

Application of Time-Domain Reflectometry To Detect Interconnect Failures

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Outlines

- Introduction
 - How far we have come?

 - 3-D stacking and Interconnects

- Project Goal

- Procedure

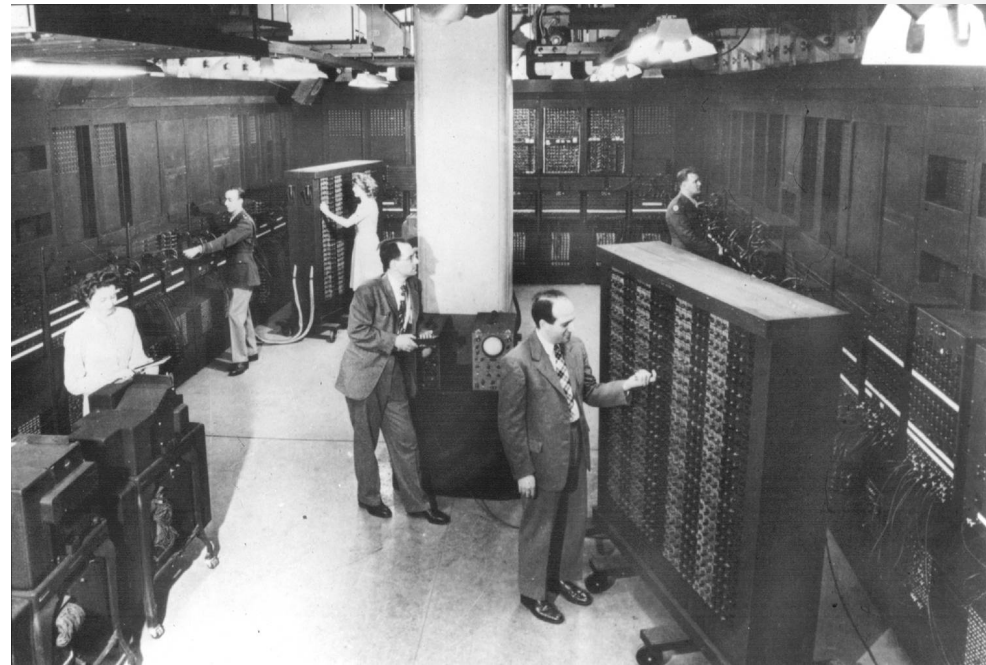
- Conclusion

-

How Far Have We Come?

Electronic Numerical Integrator And Computer (ENIAC) -1946

- 17,468 vacuum tubes
- ~1800 square feet
- ~150 kW of power



How Far Have We Come?

Ivy Bridge Processors -2012

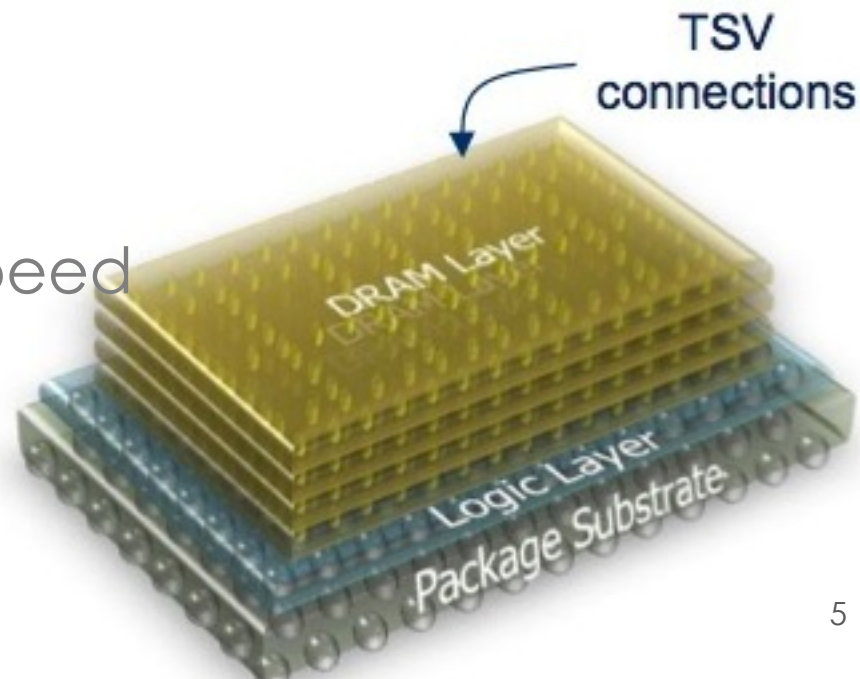
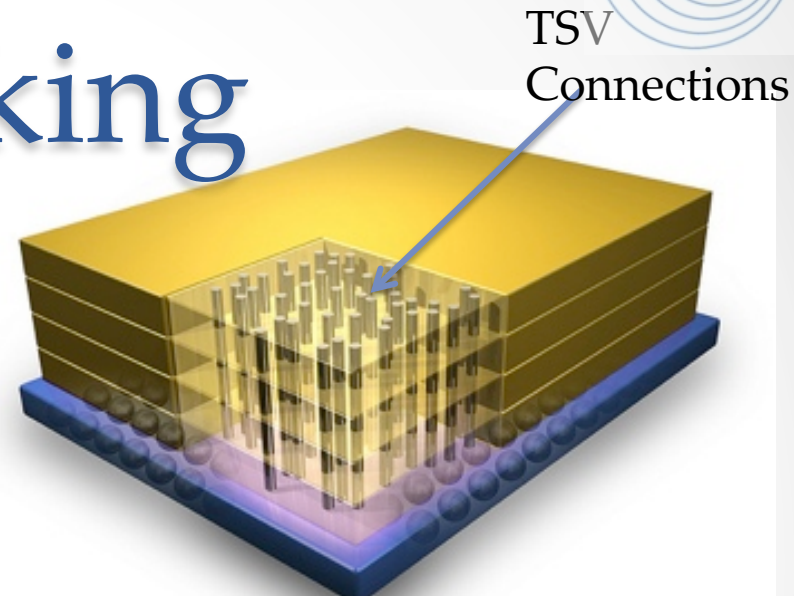
- 1.4 billion transistors (Tri “3-D” Transistors)
- 160 mm² die size
- 50% less power consumption than its predecessor.



3-D Stacking

Advantages:

- Increased portability
- Increased Functionality
- Increased Transmission Speed



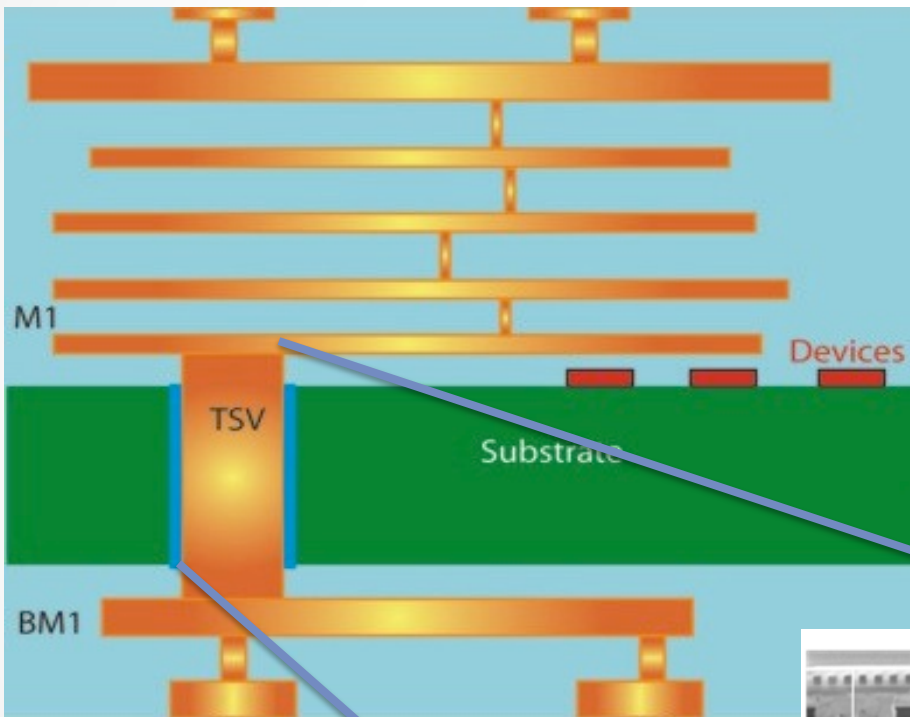
Interconnects

Back-End-of-Line (BEOL)

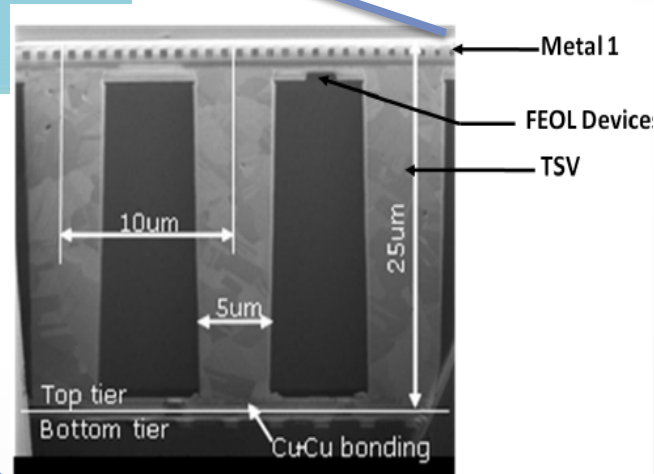
- Connects individual components like transistors and capacitors

Through-Silicon Via (TSV)

- Vertical connections that pass through wafer or die



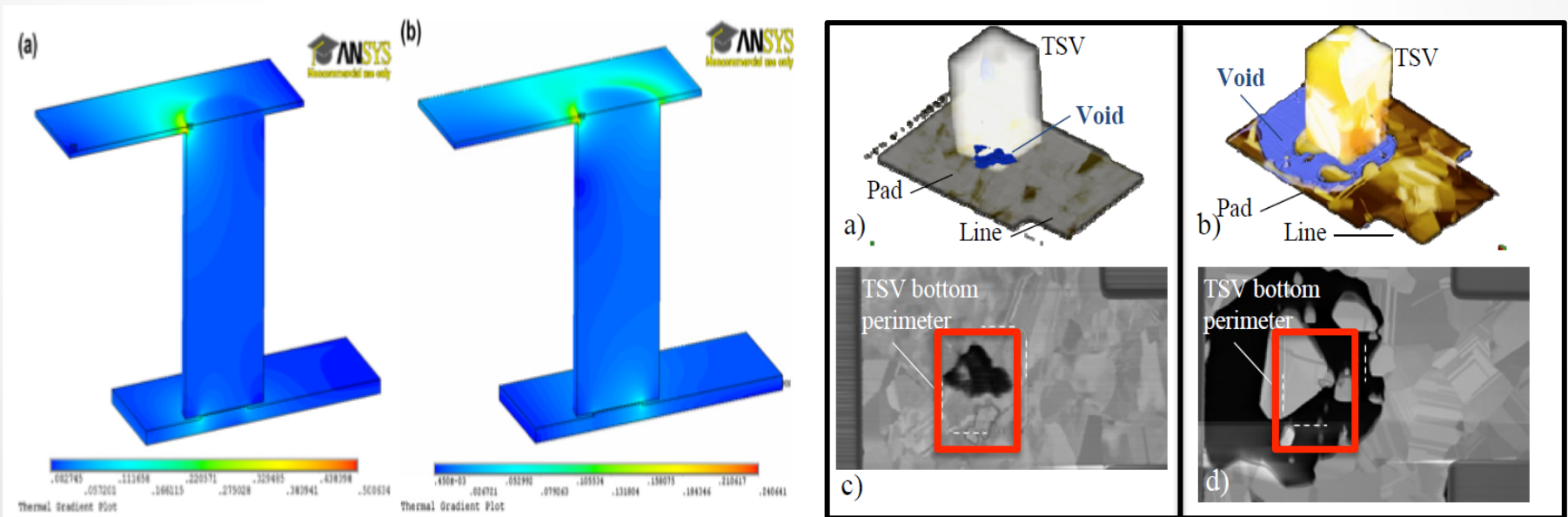
Through-Silicon Via (TSV)



..But the reliability of these interconnects are not studied well enough

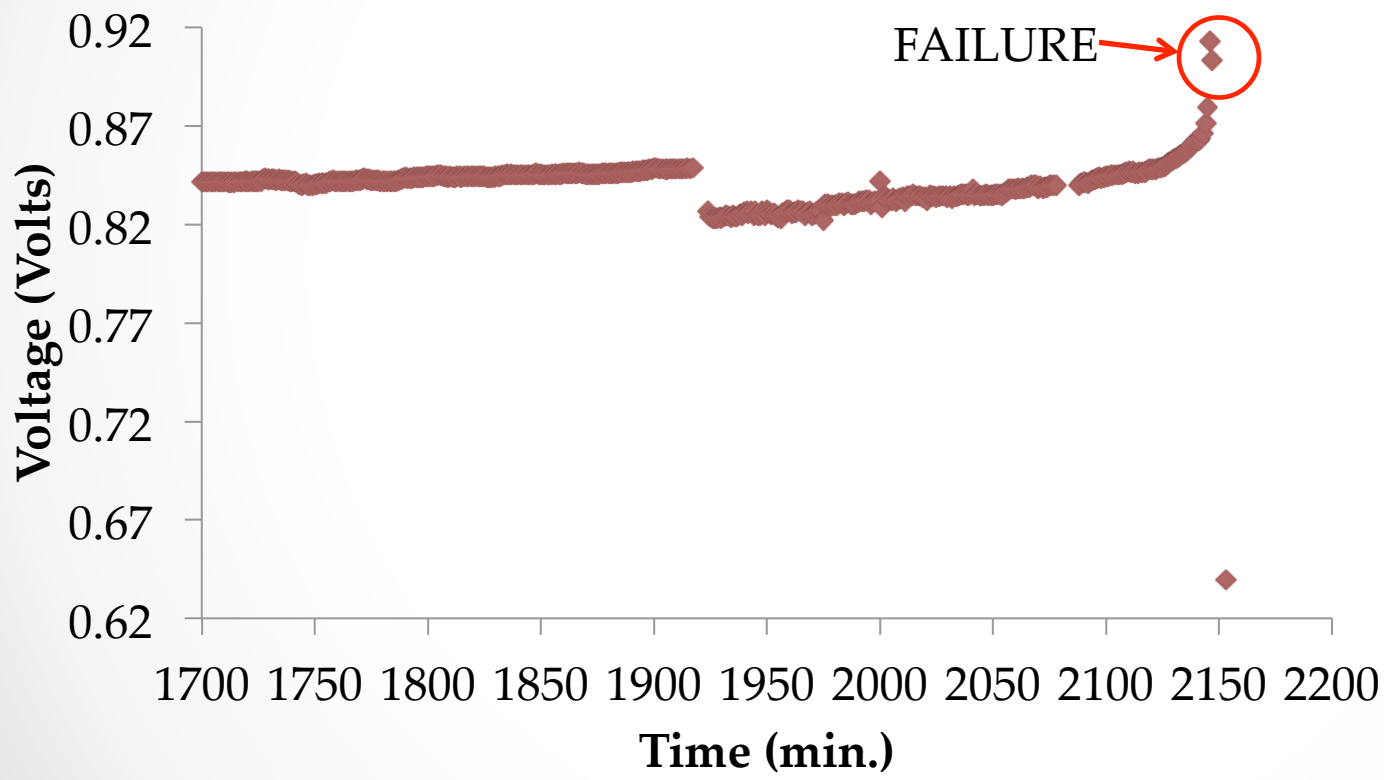
Reliability Challenges of TSV

- Void occurred at the bottom of TSV, on the connecting Cu pad due to electromigration



*Y.C. Tan et al, Electromigration performance of Through Silicon Via (TSV) – A modeling approach
 **T. Frank et al, IRPS, 2011

Reliability Challenges Contd....



$R_{\text{ambient}} = 13.3xx \Omega$

$R_{\text{initial}} = 26.3xx \Omega$

$R_{\text{final}} = 30.6xx \Omega$

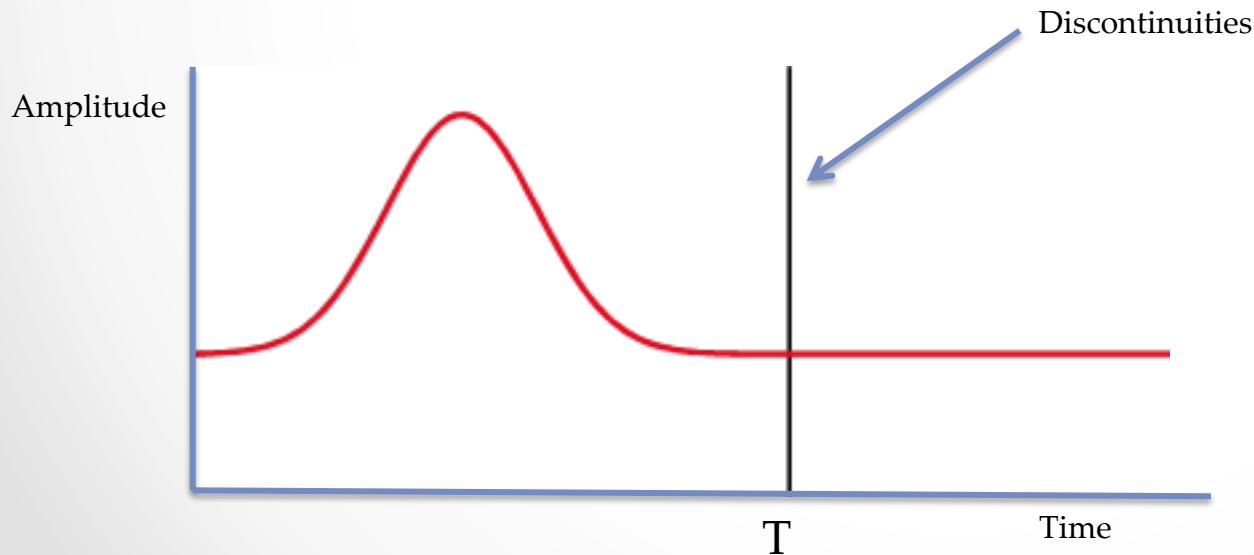
...How do we find out the location of these failures?

Project Goal

- Determine the failure locations in interconnects using Time-Domain Reflectometry (TDR)

TDR

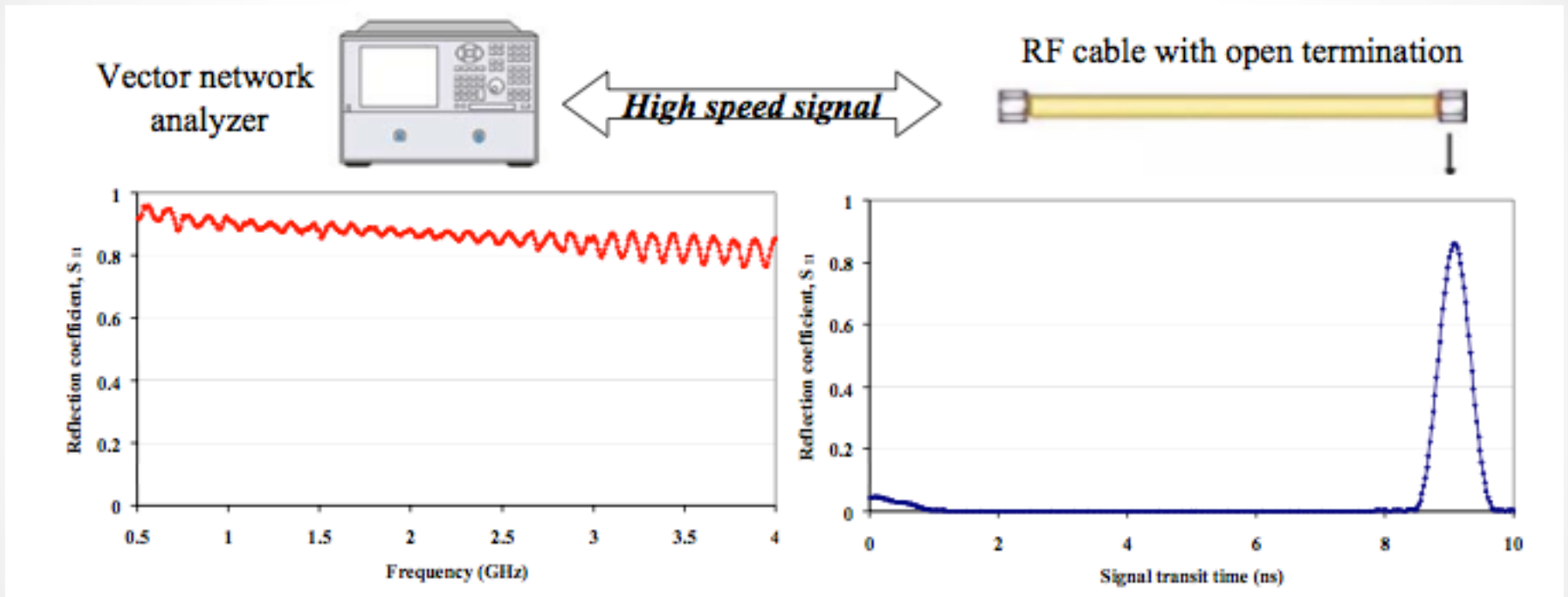
- Works on the same principle as radar
- TDR transmits a short rise time pulse along the conductor.
- Any discontinuities in the impedance causes signal to reflect back.



$$D = v_p \cdot \frac{T}{2} = \frac{v_p T}{2}$$

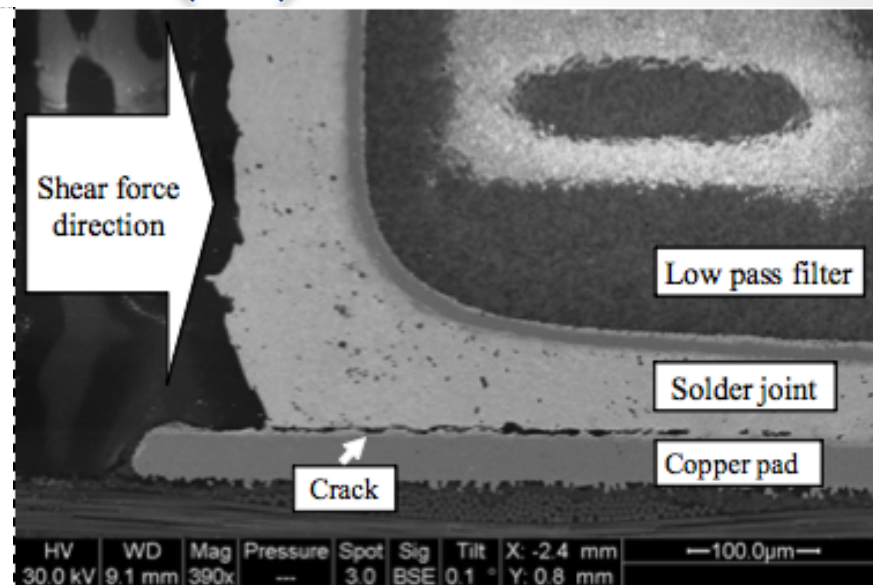
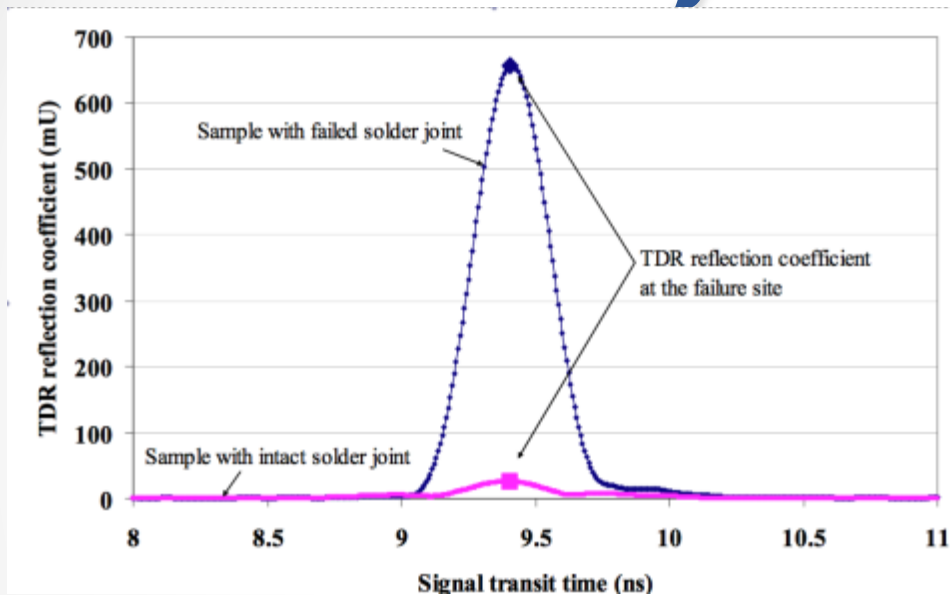
D = Distance
 v_p = Velocity of Propagation
 T = Time

Why TDR (1)?



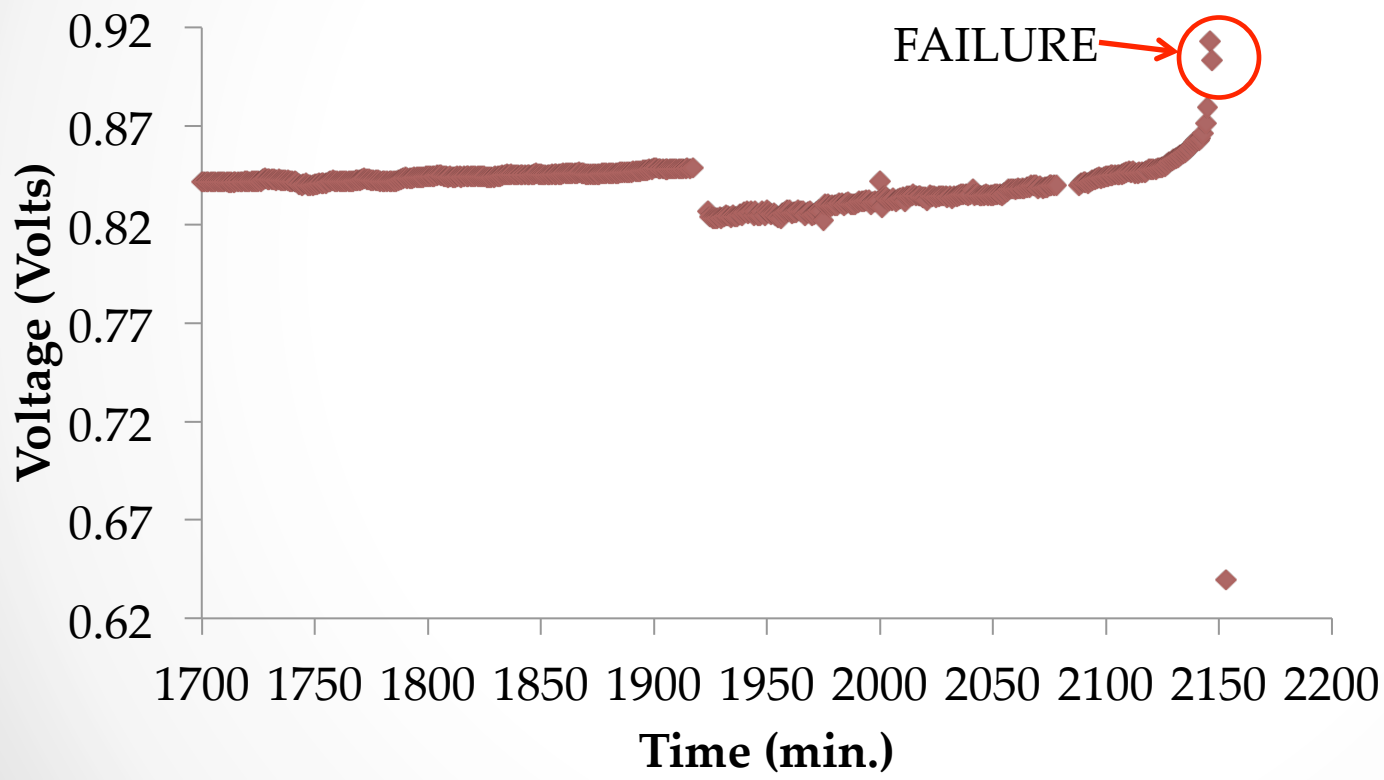
- Easy and accurate to locate failures like open termination or any kind of discontinuities.

Why TDR (2)?



- Non destructive method to pinpoint failures

Reliability Challenges Contd....



$R_{\text{ambient}} = 13.3xx \Omega$

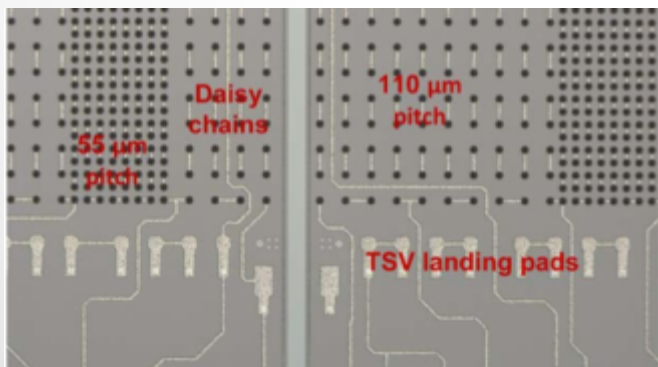
$R_{\text{initial}} = 26.3xx \Omega$

$R_{\text{final}} = 30.6xx \Omega$

...How do we find out the location of these failures in the sea of TSVs? → Use TDR.

My Task

- Prepare sample
- Learn to use LeCroy WaveExpert 100h
- Take TDR measurements
- Locate where failure occurred
- Correlate data measured from Vector Network Analyzer (VNA) with the TDR data



Test Sample



LeCroy WaveExpert 100h

Acknowledgement

- Society of Physics Students
 - Entire SPS and AIP Family
- National Institute of Standards and Technology(NIST)
 - Dr. David Seiler, Dr. Yaw Obeng, Dr. Chukwudi Okoro, Dr. John Suehle
Dr. Yaqub Afridi
 - Entire PML Semiconductor and Electronics Division Family
- Fellow Summer Interns

Thank You!