

Acoustic Impediography: A New Method for Fingerprinting and Navigation

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Intro

Fingerprinting is the most widely used biometric for human identification

Integrated into mobile devices and stationary applications increasingly replacing Password & PIN for access control

Market expectations > \$ 10 Billion by 2015 *)

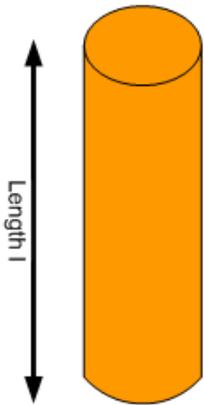
Current technology utilizes Electric Field variation due to fingerprint structure (ridges and valley) implemented in rigid ASIC's

Sonavation's goal: develop a line of swipe and touch sensors based acoustic impdiography , Ultra thin, flexible and inexpensive

Acoustic Fingerprinting Basics

The un-damped and damped rod extension vibration mode is the underlying principle differentiating ridge and valley structures in fingerprints

Longitudinal vibration of a cylinder
Rod Extension Mode



Cylinder: length l
Diameter : d
Density: ρ
Mass: $m = \rho \pi (d/2)^2 l$

Mass: $m/2$

Spring constant: k'

Mass: $m/2$



Fingerprint Structure

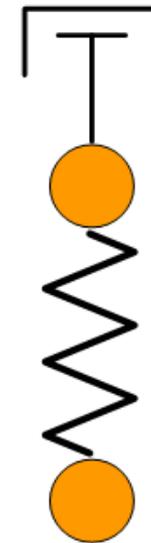
Valley

Ridge

Damping coefficient
 $R_m, k = R_m/m$

Damping: loss of mechanical energy
Via oscillator/tissue interface

Spring constant:
 $k' = Y \cdot A/l'$
 $Y = \text{Young's modulus}$
 $A = \text{Cross-section}$

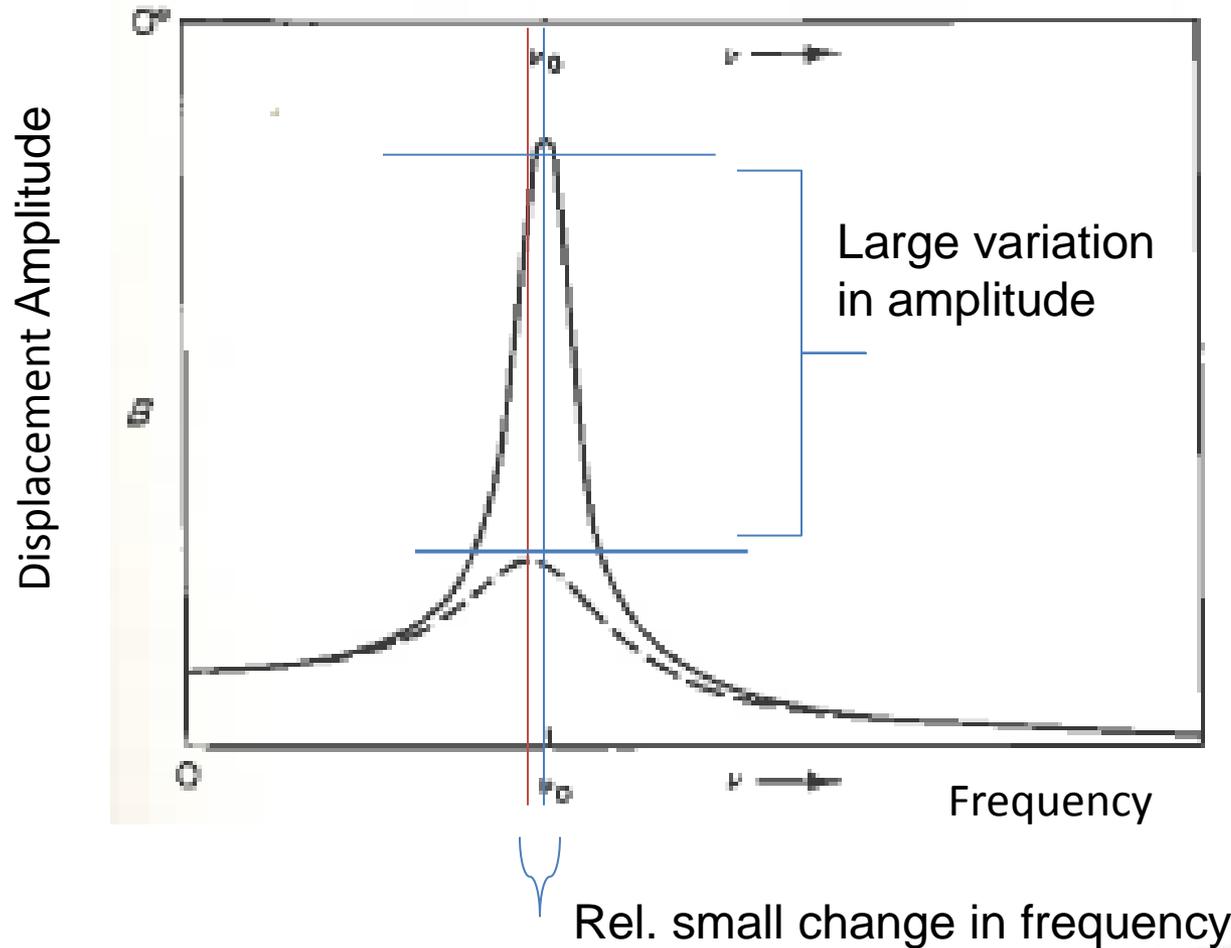


$$f_0 = \frac{1}{2\pi} \sqrt{\frac{k'}{m/2}}$$

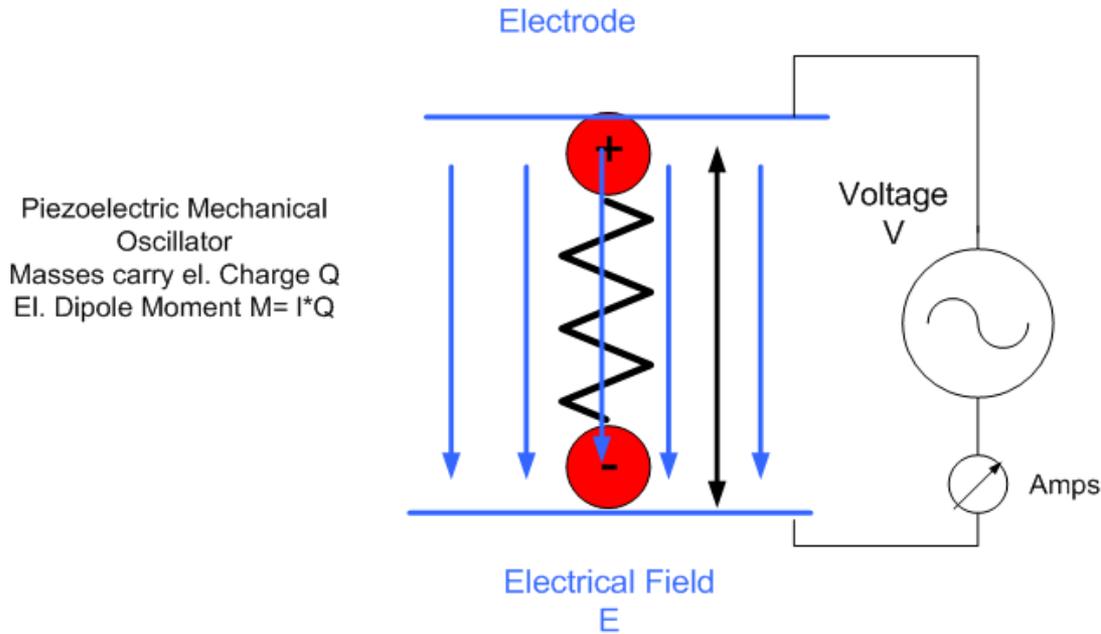
$$f = f_0 \sqrt{1 - \left(\frac{k}{2\pi f_0}\right)^2}$$

Sonavation Technology Basics

Low and highly (11x) damped mechanical resonator



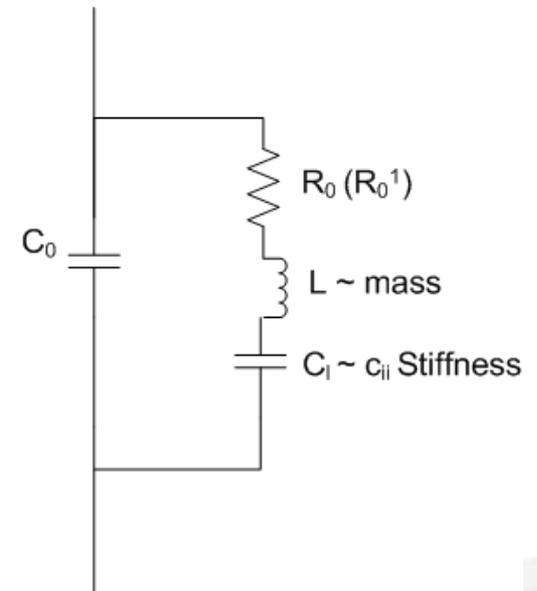
Sonavation Technology Basics



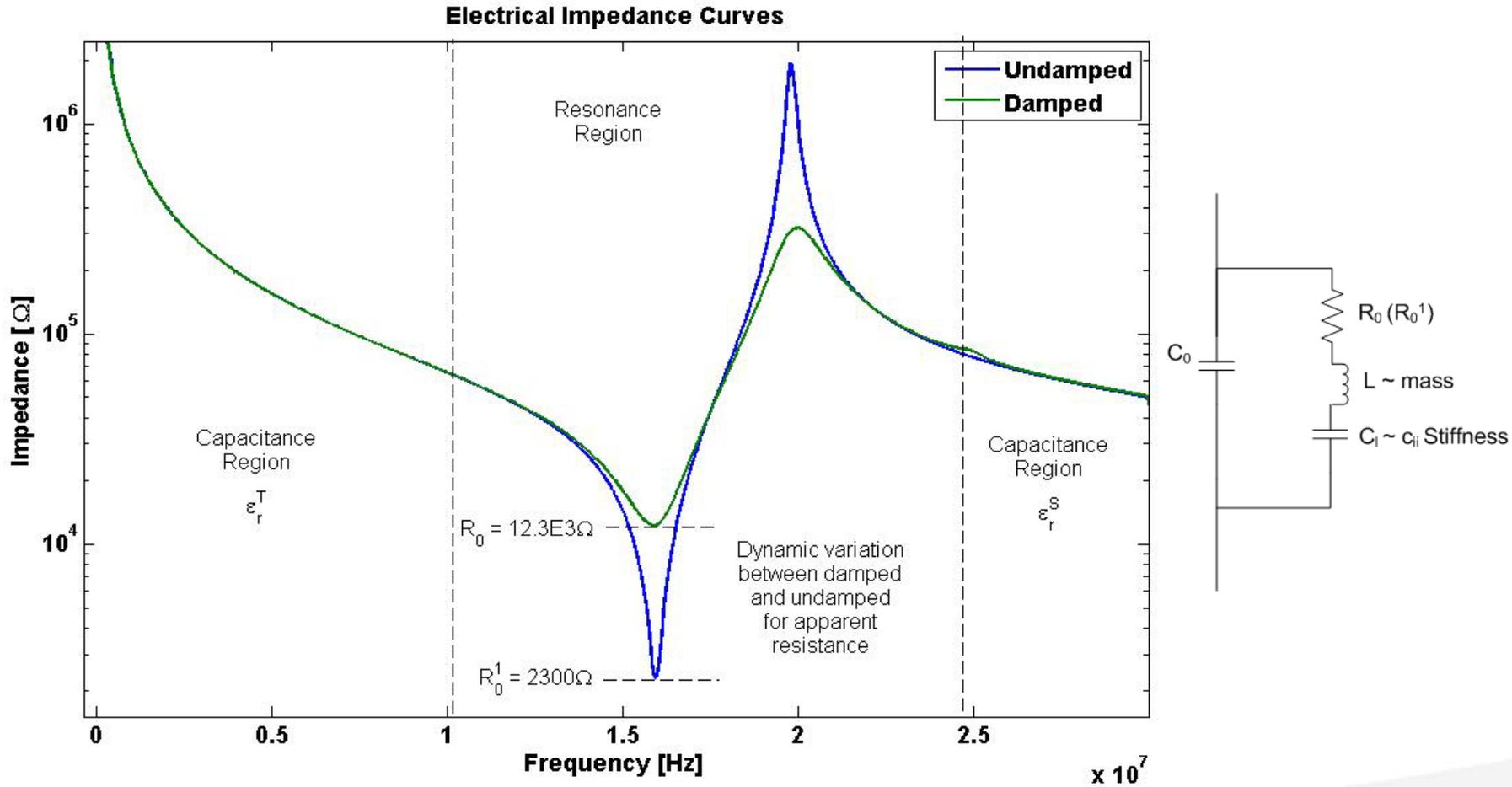
Piezoelectric Mechanical Oscillator
 Masses carry el. Charge Q
 El. Dipole Moment $M = l \cdot Q$

Use of piezoelectric mechanical resonator enables forced mechanical oscillations and detecting mechanical oscillation electrically

If a short pulse is applied the mech. response can be measured tracing the current



Electrical Impedance Loaded/Unloaded

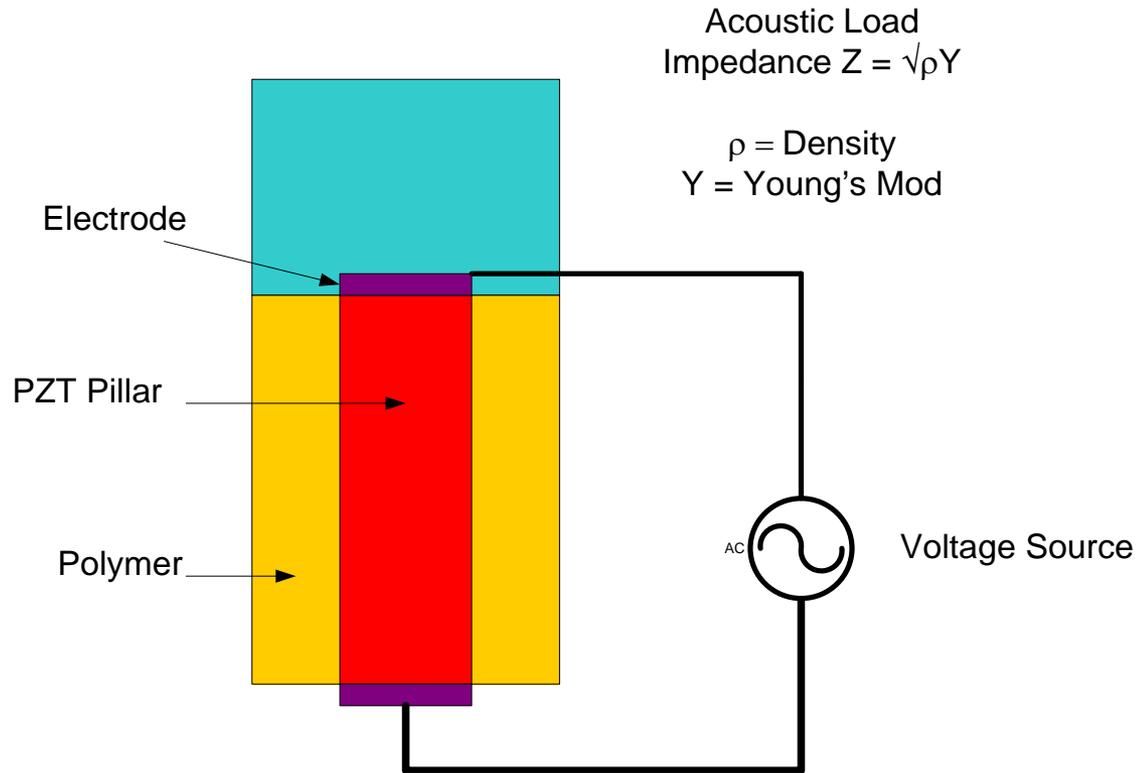


How the Acoustic Impediography works

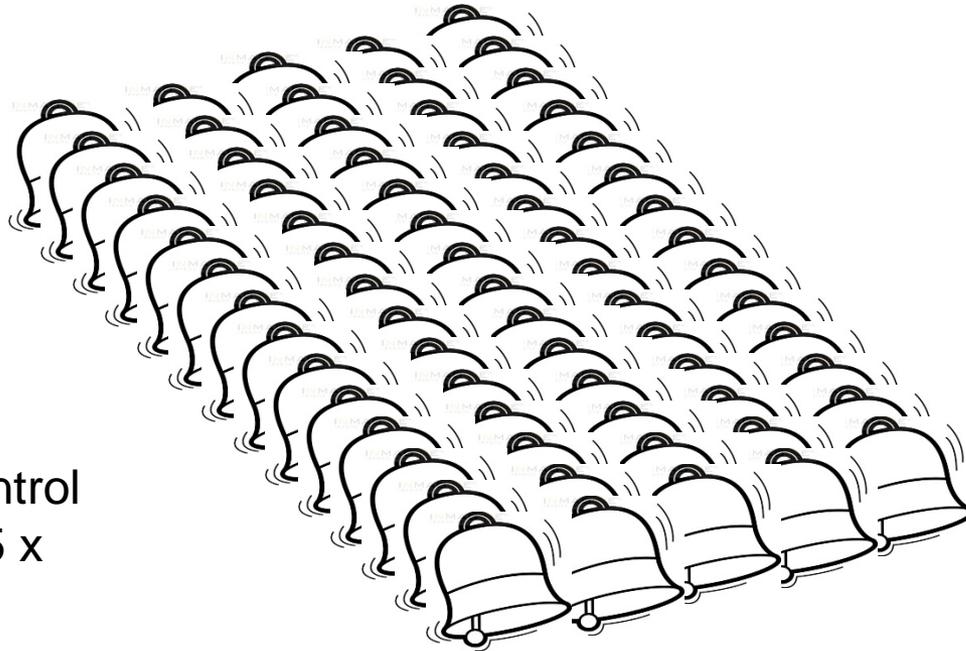


Valley: free ringing bell

Ridge: bell ringing damped



Development Challenge

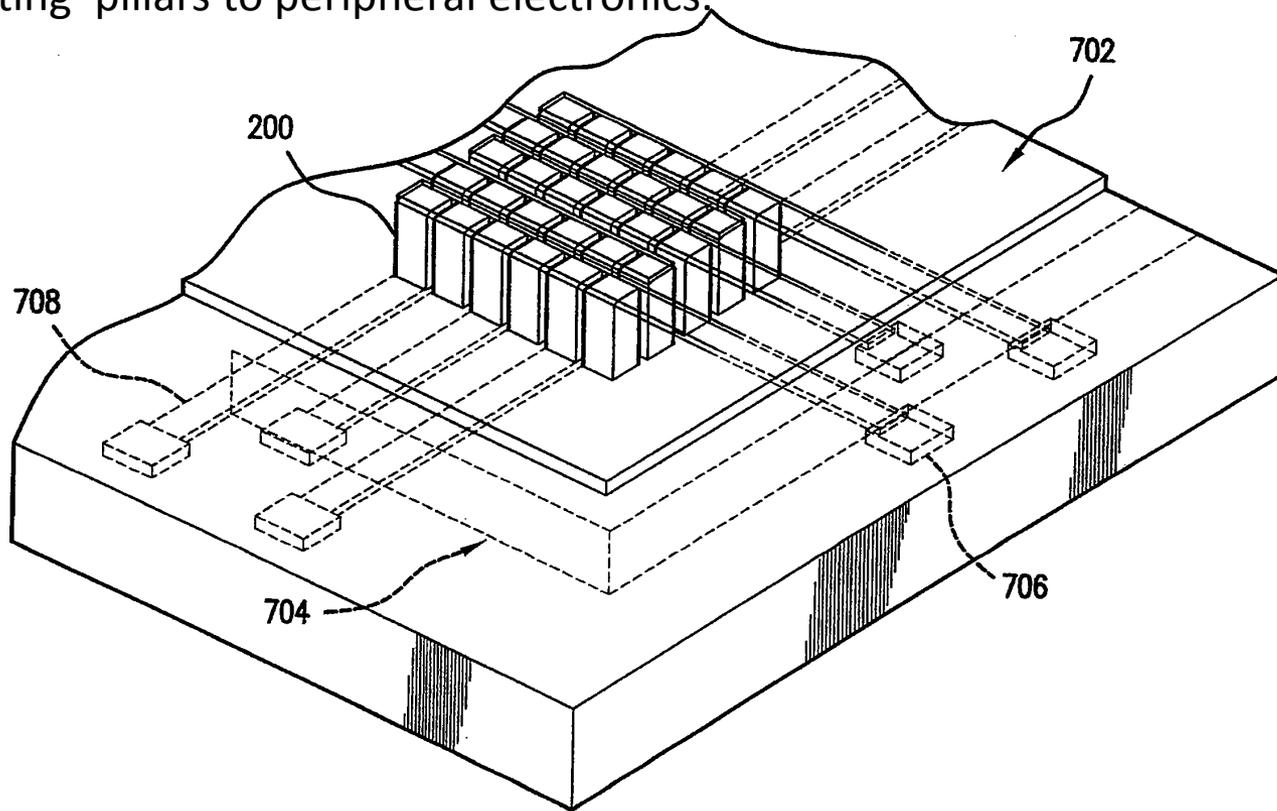


How to drive and control
250,000 bells in a 25 x
25 mm sensor ?

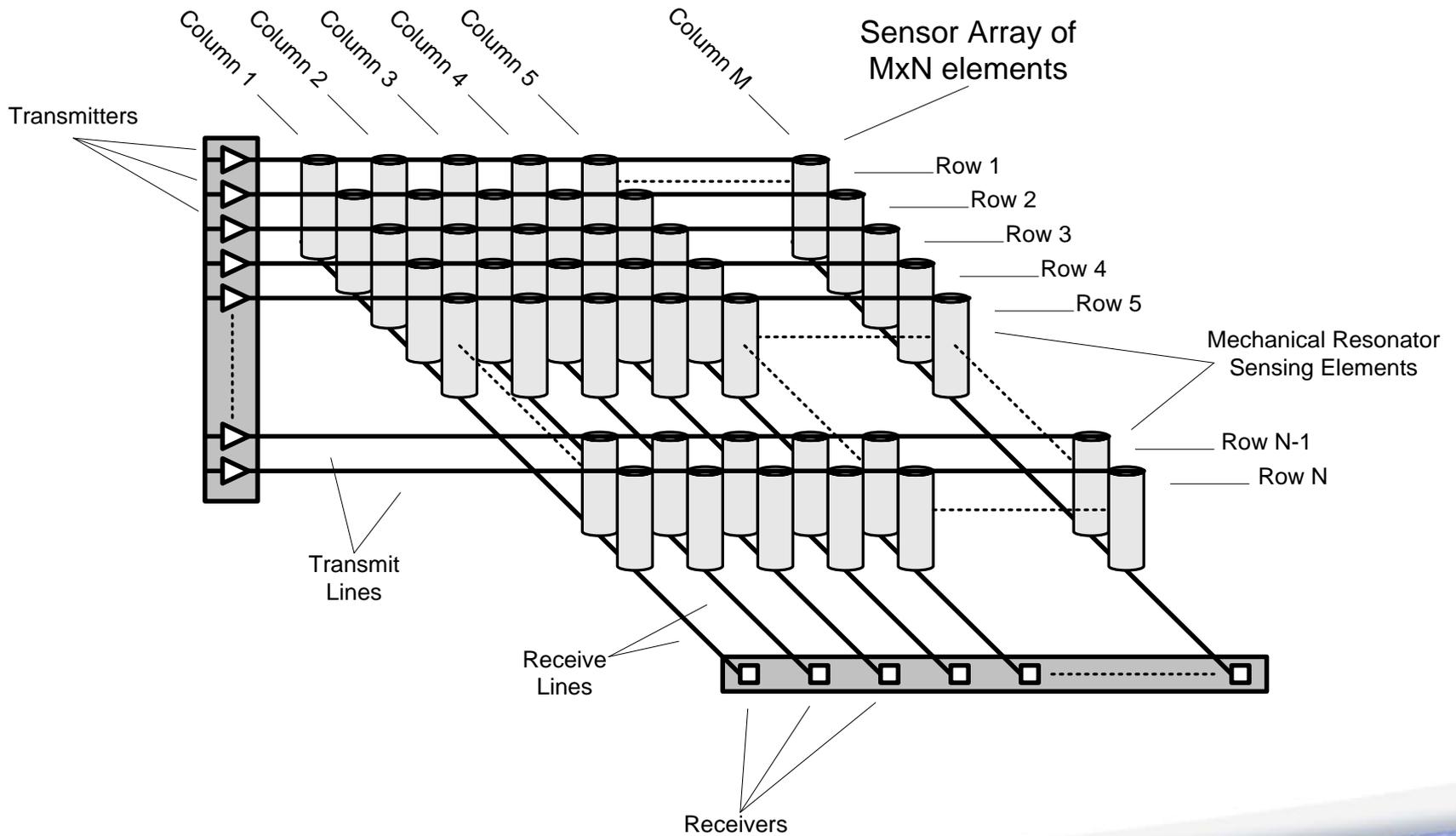
?

Matrix Addressing Scheme

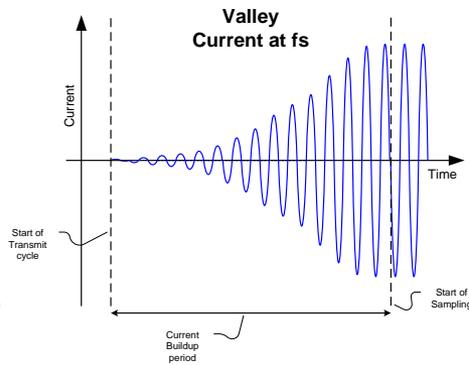
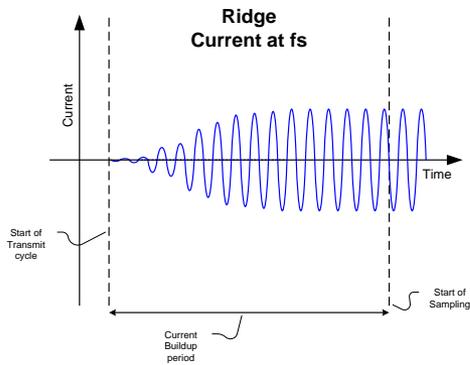
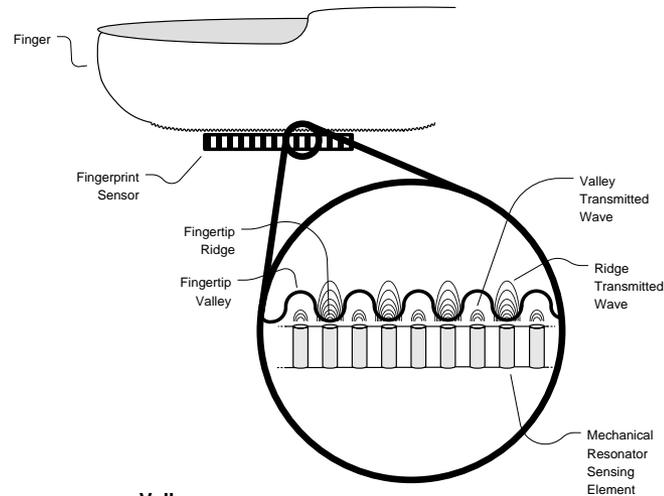
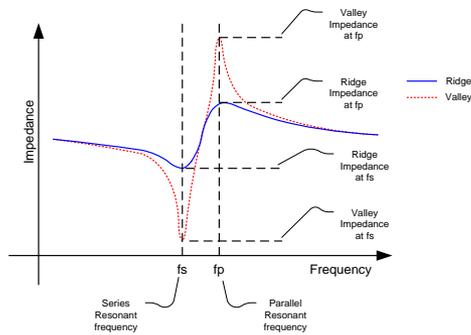
Since 1000's of pillars are hard to be addressed individually a cross-hatched pattern of electrode lines is used for interconnecting pillars to peripheral electronics.



Sensor Topography

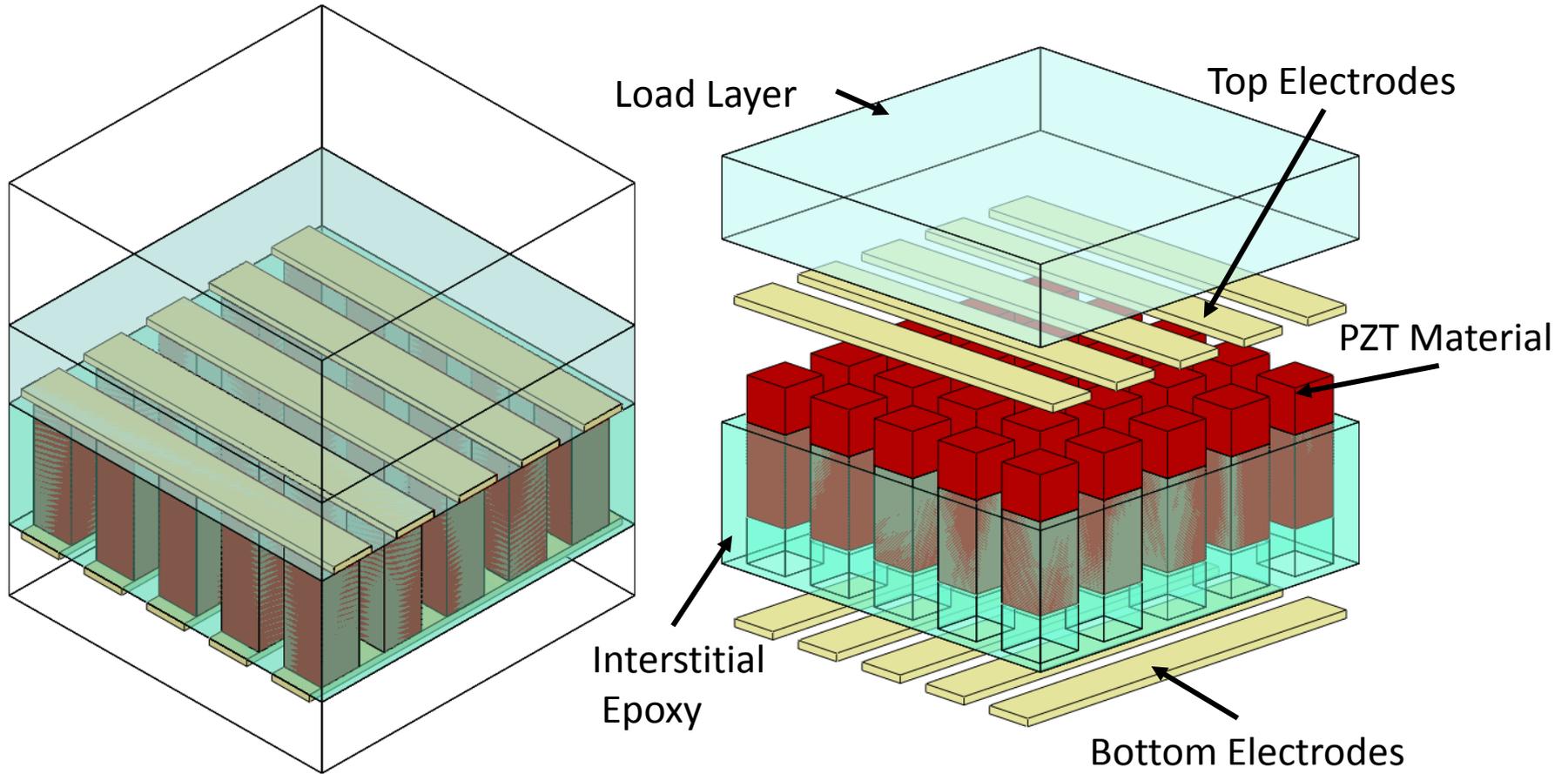


How Acoustic Impediography is implemented

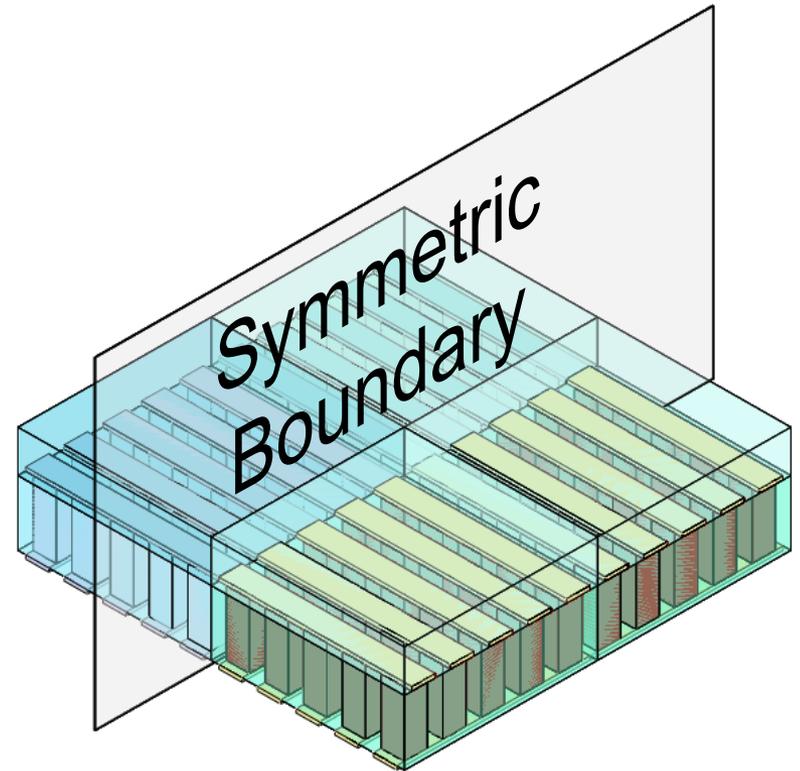
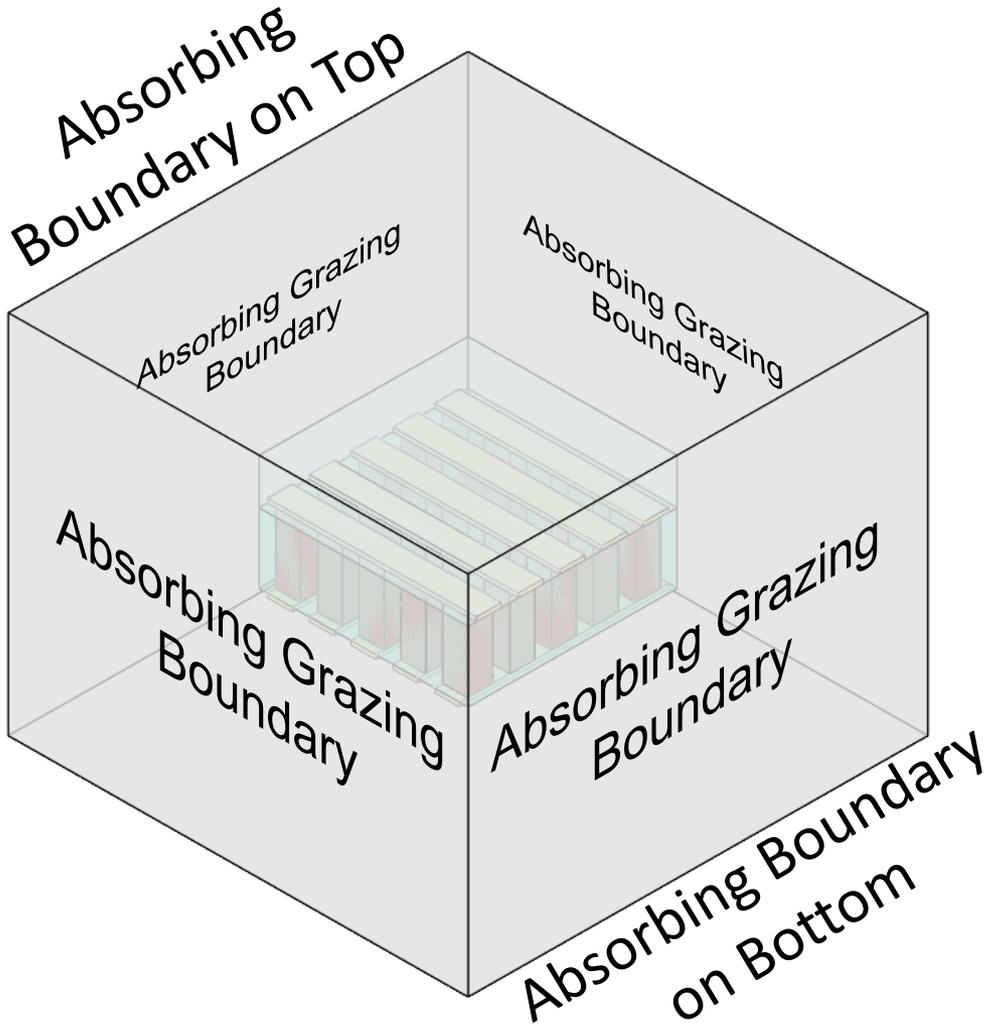


Drawing: C. Liataud

FEM Sensor Model

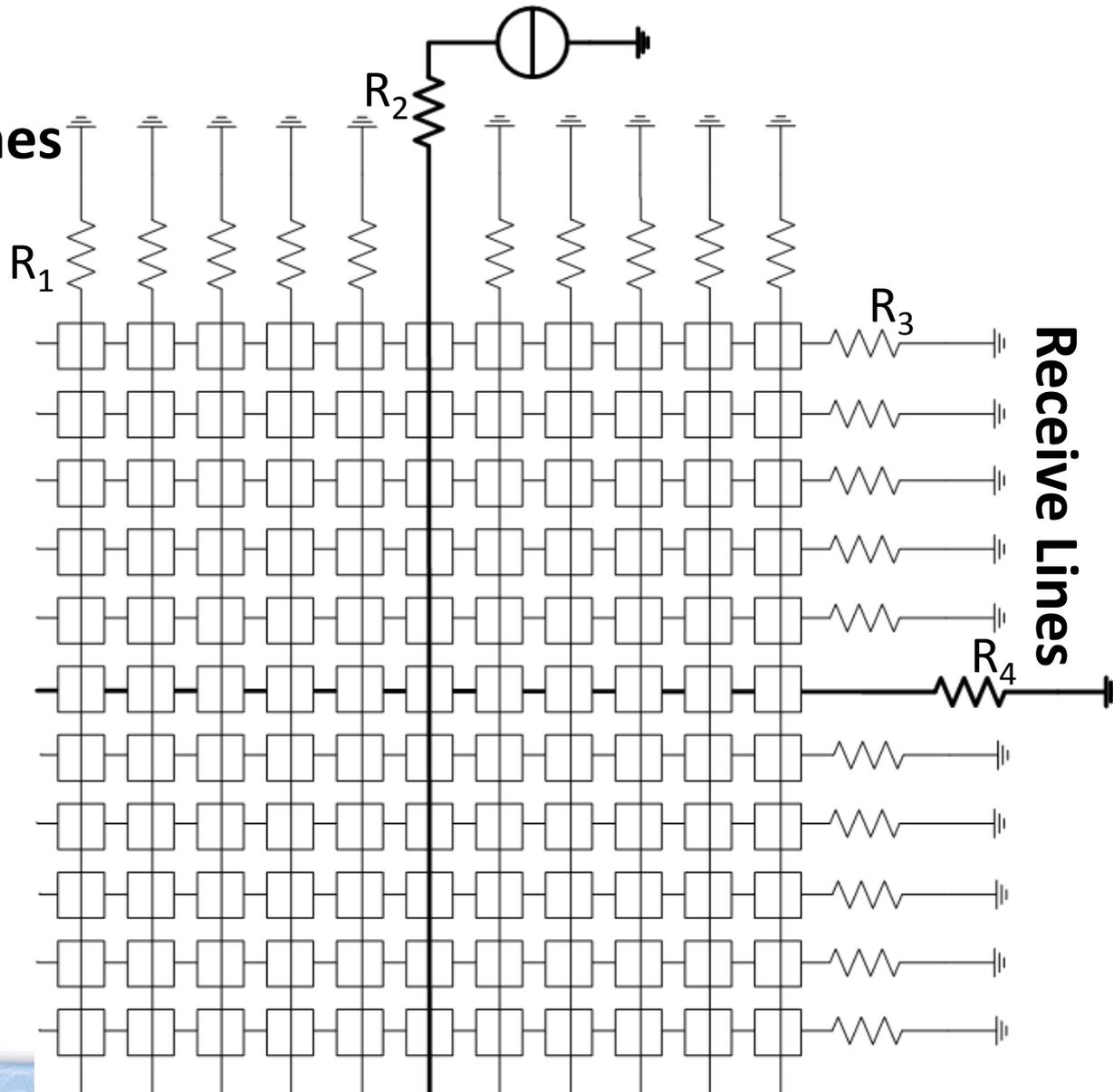


Model Boundary Conditions

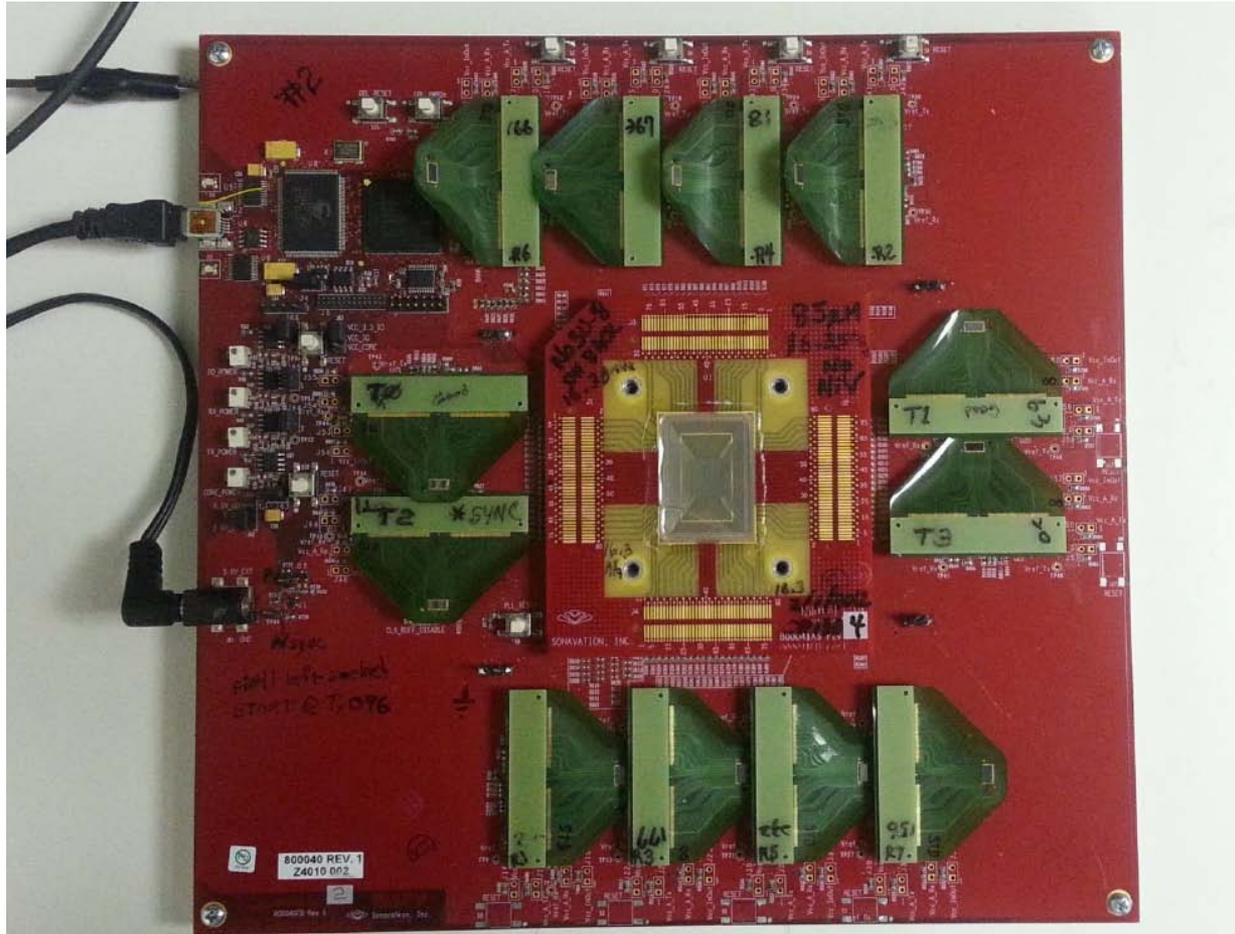


Electrical Interconnect

Transmit Lines



Test Platform



Interactive Sensor Test Platform

FEDS TPoC - Slap Image 1

File Edit View Settings Forms FEDS Commands Engineering Script Window Help

Graph Pixels

255

P-P

000

AutoScale Graphing Mode upper marker 236 lower marker 154 Default Scale

ARX_OFFSET_DATA - linked_array

0xF3

7 6 5 4 3 2 1 0 W R

ARX_GAIN_DATA - linked_array

0x04

7 6 5 4 3 2 1 0 W R

ARX_CTL - Rx_c2v_r

101 = 4K 0x05

7 6 5 4 3 2 1 0 W R

Slap Image 1

Cosmetic Im...

X: 0108, Y: 0065, Gray: 153

X: 0023, Y: 0188, Gray: 255

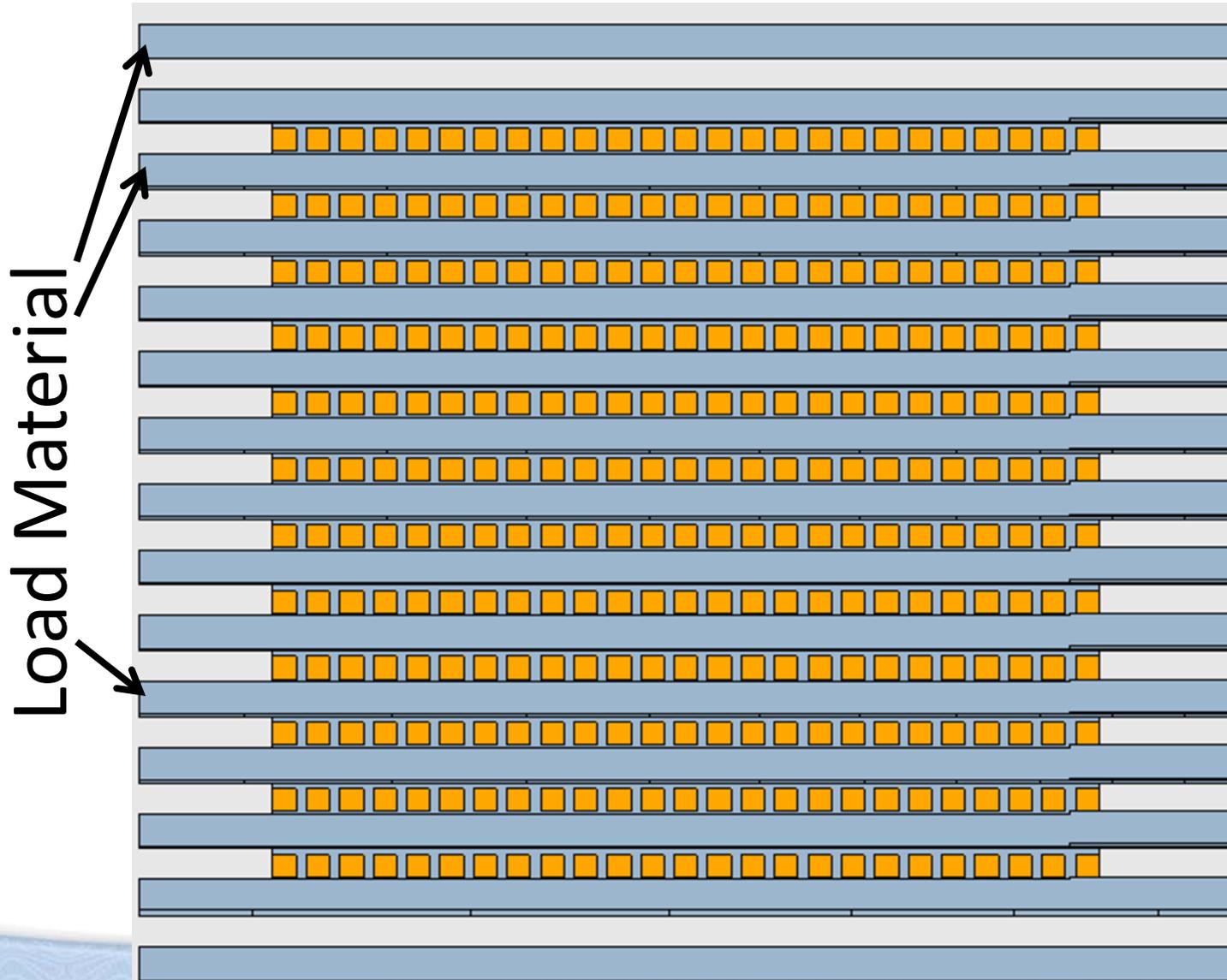
Log Window

```
Image grayscale noise: StdDevP = 0.784
FEDS build configuration: Release_f_b1

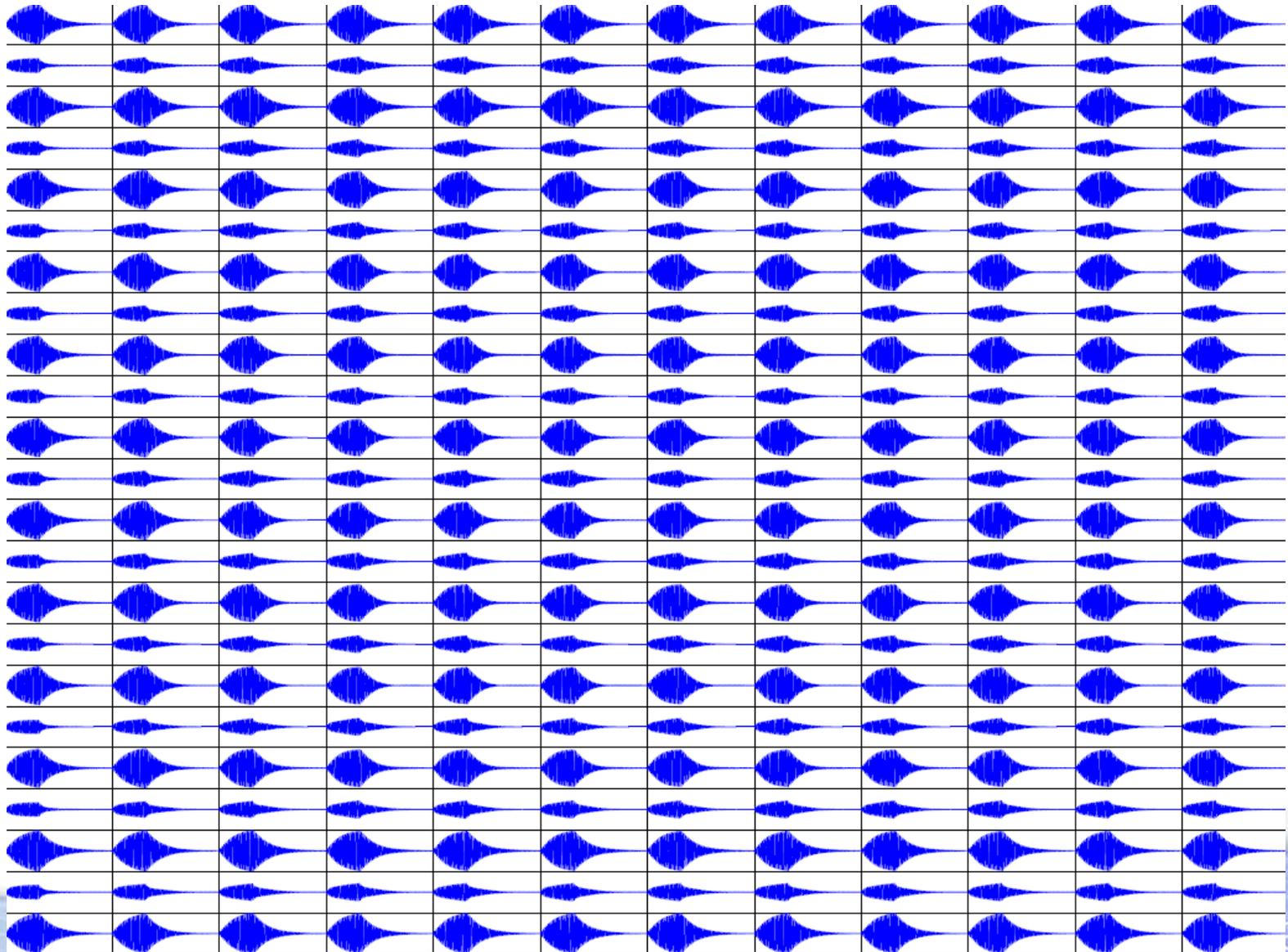
CaptureModeThread Starting
Dynamic Optimization mode is ENABLED for Enroll, Verify, and Identify.
Slope-intercept mask created and enabled.
D.O. settings for this image: Offset = 0xCC Gain = 0x0B
Minutiae count: 14
Wrote I:\FEDS\Common\TPoC\Database\Capture\RAK1_RI0160S.bmp
Wrote I:\FEDS\Common\TPoC\Database\Capture\RAK1_RI0160.xml
Cleaned-up BMP files.
Starting to append the Quality Metrics file...
CaptureModeThread Exiting
```

Ready Device is ready. NUM

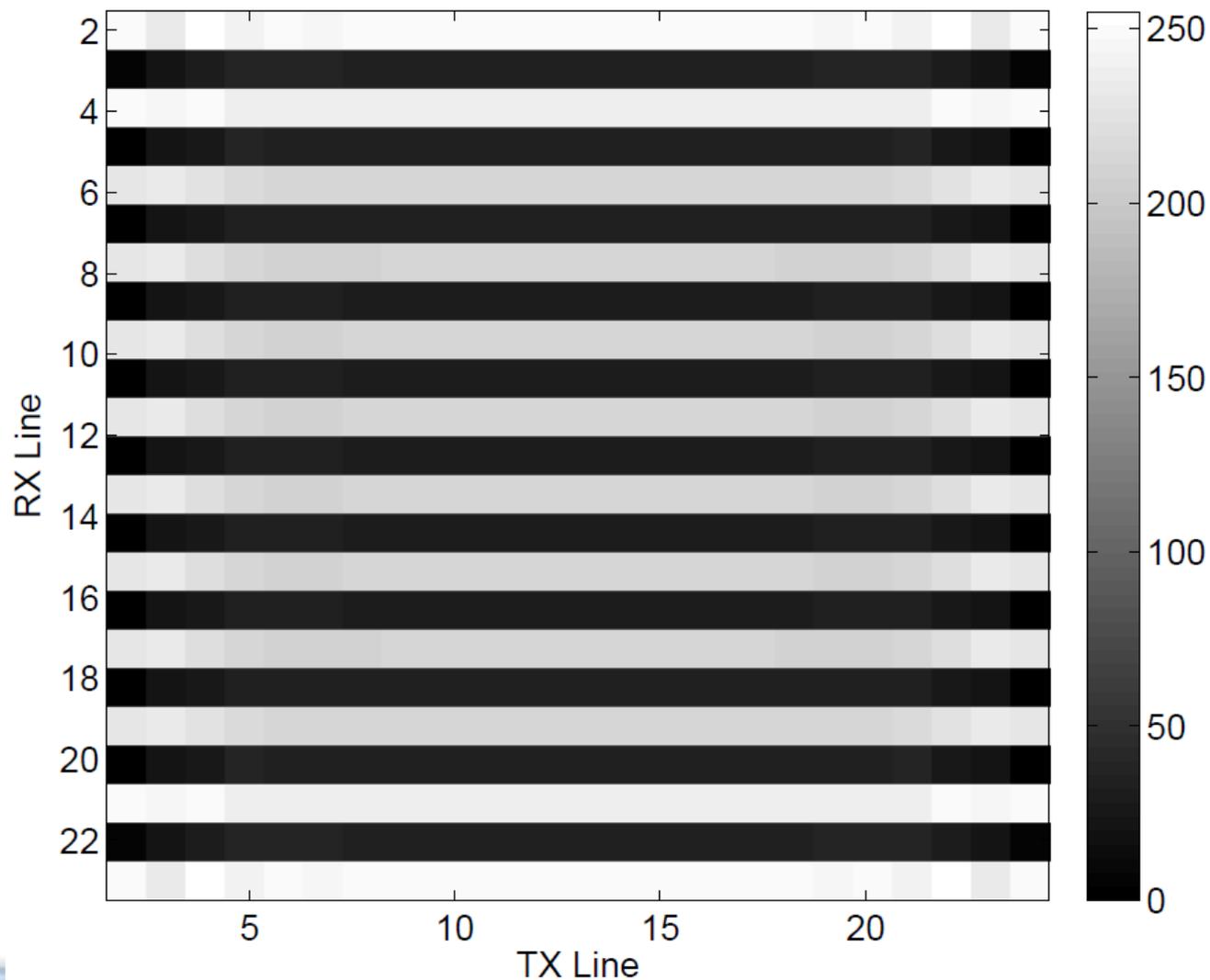
Spatial Resolution



Modeled Ridges and Valleys

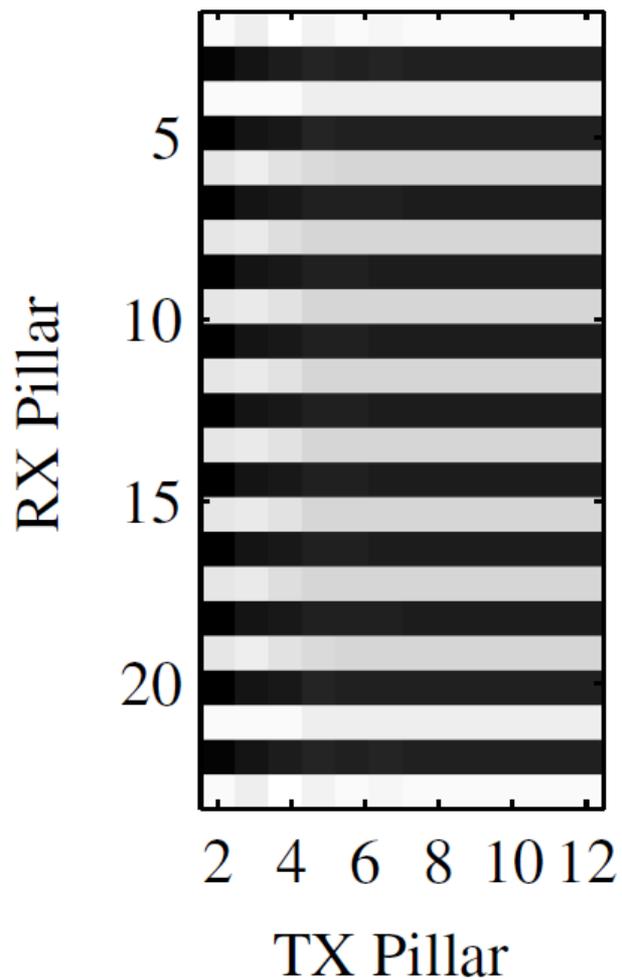


Result for 500 dpi Resolution Phantom

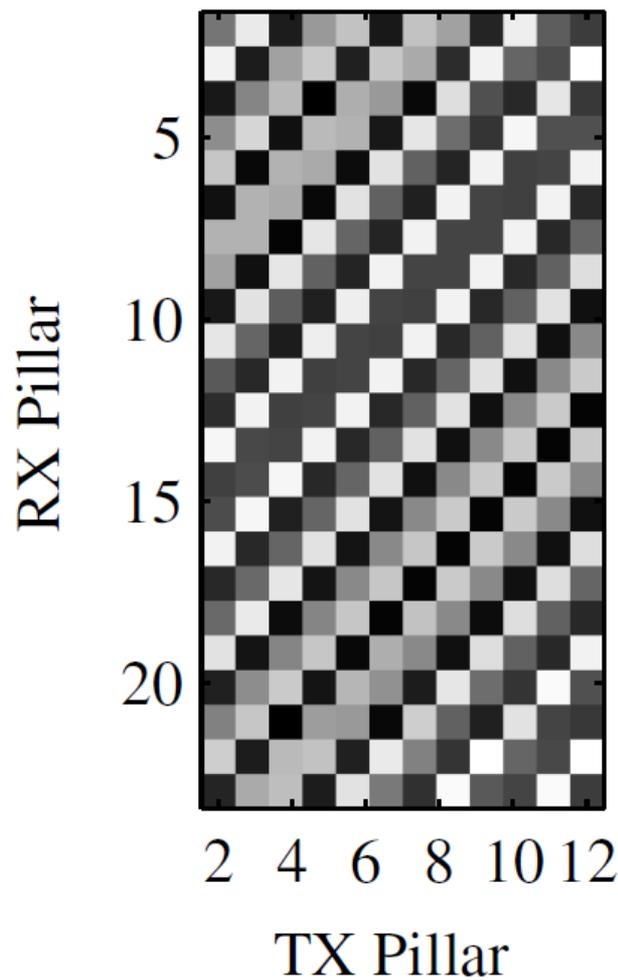


Modeled Phantoms

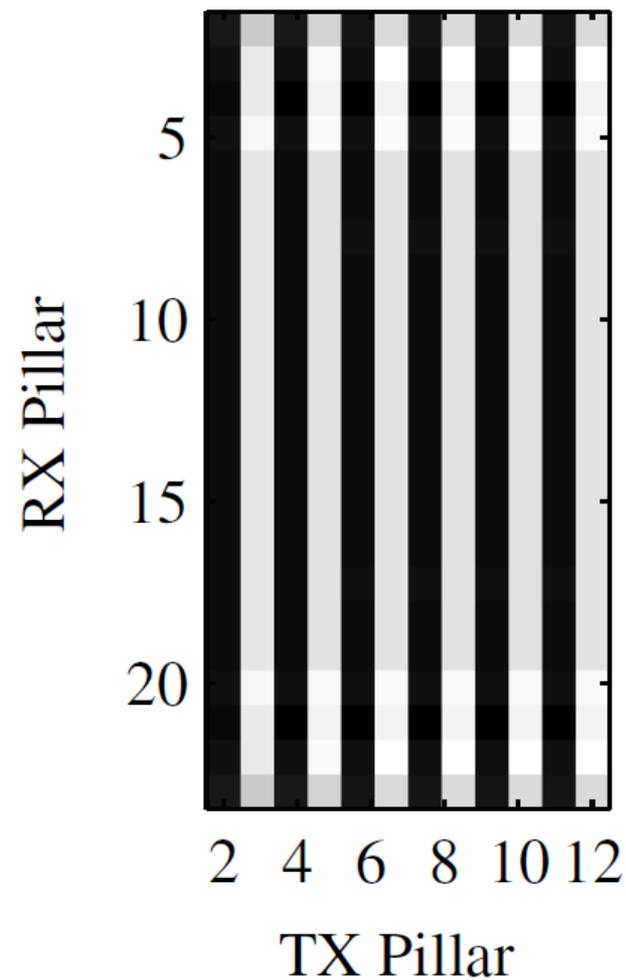
Rotated 0°



Rotated 45°



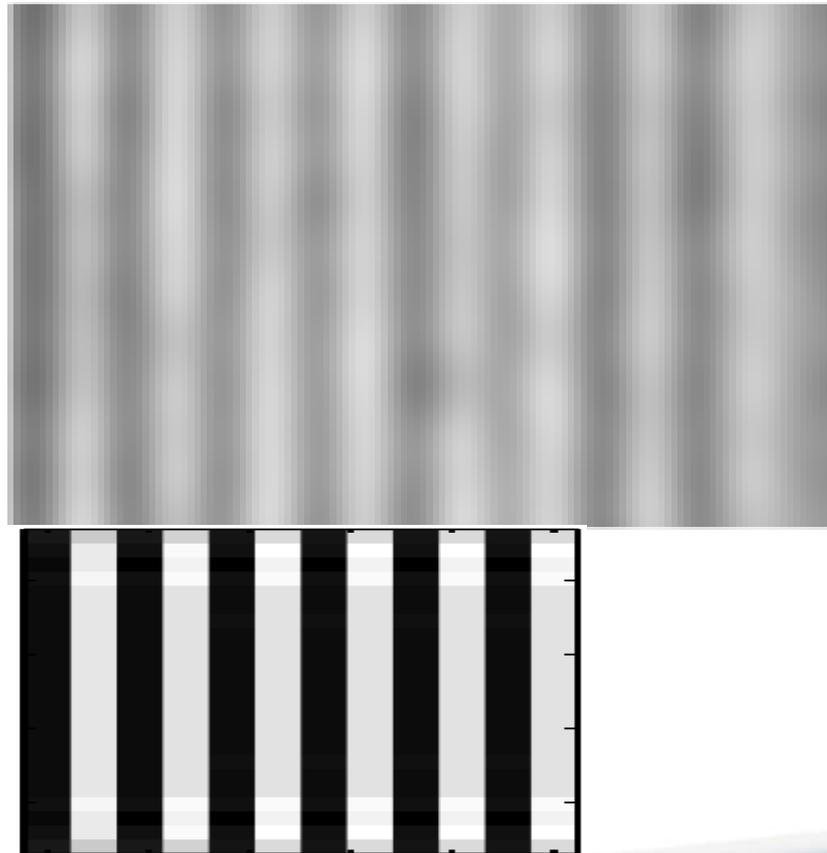
Rotated 90°



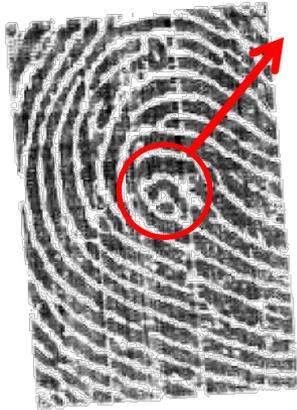
Comparison Optic Versus Acoustic



Measured Resolution
Resolution phantom: 10 cycl/mm



Navigation



Navigation is simply obtained by selecting a smaller center fingerprint and apply a 2-d cross-correlation between consecutive images to estimate in which direction the pattern has moved.

Conclusion

- The 1-3 piezo composite based acoustic fingerprint technology is proven to provide a robust, high-resolution and low cost sensor. The low thickness (< 300 um total) and the flexibility allows integration into many mobile devices and even smart cards.