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Power Spectrum Analysis

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Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL8500.

Power Spectrum Analysis (PSA) Overview

- Device frequency-domain responses to dynamic stimuli
  - Use normal and off-normal biasing/detection
  - Produce repeatable frequency domain fingerprints
  - Comparison approach
- Non destructive and short acquisition times
  - typically < 15 seconds

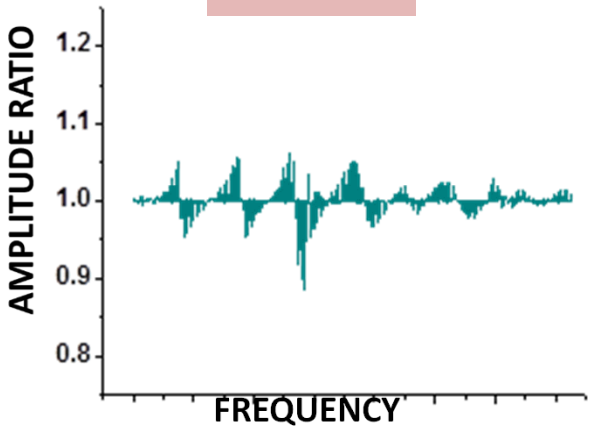
Applications

- Supply chain risk management (SCRM) at the chip, board, and system levels:
  - Determine if suppliers are providing us what we expect
- Anomaly detection:
  - Verify that parts, boards, and systems are un-modified, especially if they leave our possession
- Reliability, failure/aging detection, and radiation effects/exposure detection
- Process monitoring

Different Distributors
Genuine and Counterfeit Parts
PSA Spectra: XC4008E FPGA

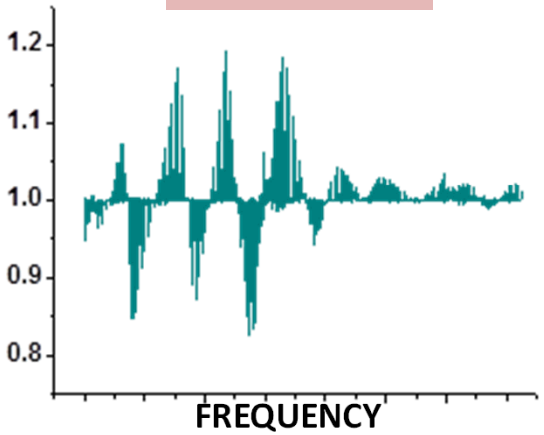
Distributor A

Genuine



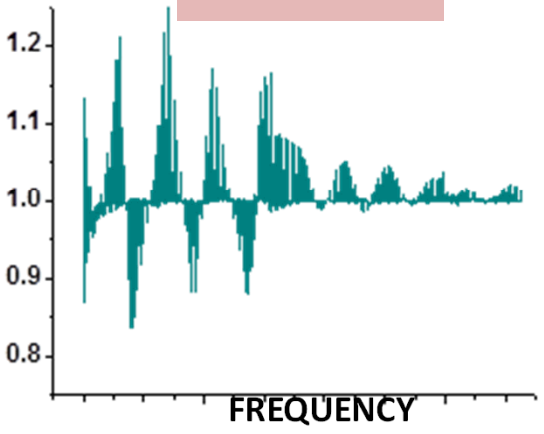
Distributor B

Counterfeit



Distributor C

Counterfeit



Different Distributors: Genuine and Counterfeit Parts

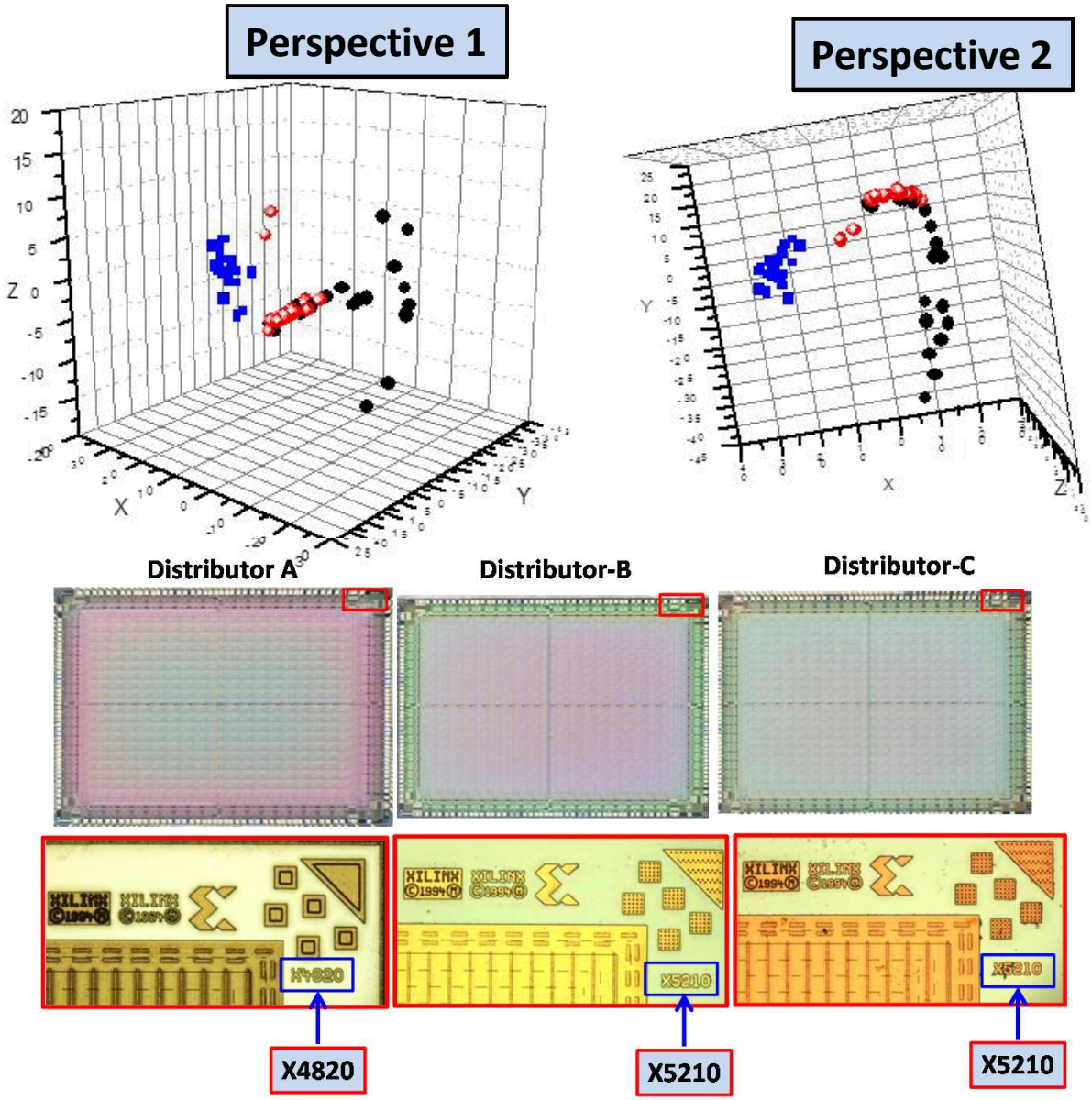
PCA of PSA Spectra of XC4008E FPGA

Distributor A population is separate from those of Distributor B/Distributor C

Distributor A samples have a more localized distribution

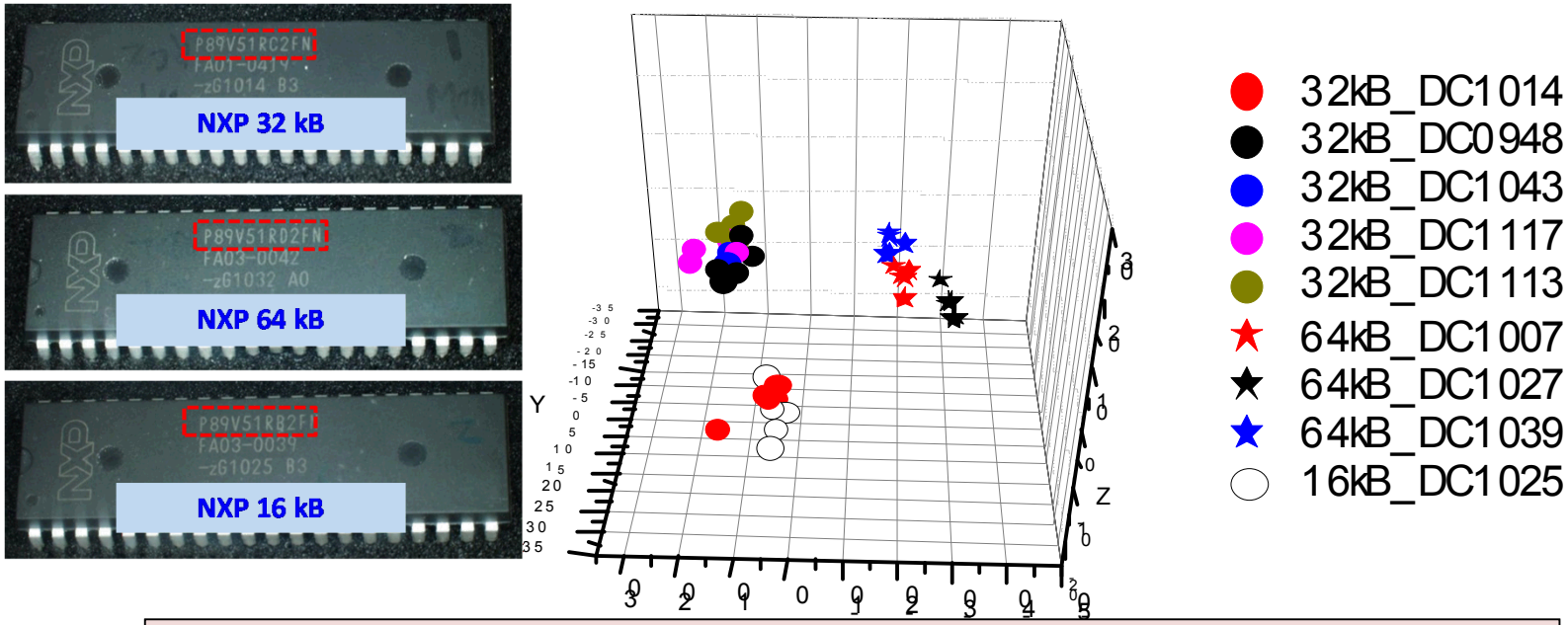
More scattering in Distributor C population

- Distributor A — Genuine
- Distributor B — Counterfeit
- Distributor C — Counterfeit



Different Memory Sizes and Date Codes

PCA of PSA Data of NXP Microcontrollers



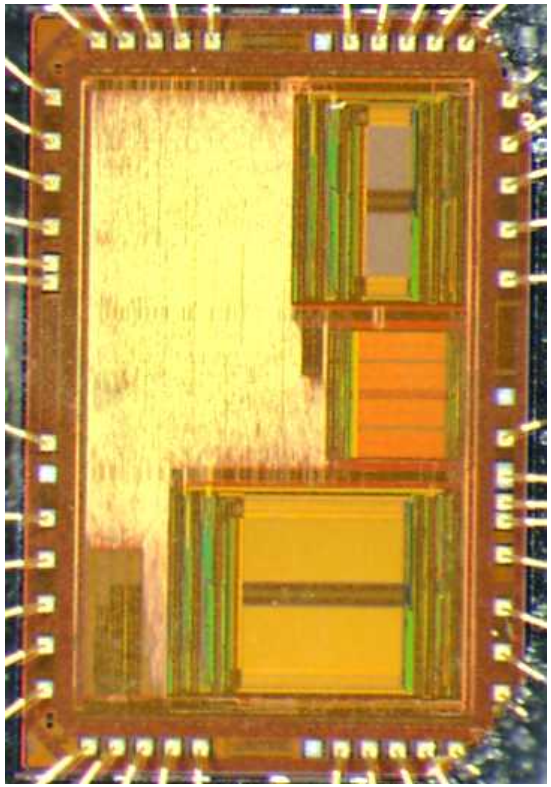
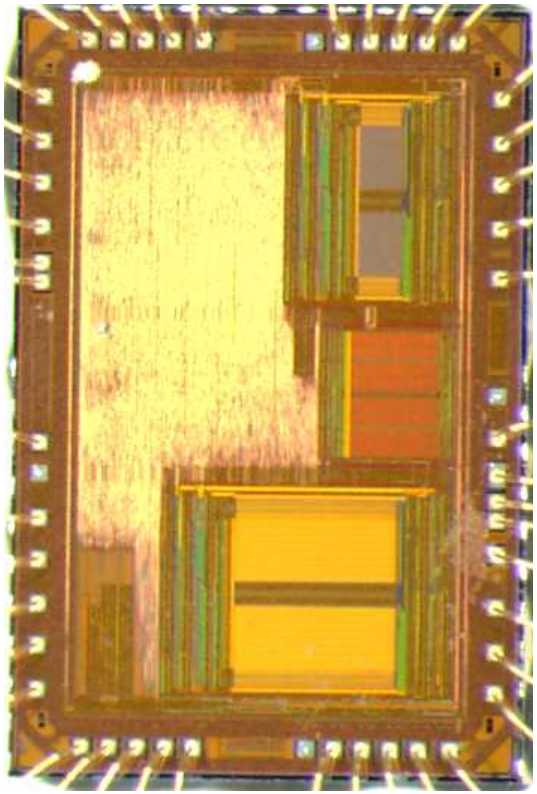
- **32 kB samples show a bi-modal distribution with samples from date code 1014 appearing in a separate cluster**
- **16 kB samples lie in the same cluster as 32 kB samples with date code 1014**

Note that PSA detected that 32kB (red) parts were the same as the parts marked as 16 kB. The next slide shows that the “16 kB” parts were really 32 kB.

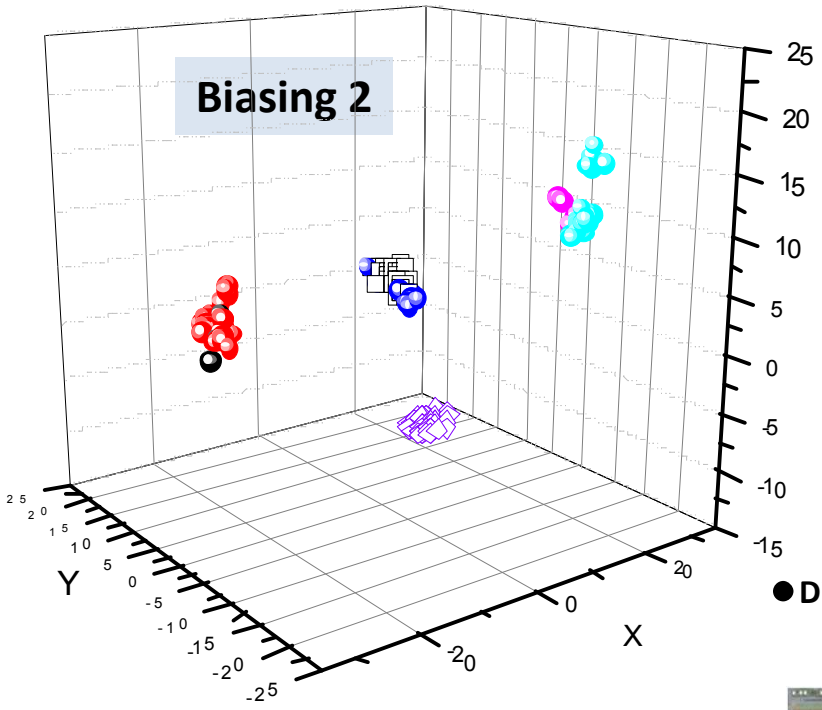
Different Memory Size (32 kB versus 16 kB)

Optical Images of NXP Microcontrollers

- Same dice type used for 32 kB and 16 kB devices
- Devices have different ID codes
- 16 kB devices can be used as 32 kB devices by ignoring the ID code verification

Device with 32 kB memory	Device with 16 kB memory
	

Principal Component Analysis (PCA) of PSA Spectra of IDT71016SA10Y Samples

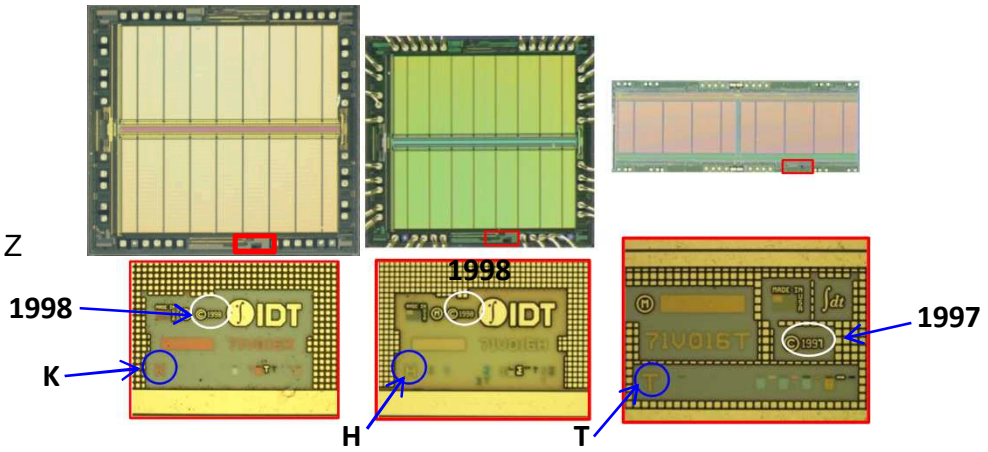


- Distributor A-1_T9930P
- Distributor A-2_T9944P
- Distributor A-3_H0922P
- Distributor A-4_H0216M
- Distributor A-5_H0429M
- Distributor B_H1324P
- Distributor C_K0122M

◇ Distributor C K0122M

▢ Distributor B H1324P

● Distributor-A-1 T9930P

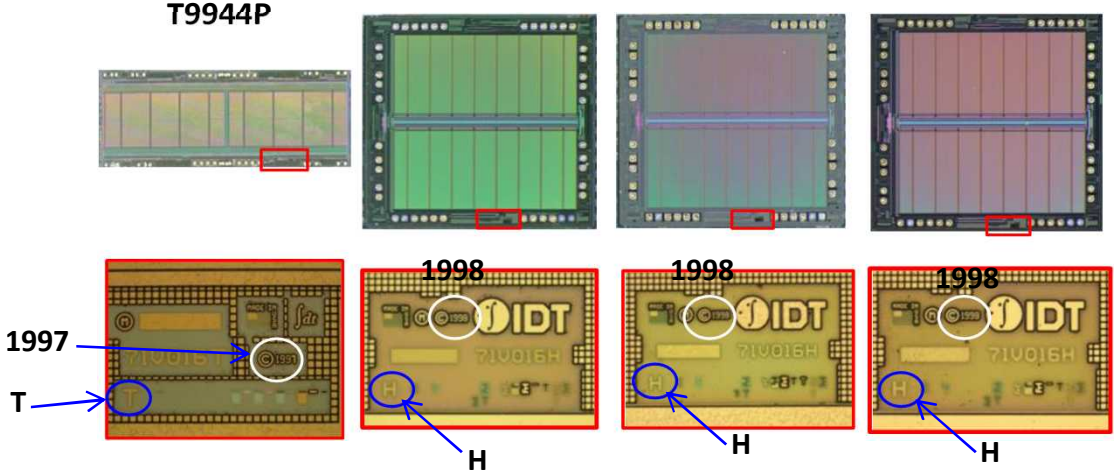


● Distributor-A-2 T9944P

● Distributor-A-3 H0922P

● Distributor-A-4 H0216M

● Distributor-A-5 H0426M



Summary

PSA is an electrical test to identify subtle device changes for counterfeit detection. Results so far have detected

- **Counterfeit devices**
  - **Differences between counterfeit parts and genuine parts**
  - **Differences in manufacturers, foundries, features**
- **Aged devices (used parts)**
- **Irradiated parts**
- **Changes in processing**
- **Changes in packaging**

Other PSA Studies

- **Used advanced modeling to understand PSA signatures**
- **Determined that PSA does not create latent damage/aging of devices being tested**