



# MEMS ULTRASONIC RANGE-FINDING SOLUTION FOR 3D-GESTURE HUMAN MACHINE INTERFACE

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# Chirp Microsystems Company Background

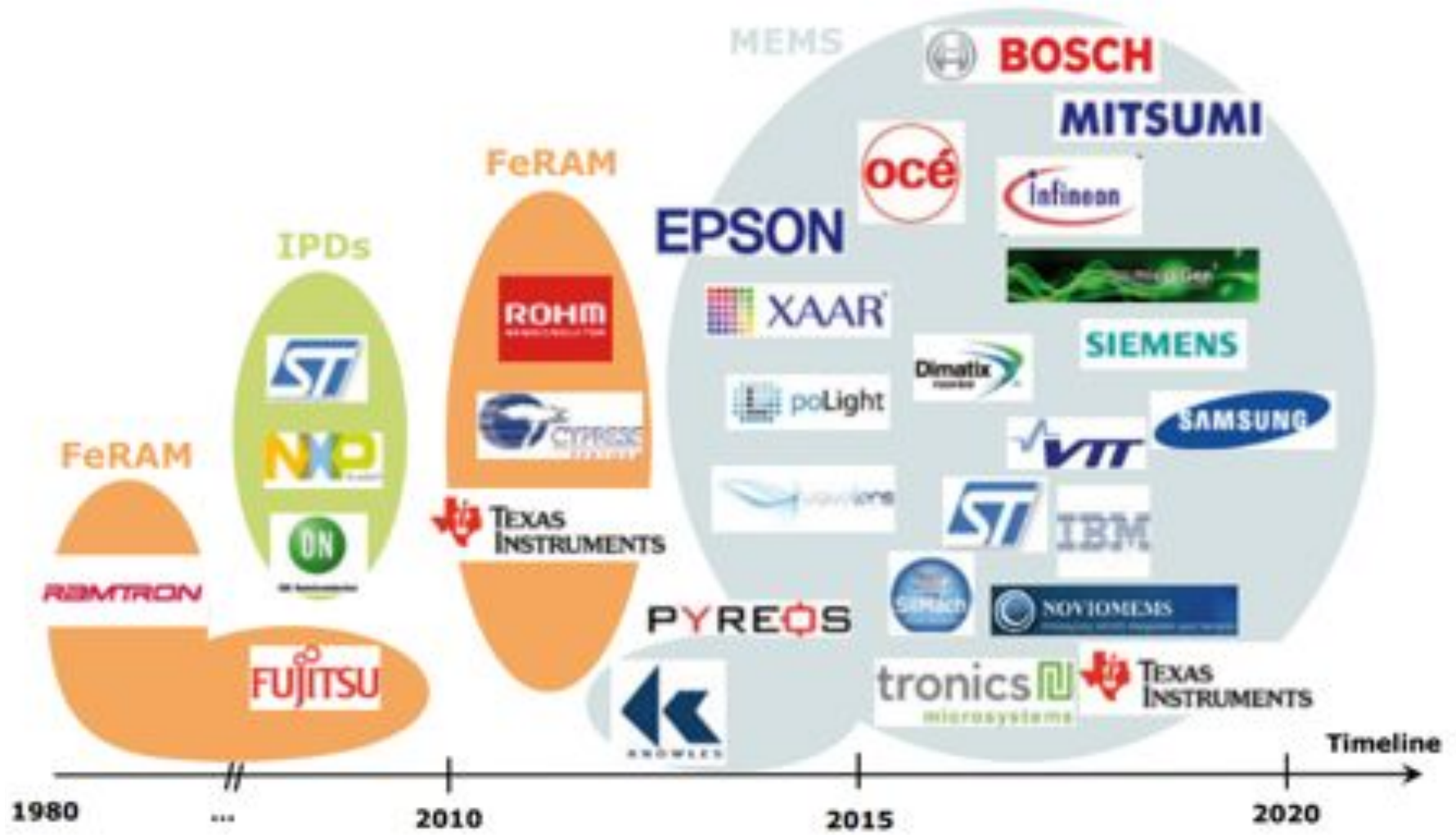
- Fabless Startup Providing Low-Power MEMS Ultrasonic 3D-Sensing Solutions for IoT
- Founded in 2013
- Technology Developed at Berkeley Sensor and Actuator Center (BSAC) at UC Berkeley/Davis
- Part of the UC Berkeley Startup Accelerator Program, SkyDeck, in Berkeley, CA



# Outline

- Introduction
- Piezoelectric Micromachined Ultrasonic Transducers (PMUTs) for Ranging and Gesture-Input Solutions
  - Market and Application Requirements
  - Competing Technologies
  - Air-coupled PMUT Arrays Design and Manufacturing Considerations
  - Demo
- Summary

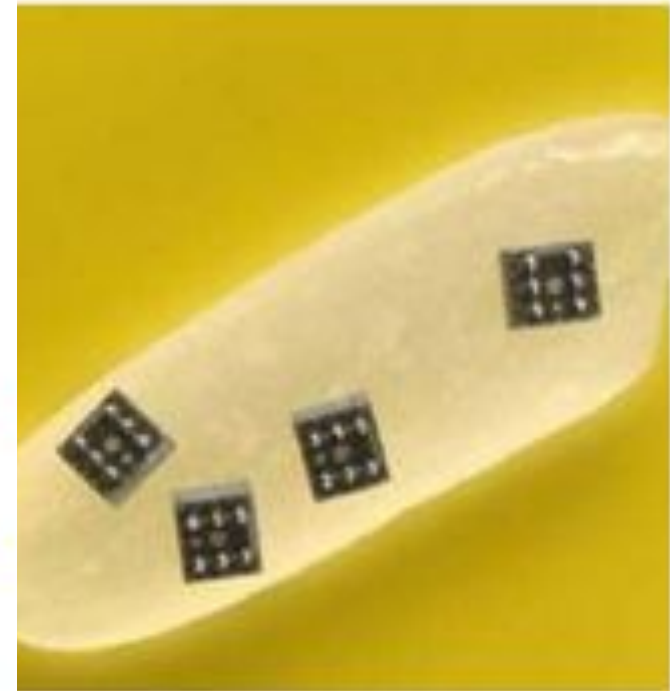
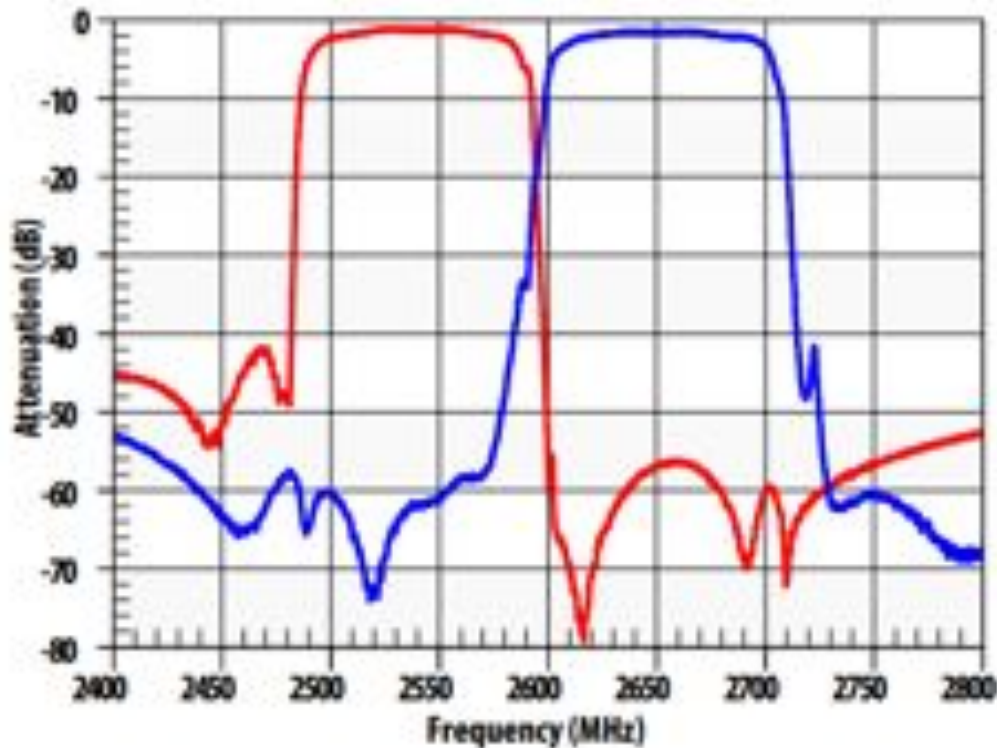
## Year of introduction of thin film PZT devices



(Yoie Développement, November 2013)

# Film Bulk Acoustic Resonator (FBAR): LTE Band Duplexer

- Avago Produces 1 Billion AlN FBARs Per Year

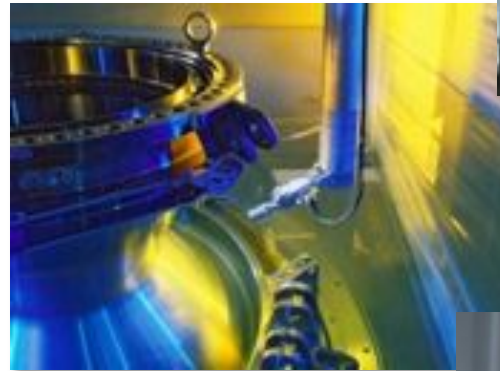


FBAR GSM filters on a grain of rice

Source: Avago

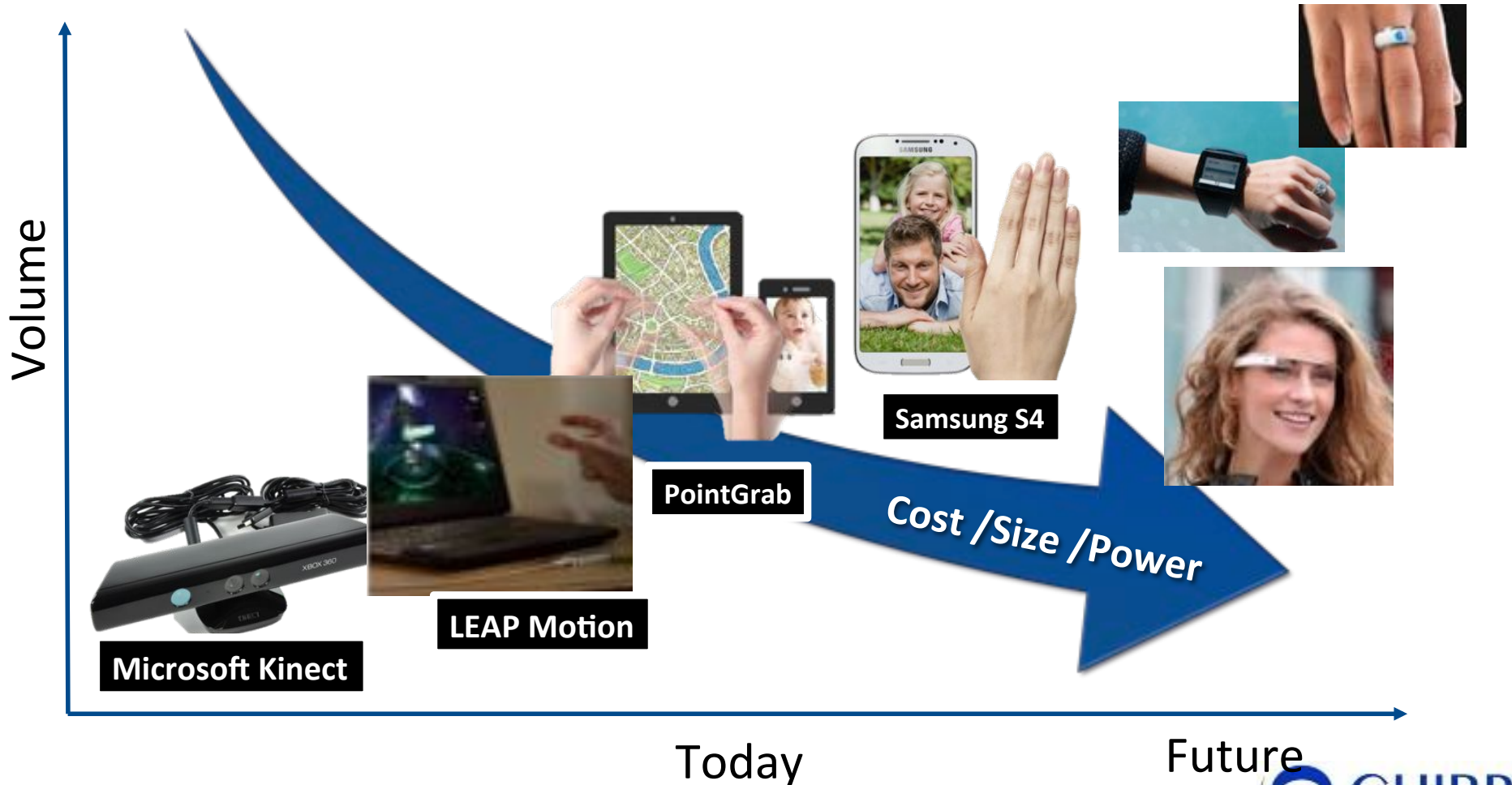
# Ultrasound Applications

- Medical Imaging
- Ranging/Obstacle Avoidance
  - Robotics/UAVs
- Automotive
- Non-Destructive Testing
- Flow Rate Sensor
- Paper Detection
- Gesture Recognition for HMI



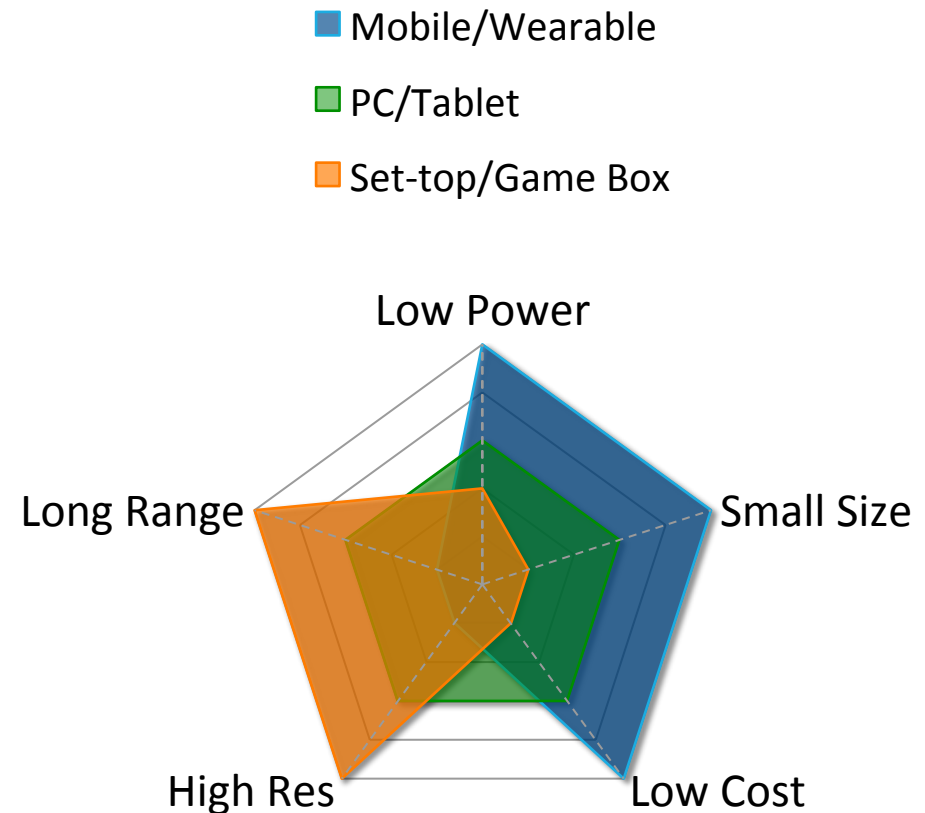
# Gesture Input for HMI

- Decreasing Power, Size and Cost to Enable High Volume Applications



# Gesture Recognition Approaches

- Illumination + Camera  
(Kinect, LEAP motion)  
**12W, 2W**
- Camera only (pointgrab)  
**>>250mW**
- Capacitive Sensing  
(Microchip, STMicro)  
**~100mW**
- Infrared sensors (Maxim)  
**>100mW from IR source**





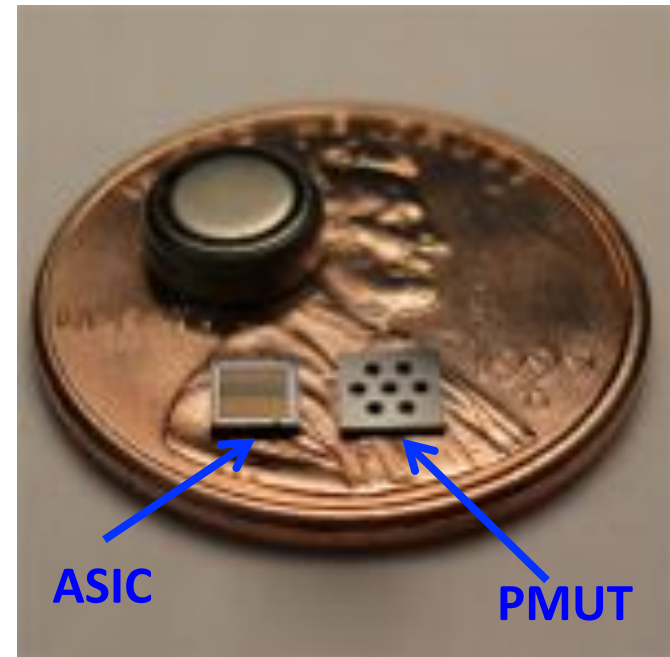
# Ultrasonic Ranging Solution



- Speed of Sound is 6 Orders of Magnitude Smaller Than Light
  - High Speed Electronics Not Required

# Chirp Ultrasonic Gesture Recognition Technology

- Very Low Power ( $\mu\text{W}$  ...  $\text{mW}$ )
  - Always-on operation possible
- Small Size (Comparable to Microphone)
  - Fits devices too small to accommodate a display
- Good Depth Resolution
- ASIC-Enabled Smart Sensor



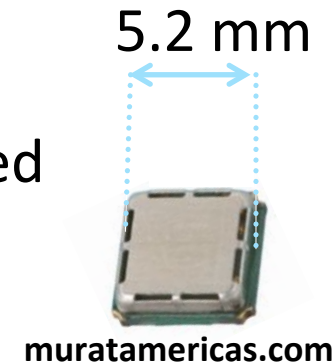
# Bulk Ultrasound Transducers

- Advantages

- Large output pressure
- Directional, if desired

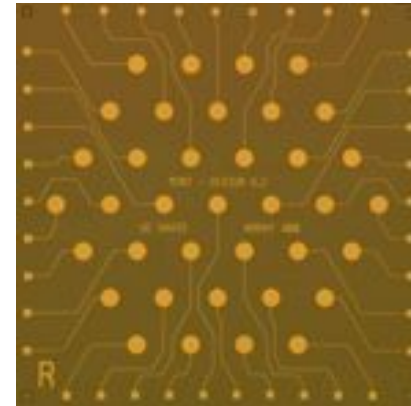
- Disadvantages

- Inefficient coupling to air
- Matching layers required
- Too big for consumer electronics
- Dumb sensor. Lots of external electronics required

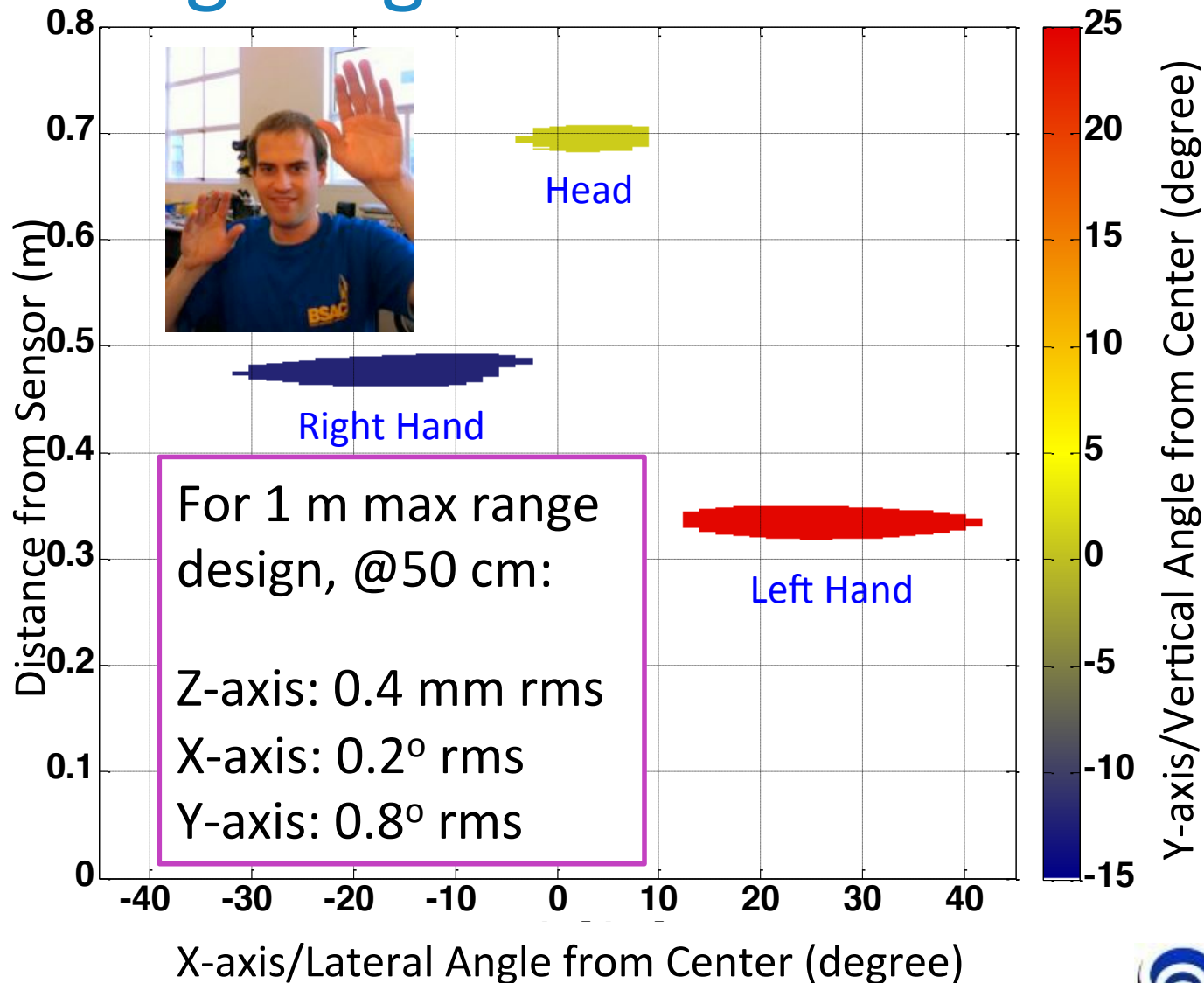


# Chip Scale Array Enable 3D Ranging

- 2D Array of Transducers
  - Output power on-axis:  $N^2$
  - Number of elements sets beam width
    - Beam width  $\sim 180^\circ/N$  for linear array
  - Individual electrodes enable electrical beam steering
  - Spacing  $\sim \lambda/2$  for  $180^\circ$  beam steering



# 3D Sensing Image of Head and Hands



# Summary

- Several piezo-MEMS devices are now in high volume production, with growing maturity of manufacturing base to enable new devices.
- While the existing ultrasound sensors lack capabilities to meet the requirement of consumer electronics applications, PMUTs represent a disruptive technology for gesture sensing and other applications especially in energy constrained environment.
- Chirp is commercializing PMUT technology to provide smart sensing solutions for consumer electronics, industrial, home automation, and beyond (IoT).

# THANK YOU

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