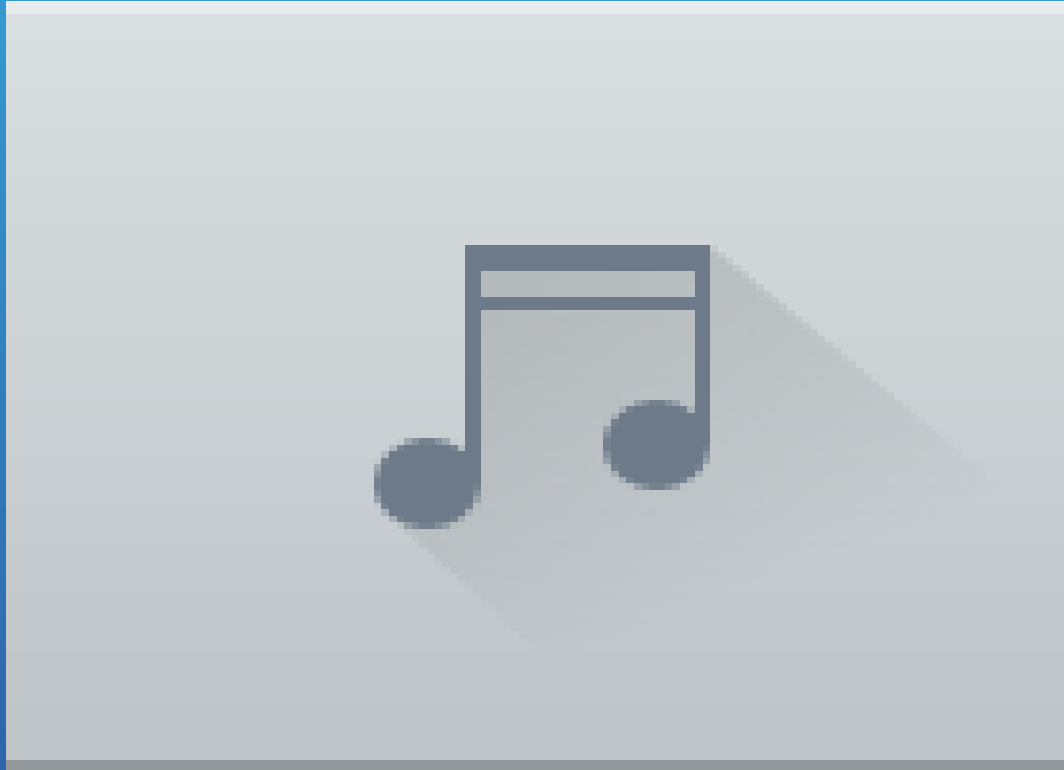
Live view



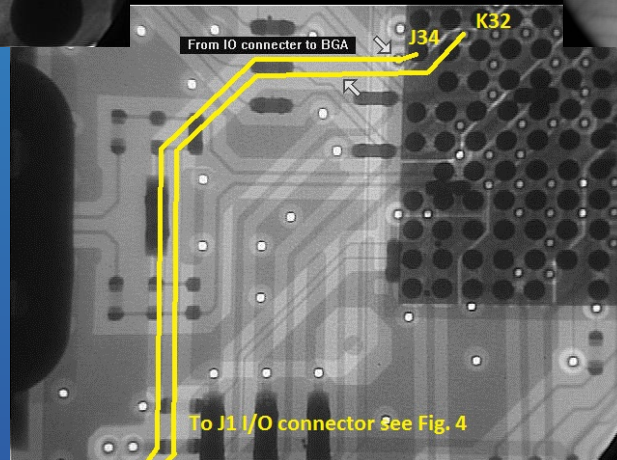
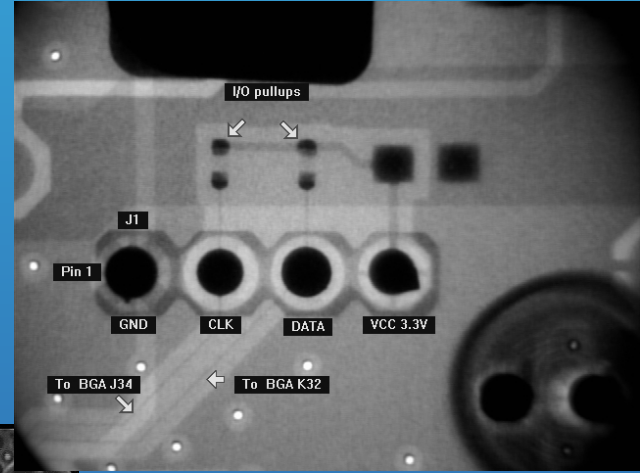
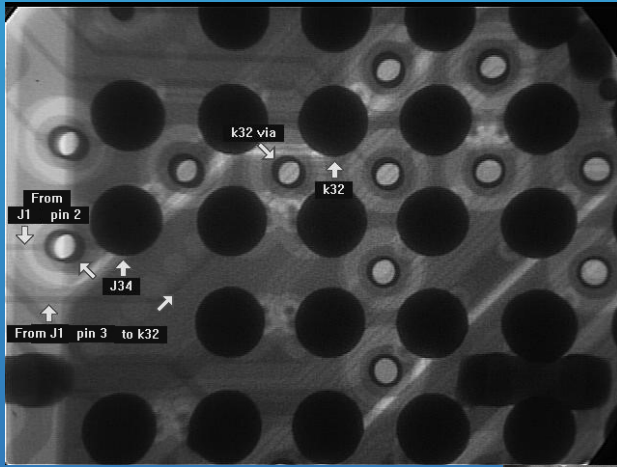
Live view zoom



Live trace

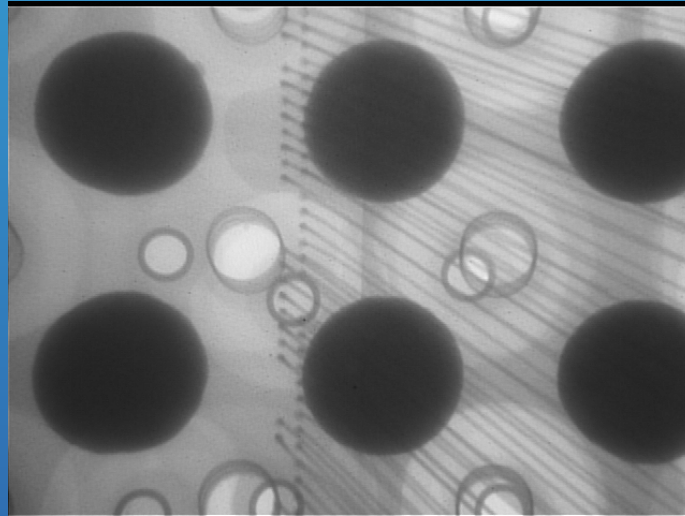


Reverse engineering BGAs becomes an easy task with X-ray



Geometric zoom allows us to see the finer details without sacrificing S/N.

.024" Spheres



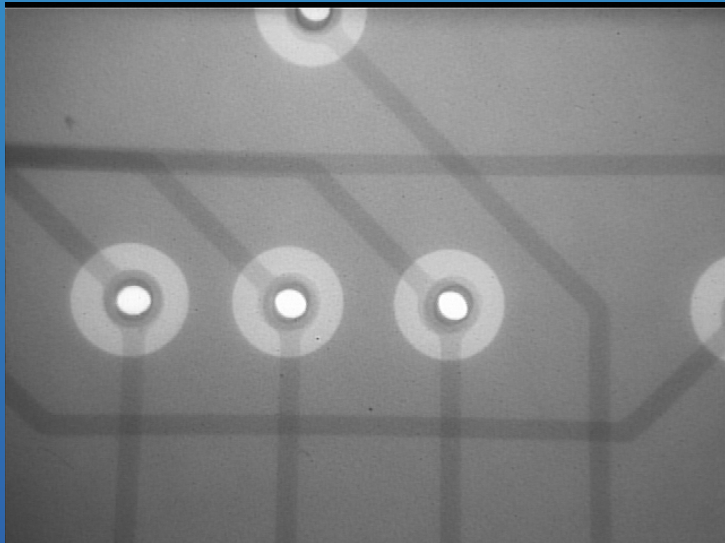
BGA internal
bond wires are visible



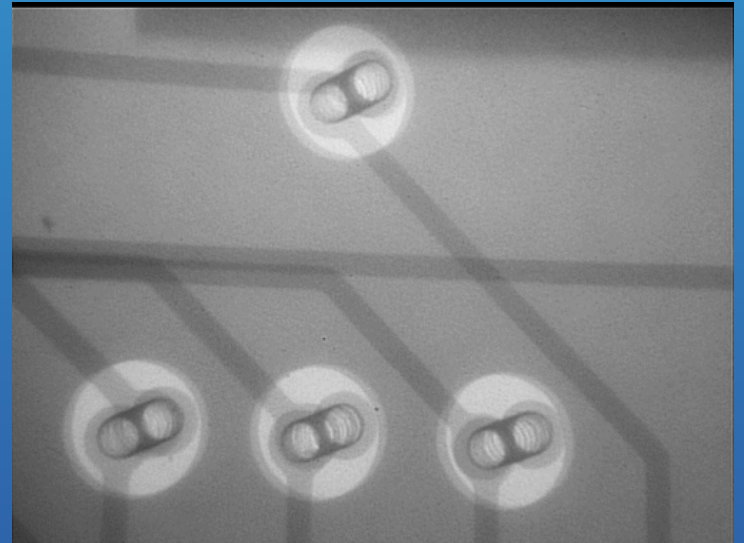
BGA VIAs and PCB VIAs

Angular view simplifies tracing multilayer circuitry.

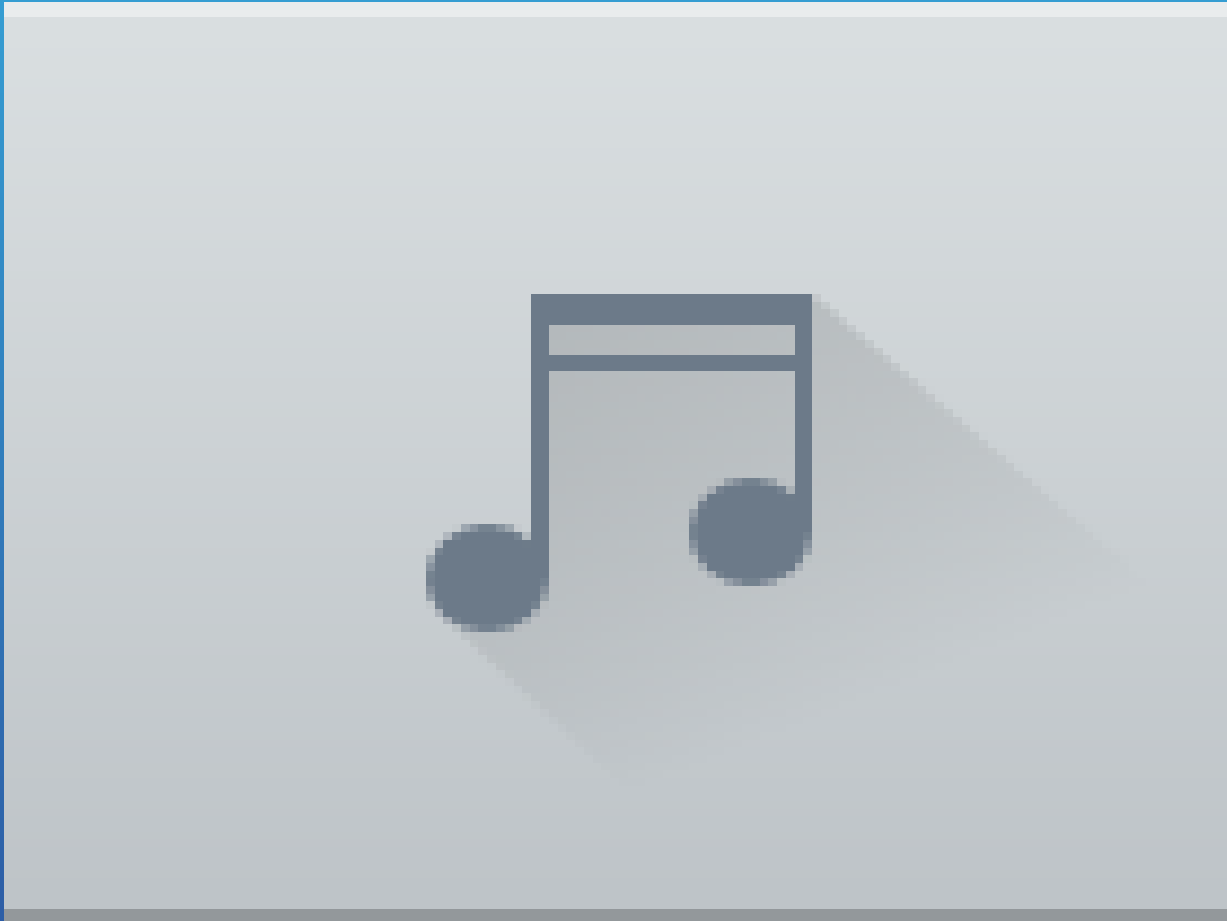
Direct view



Angular view



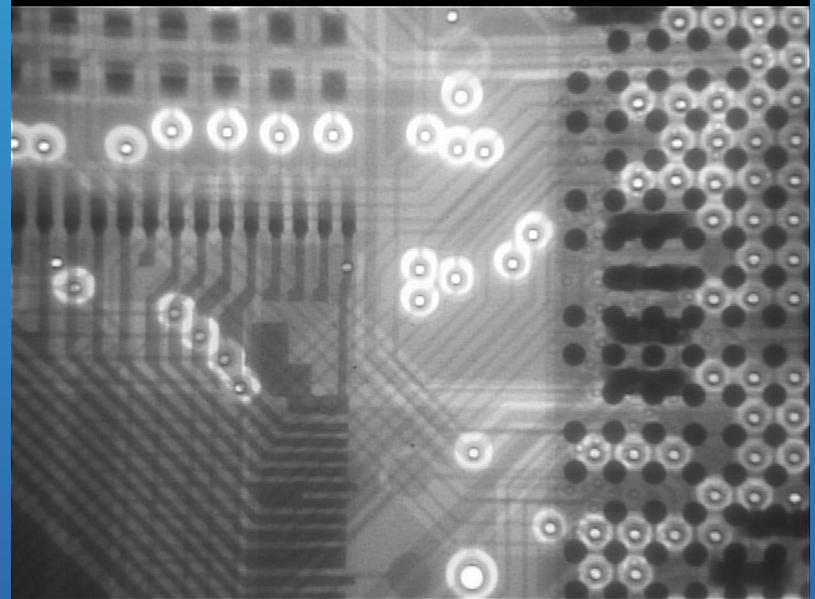
Live active tracing with tilt



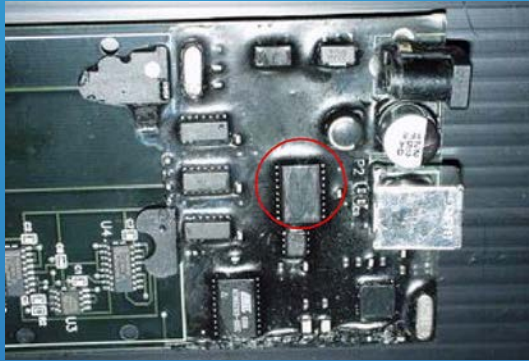
Few traces are visible to the eye.



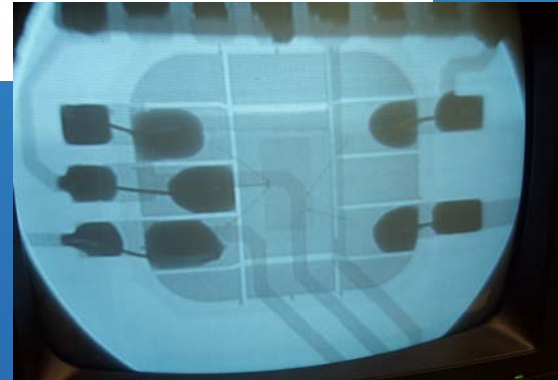
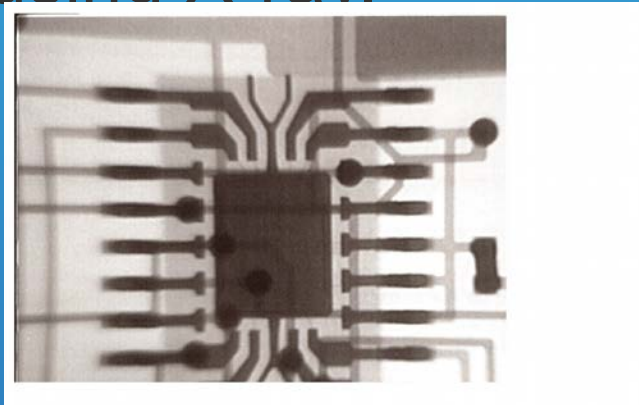
X-ray view of the same area circled in yellow.



Methods to obscure the design using epoxy are ineffective when using X-ray.

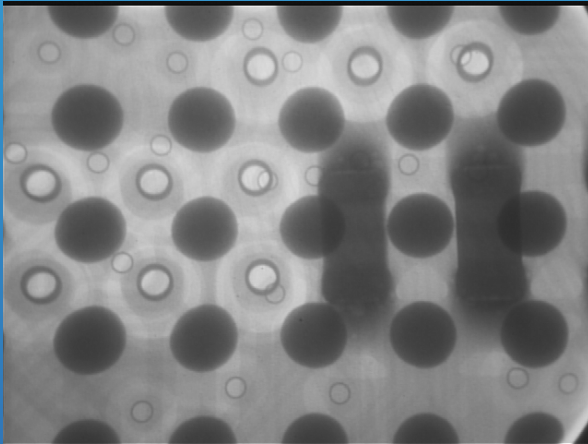


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Analysis of obstructed views using lead

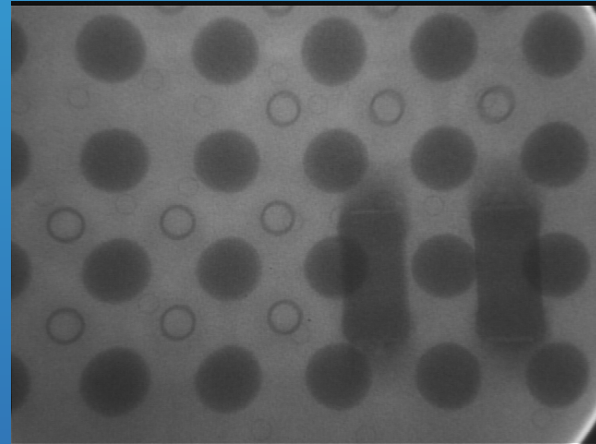
Normal View



56kv 125ua

Normal View of BGA and PCB

Lead sheet applied



79kv 99ua

Same PCB with .025" lead sheet

RAD Hardened Devices View

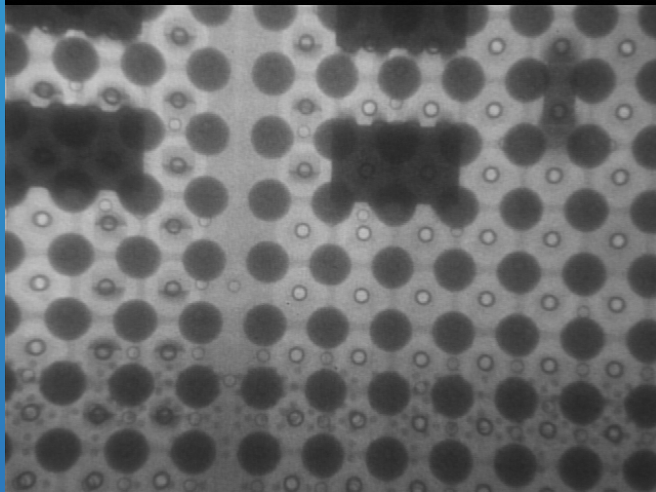


Fig. 1

Device view is harder to see requiring more power.

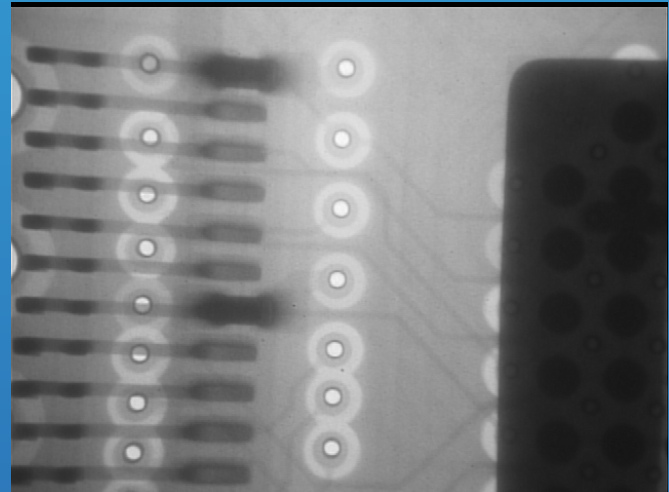
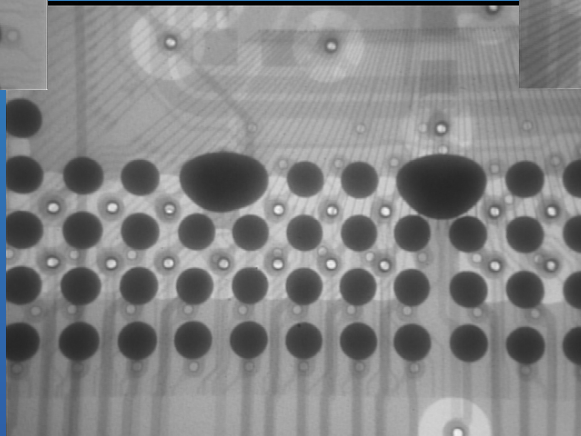
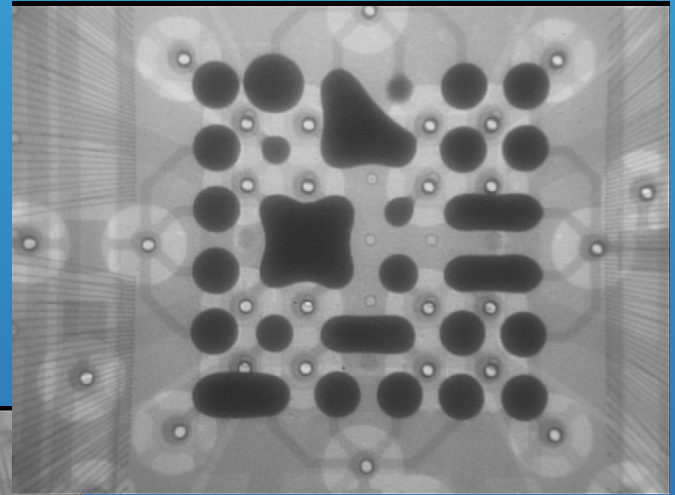
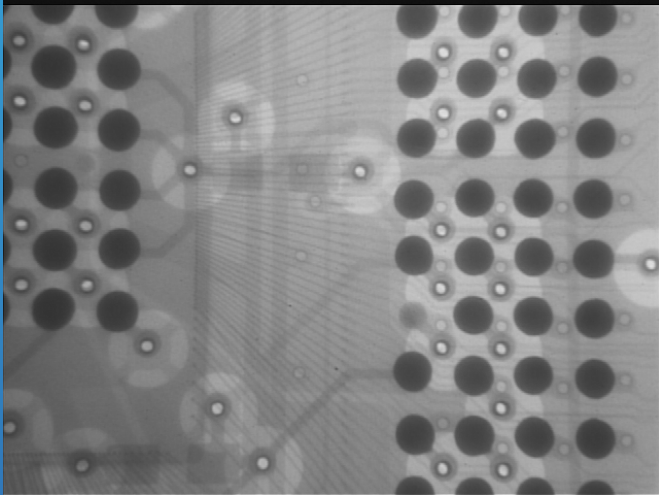


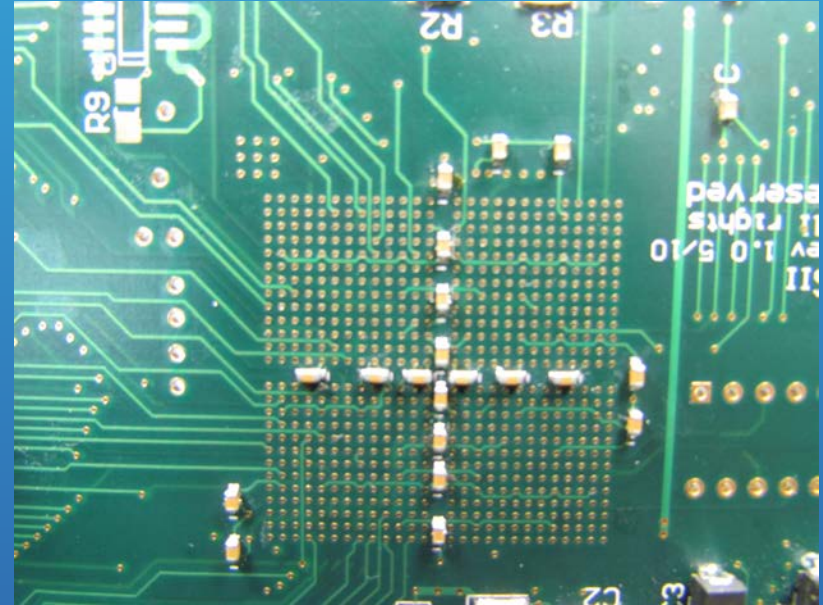
Fig.2

Hardened device compared to PCB

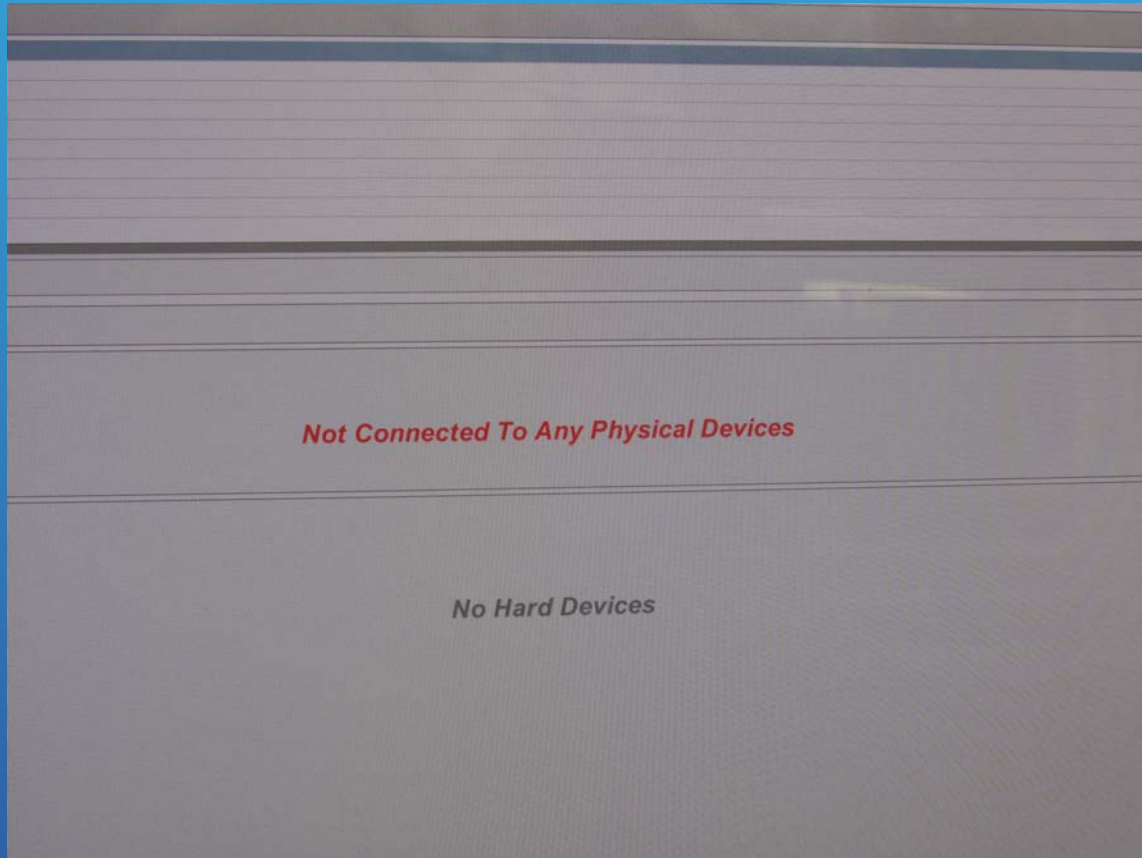
Failure Analysis



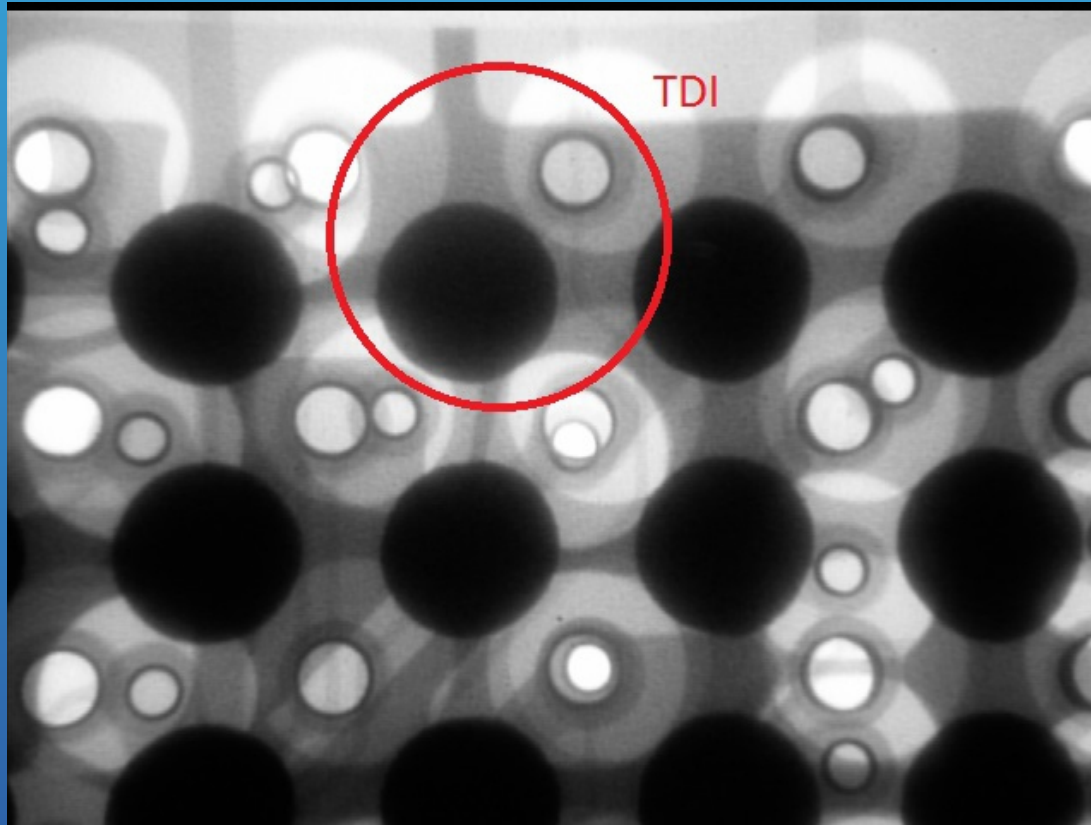
FPGA with Internal Flash



JTAG Interface Not Found



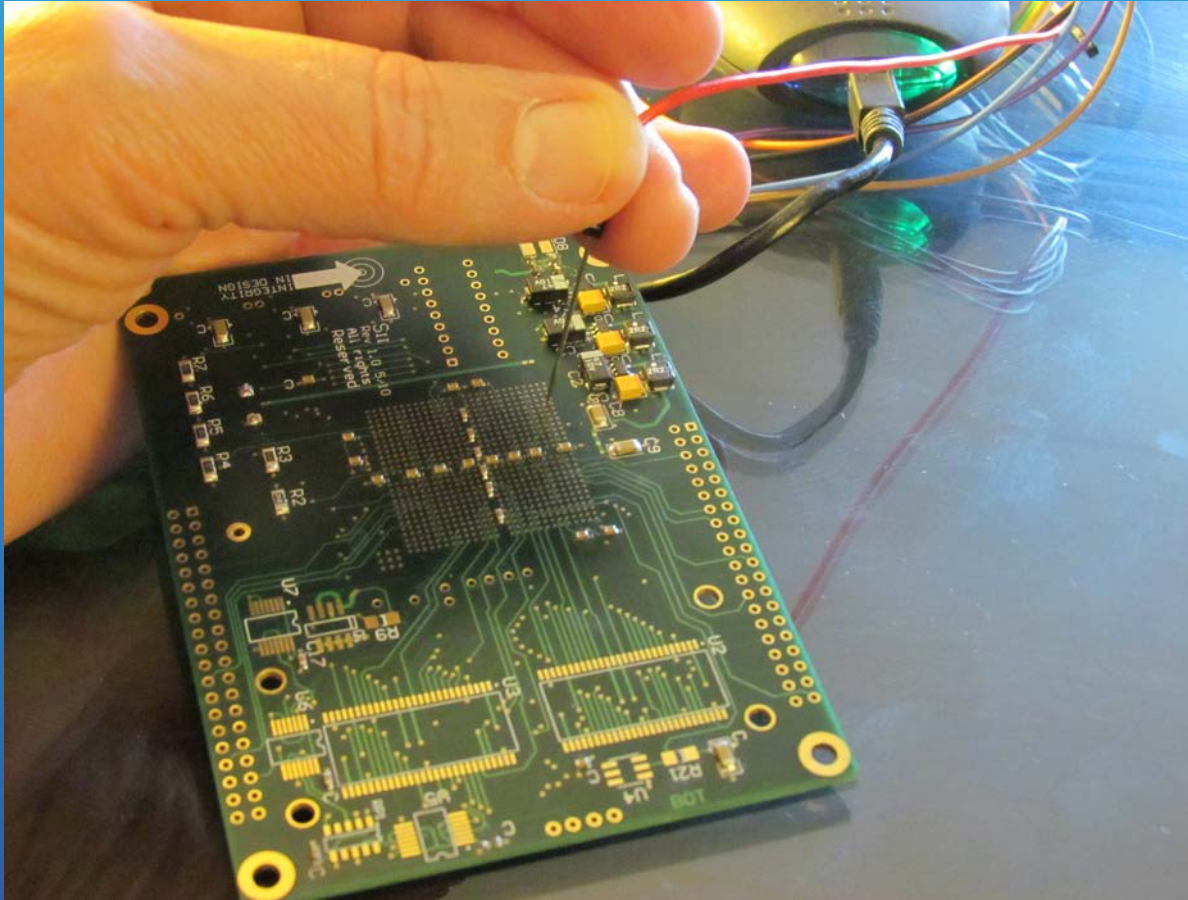
TDI Unreachable Access



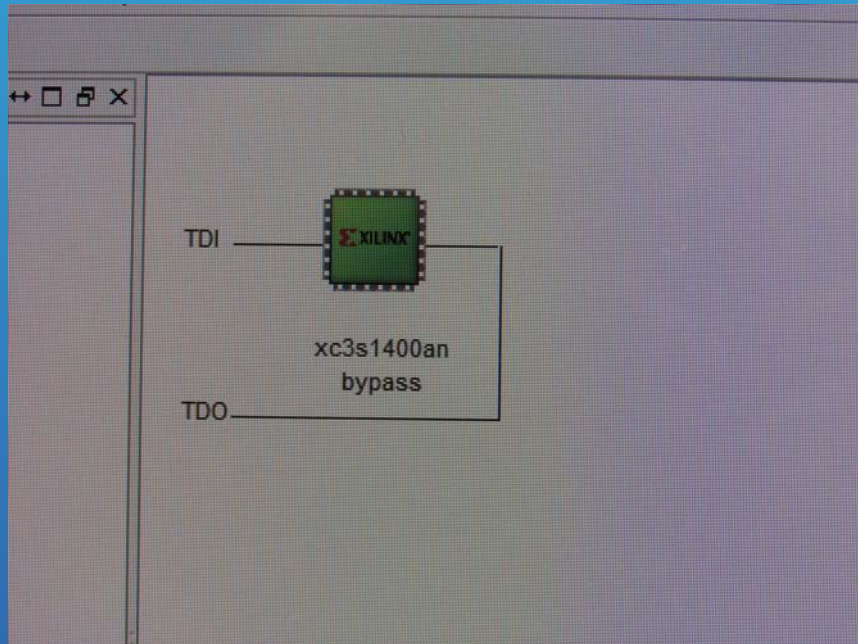
JTAG TDI Access by Drilling



Temporary JTAG TDI Connection




Success



No NanoBoards Found

No Process Flow



Spartan3AN XC3S1400AN-SFG676C
Reset

[No Compatible Project Configurations Found]

No Soft Devices

Source	Source Location
	Z:\work\allium\sheldn

The screenshot shows a software interface with several status messages. At the top, it says "No NanoBoards Found" and "No Process Flow". In the center, there is a device icon for "Spartan3AN XC3S1400AN-SFG676C" with a "Reset" button below it. Below the device icon is a blue bar with the text "[No Compatible Project Configurations Found]". At the bottom, it says "No Soft Devices" and shows a table with two columns: "Source" and "Source Location". The table contains one entry: "Z:\work\allium\sheldn".

Questions?