N2N CHALLENGE

IARPA Nail-to-Nail Challenge Registration

All Stage 1 Registrations need to be submitted to Challenge.gov by March 17, 2017

Company Info		Technical POC	
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N2N System Description			
Title:GHz Ultrasonic Fingerprint Sensors		☐ Software Solution (uses conventional sensor) ■ Hardware/SW Solution (custom hardware and software)	

Abstract

At a high level, what do you propose to do?

We plan to develop a N2N and latent finger print imaging tool that utilizes GHz ultrasonic transducer arrays that are rotated or moved above the finger for imaging the nail-to-nail fingerprints, and acquire latent fingerprint images. The GHZ ultrasonic using ultrasonic waves at GHz frequencies. The resolution of any imaging system utilizing waves is proportional to the wavelength. At GHz frequencies, the wavelength of ultrasonic waves in tissue is 1-3μm. Such wavelength is much smaller than features on skin surface. We have already demonstrated imaging fingerprint with a single line of 64 GHz US pixels. We will use these arrays to acquire fingerprints, and then process the data to prepare data files for the government analysis tools. In addition to N2N fingerprint we aim to acquire latent images utilizing the high absorption property of ultrasound at GHz frequencies. The high absorption would enable us to identify oils from latent fingerprints. Initial data acquisition suggest that we can identify oil versus paper versus lotion.

Concept of Operations

How would a user interact with the device?

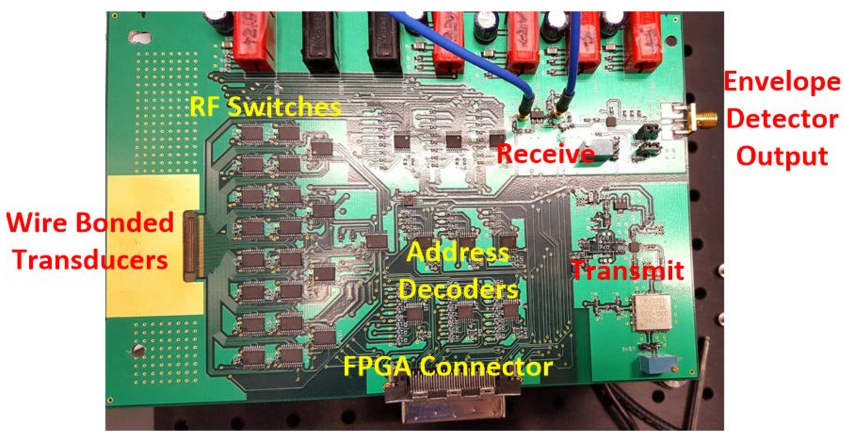
For N2N: The use will insert one finger in the device, and the device will rotate the sensor line around the finger to image the finger. The sensor chip will consist of 64 pixels that will be connected to a pc-board to process the information and transmit the fingerprint info on an on-board microcontroller.

For Latent Imaging: the sensor chip single pixel line will be moved across the area to be scanned to obtain absorption versus coordinates to identify latent images.

System Diagram

What are the main system components and their interrelationships/dependencies?

The main component will be a PC board shown to the right, with the integrated AlN pixel array, and all electronics to read each pixel. This board will be connected to a PC to acquire data.



- *Electric/Power source (supply voltage, current) and any battery specifications (if applicable)*
  - *The power source will be a power supply box that we will bring. This is a 12V power supply that is sued to power the pc-board.*
- *Materials of construction – particularly for any part(s) that would contact the subject*
  - *The silicon chip backside will be in contact with the finger surface. This surface has no sharp points and is being used to acquire fingerprints daily.*
- *Optics/"light" information (type, wavelength, frequency, power)*
  - *No optics will be used. We will utilize GHz ultrasonic pulses to reflect off finger surface. The wavelength in the silicon chips are in the 5-10micron range, and in tissue about 1-2microns.*
- *Original specs from any COTS parts, plus info about any modifications*
  - *COTS RF electronics including switches, transmitters, receivers, demultiplexors, will be used. Eventually these components can be integrated onto CMOS.*
- *Description of any mechanical movements*
  - *A linear motor will move the pc-board as the subject rotates the fingers. A planar x-y actuator will move the sensor chip for the latent image acquisition. Each finger will take approximately 5 seconds.*

Anticipated Equipment

What are the software packages and/or hardware components?

The hardware used will be a miniaturized version of the board already developed as shown below. The software to extract the fingerprint data has been partially developed. As part of this effort we will be further developing the software to extract the fingerprints from the edge data.

Devices

Will you be constructing a new device for this challenge or will you be extending the use of an existing device for this challenge? Please select one of the following: Creating New Device or Augmenting Existing Device.

We will be modifying existing devices and boards, developed under the I-ARPA TIC program to make the device.

Matchers

*A) Which Matcher will your team use for the **tenprint** to **tenprint** comparison? Please select one:*

__X__ Government ___ Custom ____ Not Sure

*B) Which Matcher will your team use for the **latent** to **tenprint** comparison? Please select one:*

__X__ Government ___ Custom ____ Not Sure

Safety Assessment

Are there any components (electrical components, illuminators, etc.) in your design which may cause safety concerns with human subjects testing?

None. The ultrasonic power in pulses is in the nano-watt to microwatt levels.

Innovation

While there are many other ultrasonic fingerprint sensors, they tend to operate at low frequencies of a few MHz that prevents high resolution stand-off from transducer imaging. Our solution allows the finger to be placed at opposite side of the sensor, enabling decoupling of the electronics with the sensor interface. Furthermore, the GHz operation enables direct CMOS integration such that simple single chip solutions with a RF interface are possible. This proposal describes a nail-to-nail fingerprint technology based on novel GHz Ultrasonic TActile piXEL (taxel) arrays. The most important preliminary result is related to ultrasonic fingerprint sensing [1, 2] (Best paper award at IEEE MEMS 2017). The result demonstrates

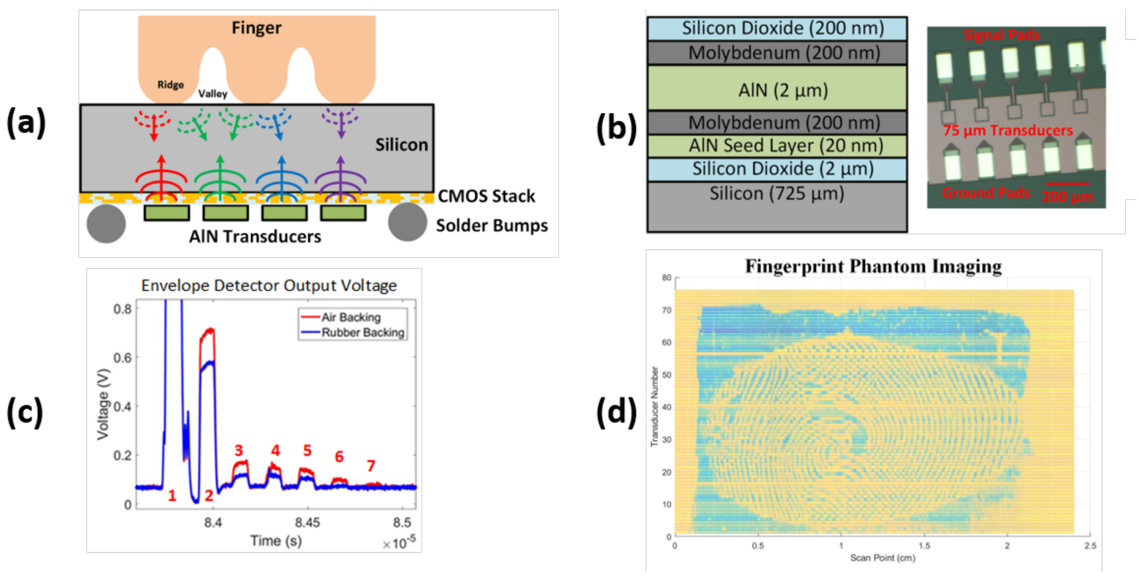


Figure 1: Gigahertz ultrasonic transducers, made of thin-film piezoelectric AlN material, can be post-fabricated onto CMOS wafers to provide phased arrays of gigahertz sonics energy.

our ability to measure fine details down to $< 20\mu m$ resolution, with a 64-AlN taxel array operating at 1.3 GHz. The GHz ultrasonic packet trains are transmitted from the transducer side of wafer, shown at the bottom in Fig. 1a,b. The pulses are received back after reflected from the opposite side where the finger is placed (Fig. 1a,c). The return signal amplitude and identify fingerprint ridges and valleys (Fig. 1d). A key advantage of the architecture is that the ultrasonic transducers and *electronics are one side of the CMOS chip, while the sensing is done on the opposing side*. Hence sensing side can have uniform coatings without the need for special interconnect technologies such as through-silicon vias. The touch surface is electrically and mechanically isolated from the transducer side.

Based on the above result, we define a new imaging concept - The taxel array is a tactile camera, or a TAMERA. Each tamera chip can image fingerprints at 5um resolution at an effective dpi of 5000dpi, with a power consumption of 0.6-mW for a 50Hz framerate output of a 300x300 pixel data. Tamera chips will be 5mmx10mmx200μm dimensions that will have four-wire serial communications (SPI-like) bus to communicate the data collected on each chip. *Because of the integrated data connectivity, and the very small dimensions of the* *chips, and low power with no local heating, the chips can be arranged in many possible 3D configurations such that the form-factor of eight or more chips can still be placed around a finger volume.* This will allow our technology to be used in many different configurations that maybe needed for settings in immigration lines, versus covert fingerprint detection.

1. *Image surface particles:* The high operating frequency of 1-2GHz allows for ultrasonic wavelengths of 4-9mum in silicon and 1-2mum in tissue. These small wavelengths allow for differentiation of surface ultrasonic impedances of even E.coli or anthrax particles.

2. *Temperature and thermal conductivity measurement:* In addition to ultrasonic impedance measurement, we also measure the time-of-flight of ultrasonic pulses.

3. *Ultrasonic dispersion:* can be obtained over a wide frequency band between 1.1GHz to 1.6GHz, which would enable identification of different materials, and even identify potential artificial skins or skin transfers.

4. *Surface moisture content:* can be measured to identify sweat content to potentially measure nervous or stress in the subject being fingerprinted.

5. *Surface particle dislodging and radiation force application:* The arrays of taxles can be driven at different phases and delays to realized a focused beam of ultrasound with sufficient radiation pressure to loosen stuck particles on the skin. The pressure maybe sufficient to force tissue fluids to be released for sampling. After the fingers are removed, any left over particles can be imaged by tamera chips to indicate that sufficient dust particles came off such the sensor surface needs to be wiped to collect the samples.

6. *Latent Fingerprint Imaging - High absorption at GHz Frequencies:* Ultrasonic wave absorption with waves at a frequency f in materials increases as f^2. This absorption is high enough such that a 1.3GHz wave will aborb in a 20-30um layer of tissue. By increasing the frequency to 2-3GHz, this absorption occurs in less than a micron. Hence, very thin coatings of oil or bio residue will show absorption.

References

[1] J. Hoople, J. Kuo, M. Abdel-moneum, and A. Lal, "Chipscale GHz ultrasonic channels for fingerprint scanning," in *2015 IEEE International Ultrasonics Symposium (IUS), 21-24 Oct. 2015.* Piscataway, NJ, USA: IEEE, 2015, p. 4 pp. [Online]. Available: http://dx.doi.org/10.1109/ULTSYM.2015.0027

[2] J. Kuo, J. Hoople, M. Abdelmejeed, M. Abdel-moneum, and A. Lal, "64-Pixel Solid State CMOS Compatible Ultrasonic Fingerprint Reader," in *2017 IEEE International Conference on Micro Electro Mechanical Systems (MEMS), 22-26 Jan. 2017.* Piscataway, NJ, USA: IEEE, 2017, p. 4 pp.