

10th LEIBNIZ CONFERENCE OF ADVANCED SCIENCE

Silicon Micro Ultrasonic Transducer: Challenges and Opportunities

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Content

- 1. Introduction**
- 2. Fabrication Technology**
- 3. Applications**
- 4. Challenges and Solutions**
- 5. Summary**

Advantages of Micro Ultrasonic Transducer

- High energy-conversion efficiency
- High device uniformity for array operation
- Large bandwidth
- Wide applicable temperature range
- Low fabrication cost

-> Suitable for airborne and immersion applications

Content

1. Introduction

2. Fabrication Technology

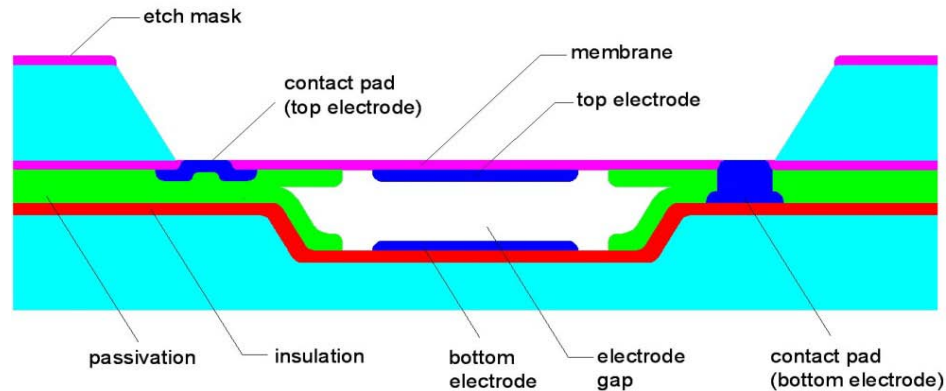
- Bulk process
- Surface process

3. Applications

4. Challenges and Solutions

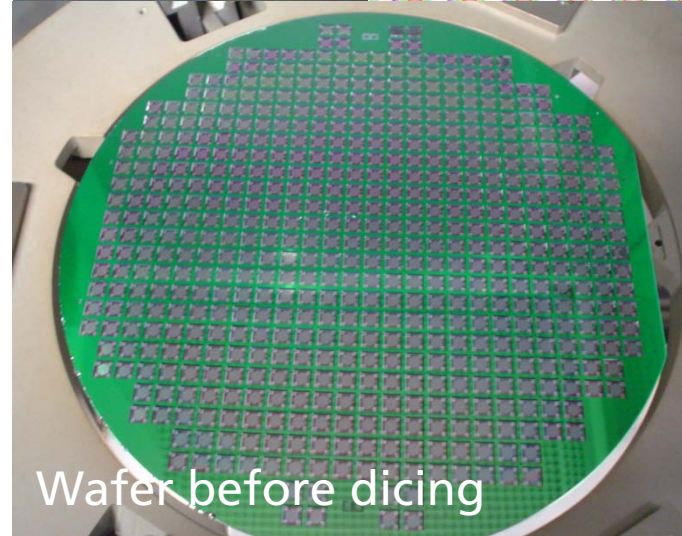
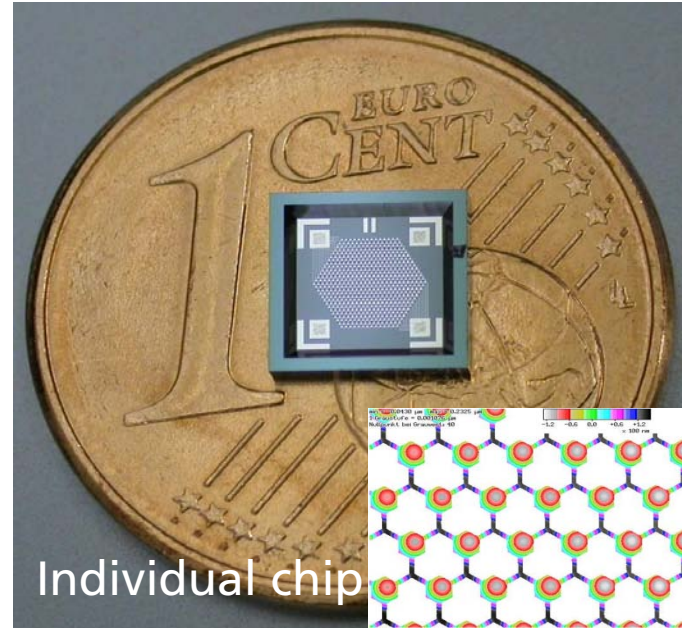
5. Summary

Silicon Micro Capacitive Transducer (Bulk Process)



Major Technical Specifications

Dimension	5x5x1mm
Break voltage (dc)	>100V continues
Break voltage (ac)	<200V, 20kHz pulse
Resonant frequency	2.7MHz
Bandwidth	50kHz
Static capacitance	200pF

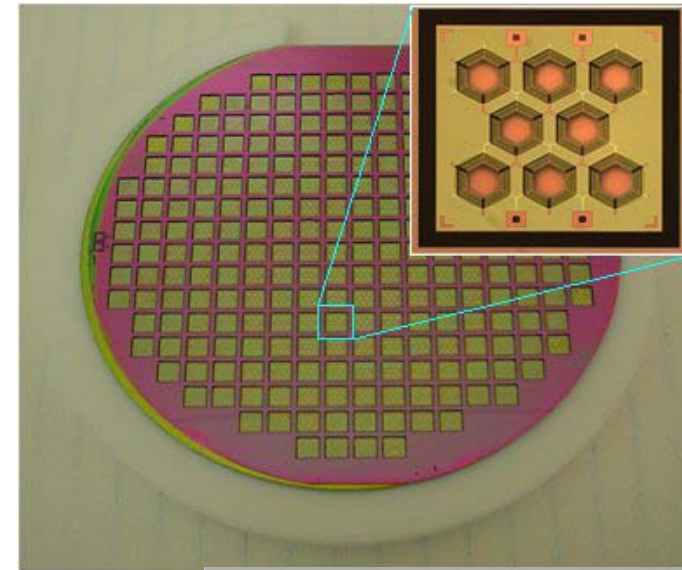


Performance Improvement

- **Reduce parasitic capacitance**
- **Improve sensitivity**
- **Connection with electronics**
- **Packaging**

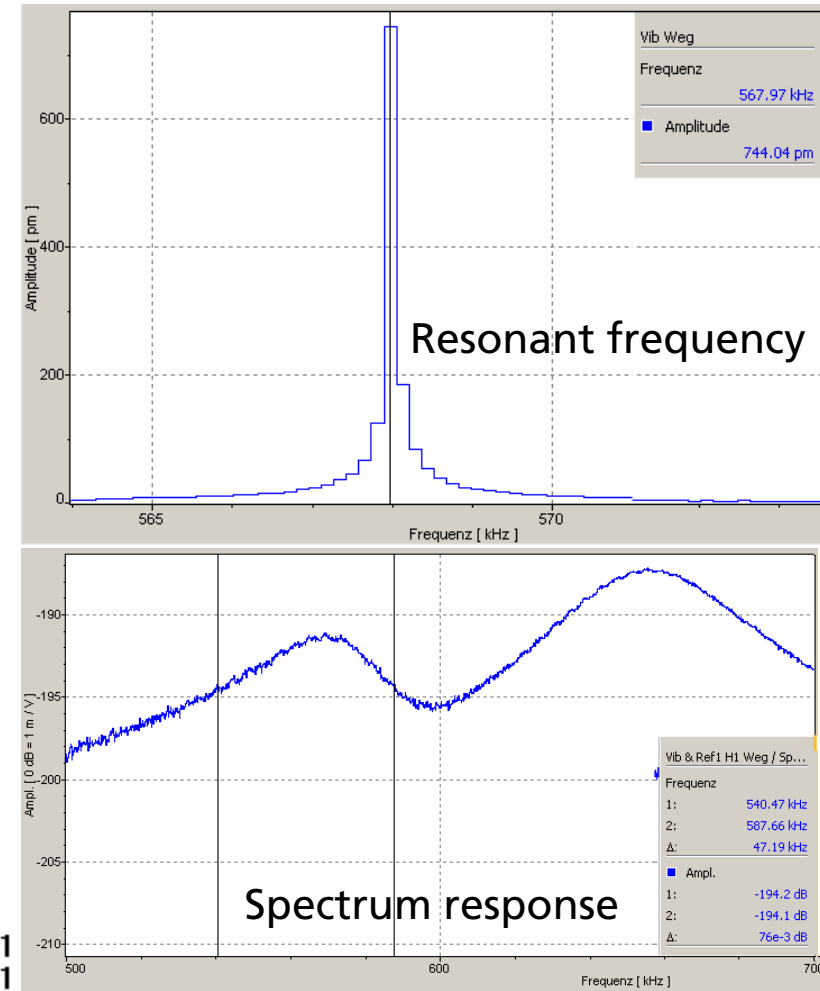
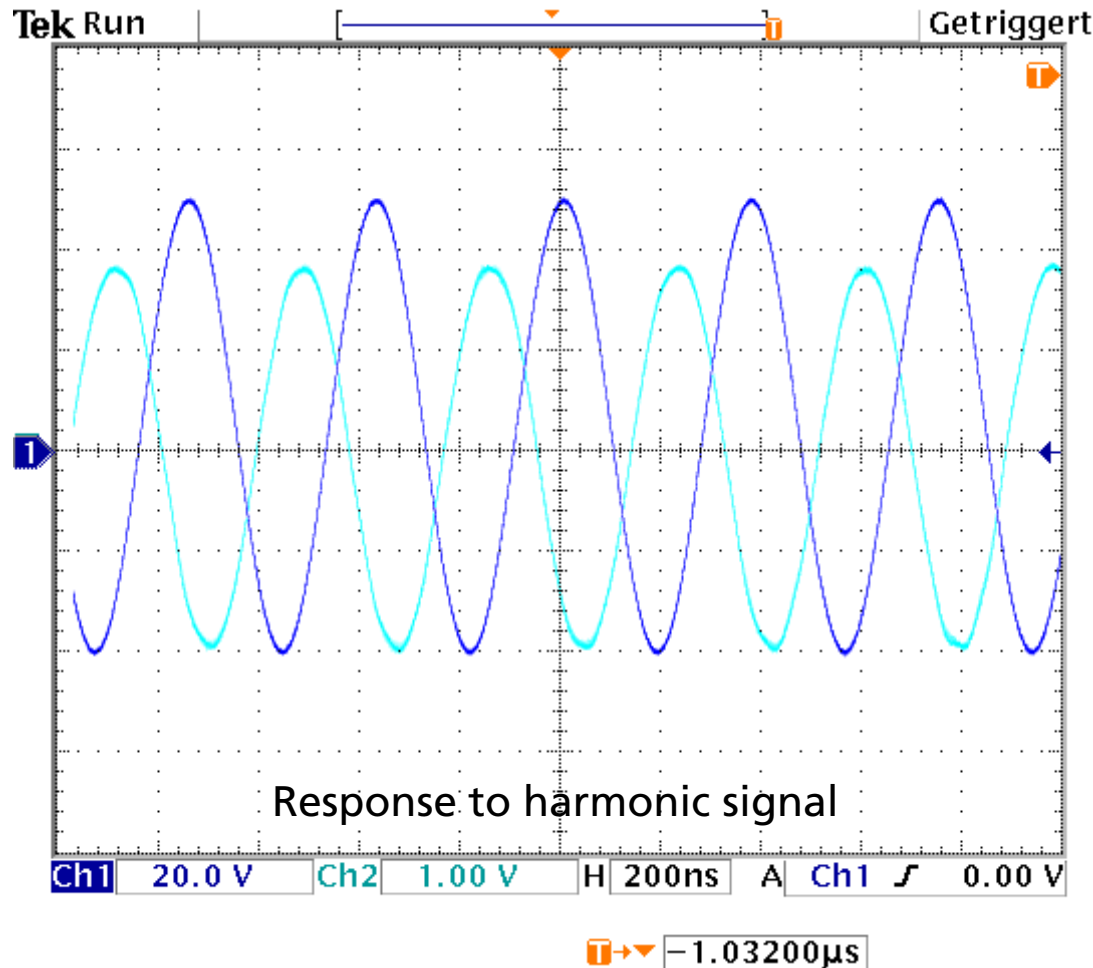
Major Technical Specifications

Dimension	5x5x1mm
Break voltage (dc)	>100V continues
Break voltage (ac)	<200V, 20kHz, pulse
Resonant frequency	560kHz
Bandwidth	50kHz
Static capacitance	20pF

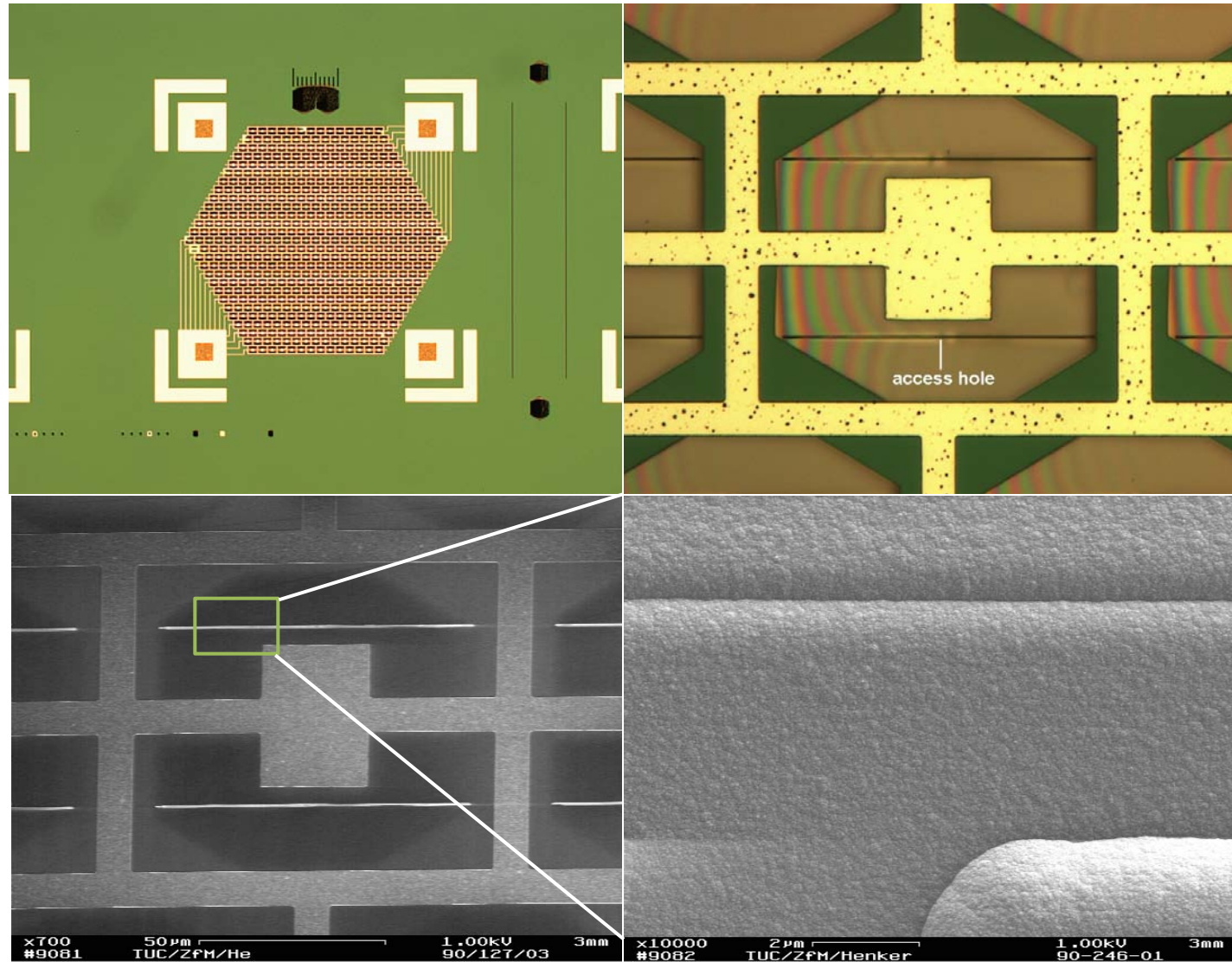


By courtesy of Gefell Mikrotech

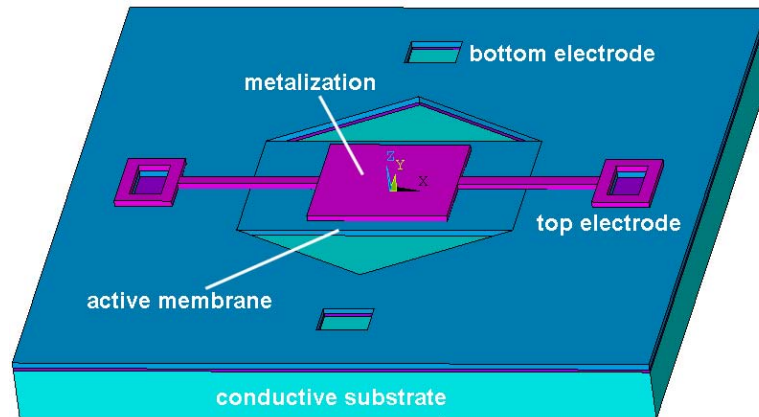
Transducer Dynamic properties – bulk process



Surface Micromachined Ultrasonic Transducer

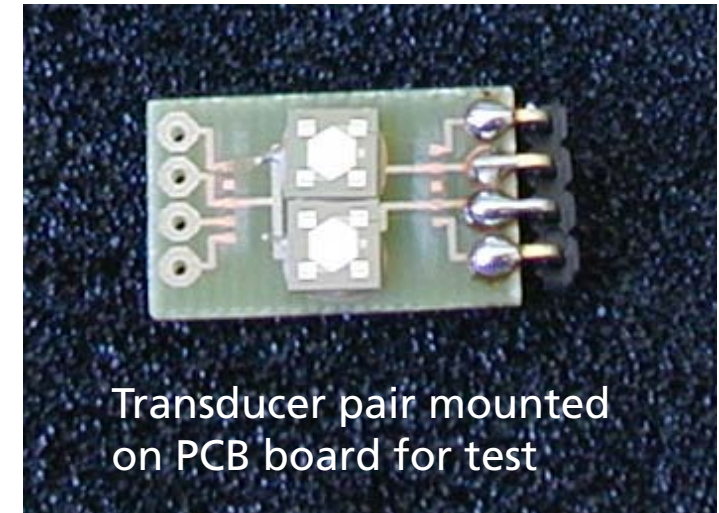


Silicon Micro Capacitive Transducer (Surface Process)

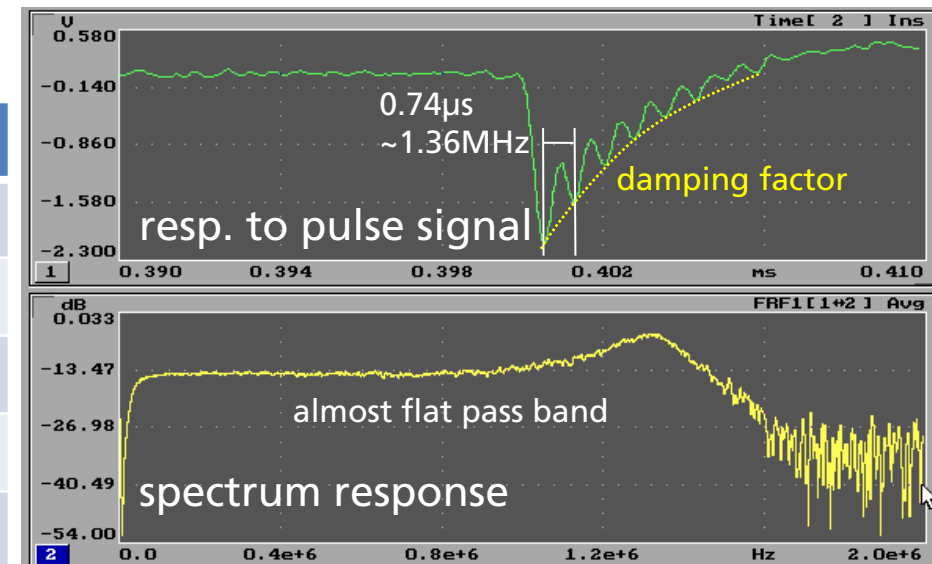


Major Technical Specifications

Dimension	5x5x1mm
Break voltage (dc)	>100V continues
Break voltage (ac)	--
Resonant frequency	1.4MHz
Bandwidth	Broad band
Static capacitance	120pF



Transducer pair mounted on PCB board for test



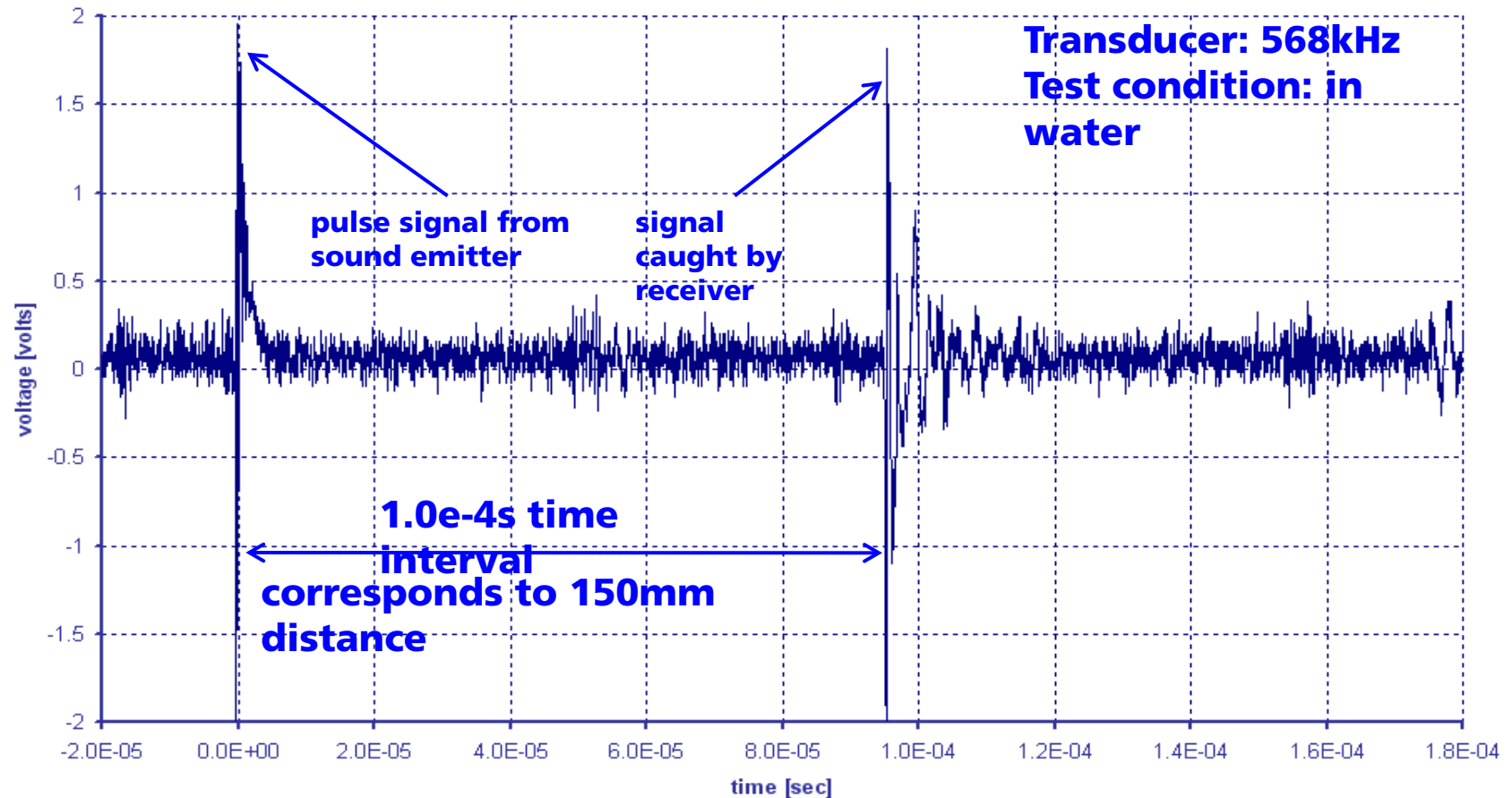
Surface Process vs. Bulk Process: A Comparison

	Bulk process	Surface process
Wafer count	2	1
Process flexibility	good	limited
Reliability	excellent	acceptable
bandwidth	good	excellent
sensitivity	high	limited
Parasitic capacitance	small	large
Monolithic integration	difficult	easy
Bonding dependent	yes	no
Yield rate	high	acceptable
Other problems		stiction, dielectric absorption

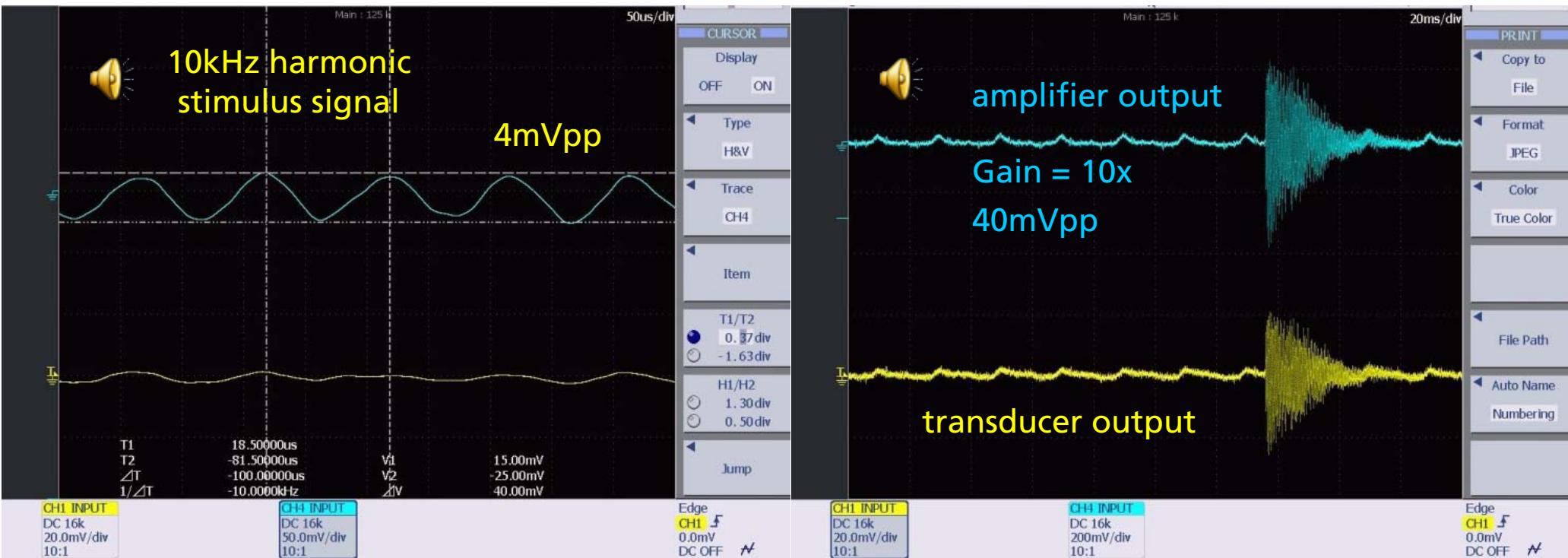
Possible Applications

- **Flow rate / liquid level monitoring – compact / cost**
- **Microphone for Leakage detection / Hydrophone - bandwidth**
- **Capacitive pressure sensor with overload protection – size factor, flexibility**
- **Non-contact air-couple ultrasonic analysis – acoustic impedance**
- **Ultrasonic imaging in phase-array mode - uniformity**

Pitch-Catch Experiment: Result



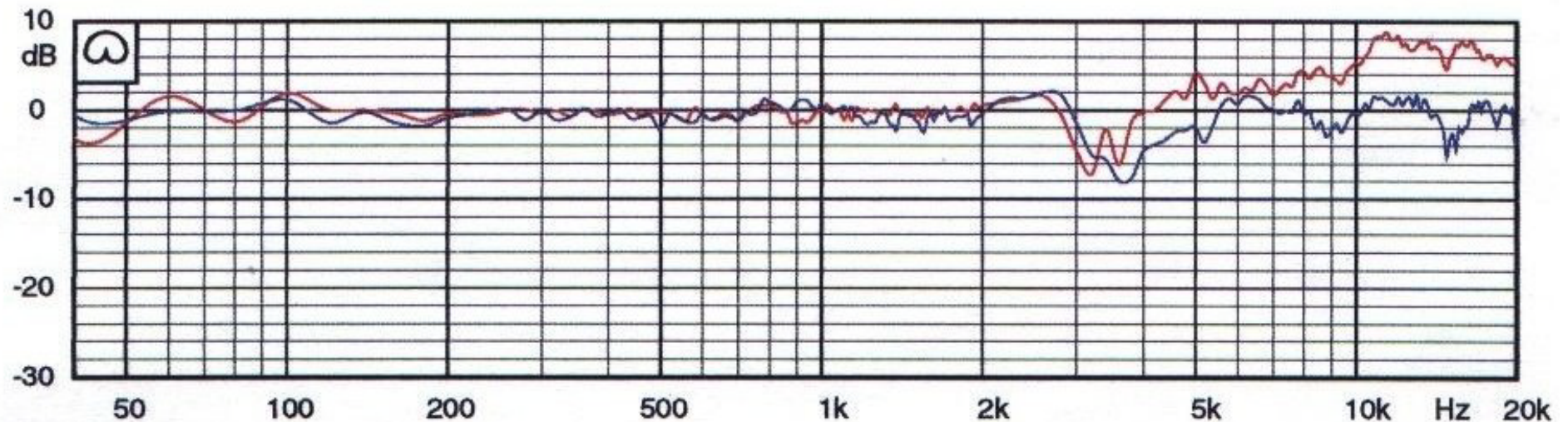
Response to Audible Signal



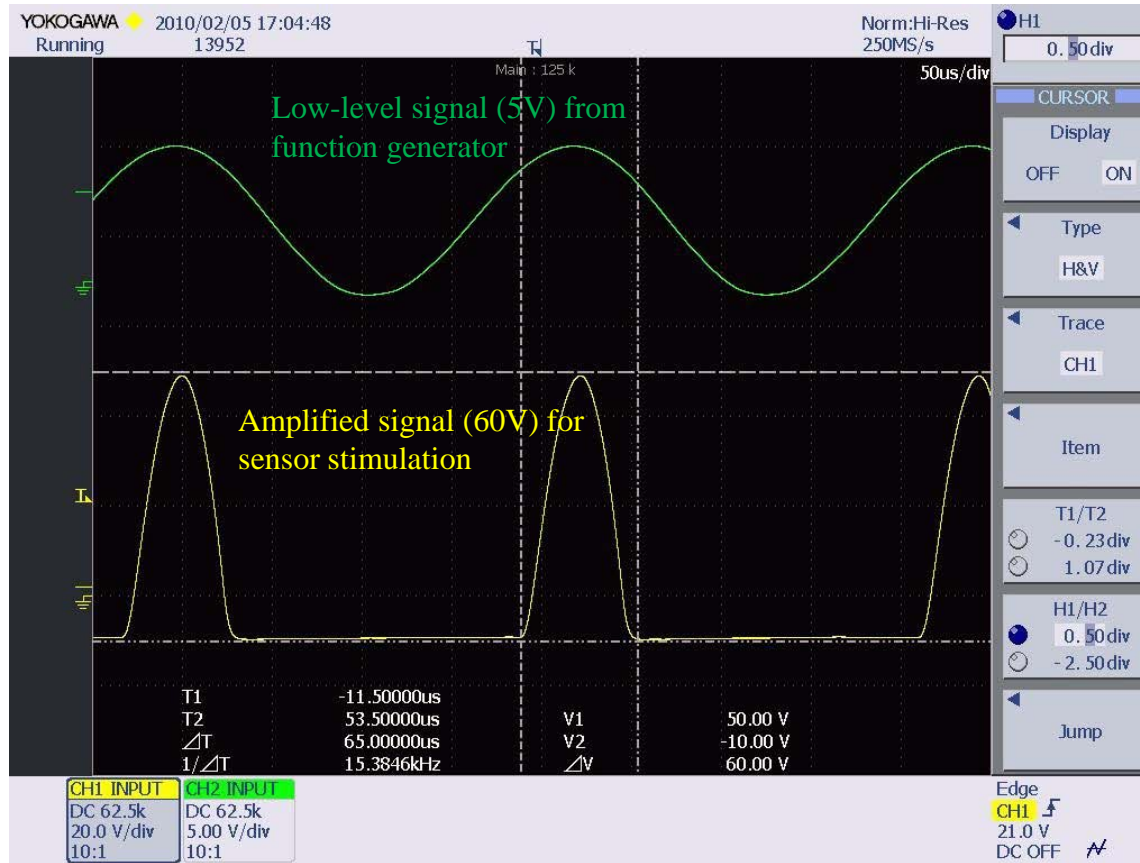
**Distance between source and chip: 5cm ...
100cm.**

Response in Audio Frequency Range

Nr.: 0001
Empfindlichkeit: 1.2 mV/Pa = 0 dB
Richtcharakteristik: Niere



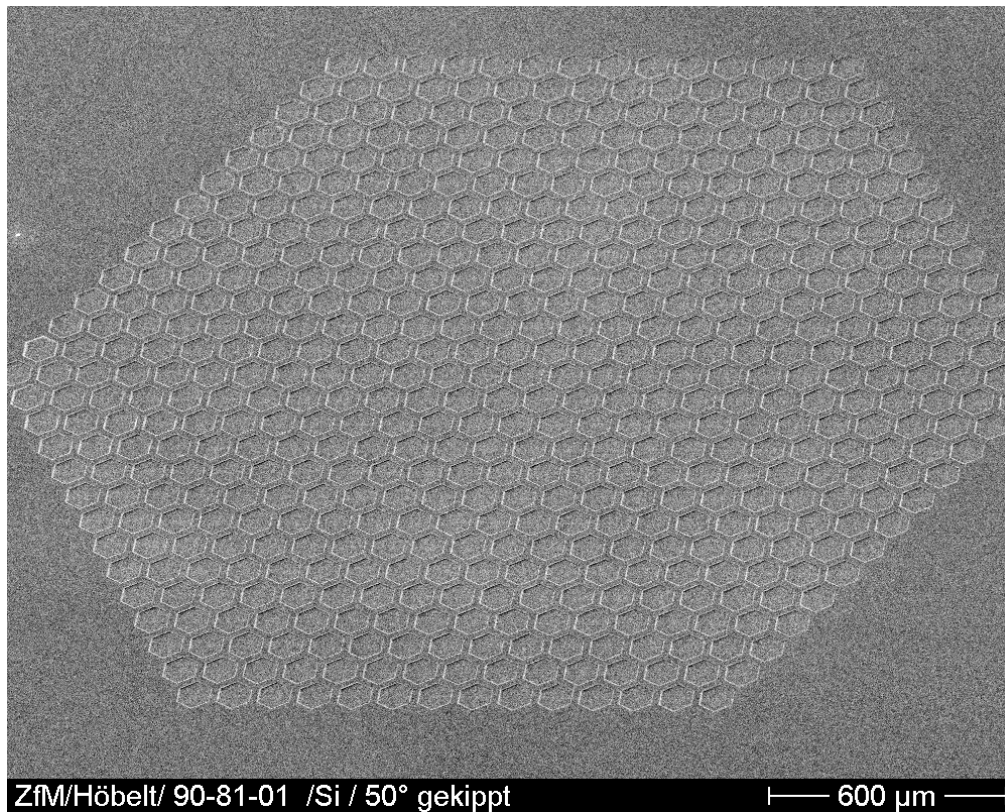
Transducer acts as Loudspeaker



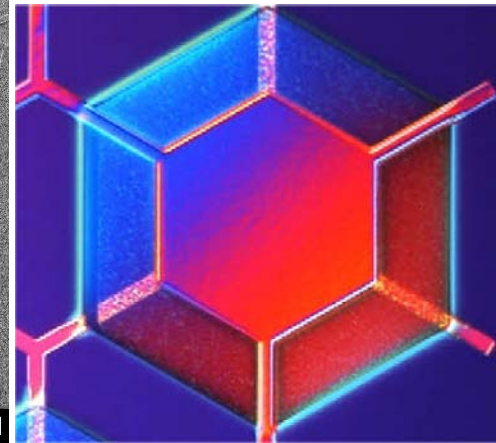
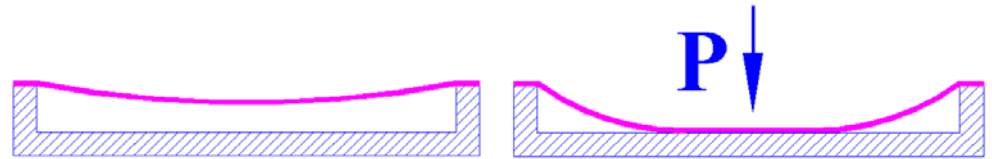
Audio output

Maximal stimulus: <70V

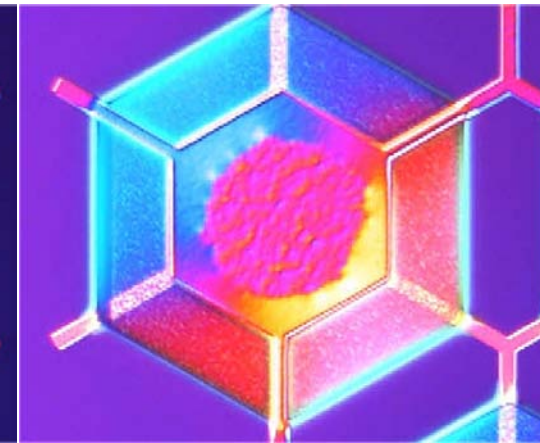
Capacitive Pressure Sensor with Overload Protection



Honeycomb-like supporting structure



Normal condition



Overload

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Current Problems and Solutions

- Sensitivity - electrode gap
- Integration with electronics
 - Interface with electronics
 - Interference shield
 - SNR
- Packaging
 - wire bonding
 - Flip-chip bonding
- Reliability and durability
 - Residue stress
 - Protection against mechanical impact

Summary

- **Micro ultrasonic transducer: alternative to ceramic transducer in fluid applications. Improvements still desired.**
- **Major advantages : size, cost, consistency. Applications: capacitive ultrasonic transducer, microphone, pressure sensor etc.**
- **Successful application of micro transducer still depends:**
 - **sensitivity improvement**
 - **higher yield-rate**
 - **suitable packaging plan for transducer die**
 - **sufficient reliability in field environment**
- **Partners interested in cooperative development are welcome**
 - **Transducer itself**
 - **Technology employed: wafer bonding, precision etching etc.**