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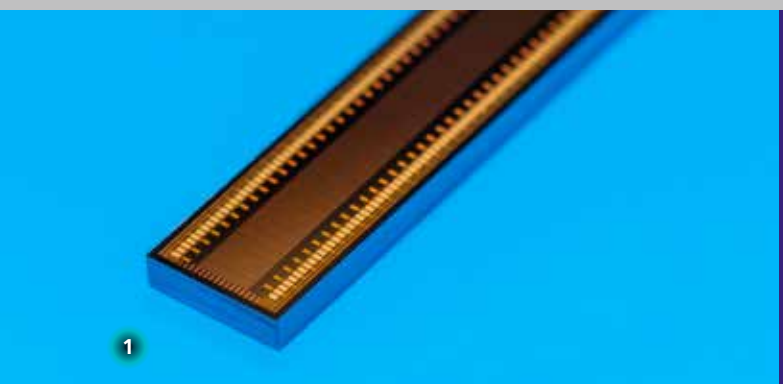

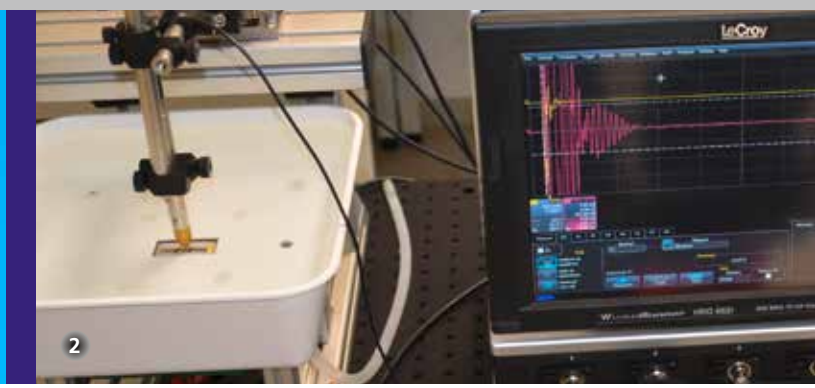

1 *128 channel CMUT chip.*
2 *Immersion test setup for CMUT characterization.*

CAPACITIVE MICROMACHINED ULTRASOUND TRANSDUCERS (CMUT)

Introduction

Capacitive Micromachined Ultrasonic Transducers (CMUT) are micromachined structures that can be used to generate and sense acoustic signals in the ultrasonic range. High-quality and miniaturized ultrasound transmitters and receivers can be realized with CMUTs. In addition to miniaturization the integration on top of a CMOS IC is a particularly outstanding property of CMUTs. Moreover, CMUTs are reliable even at high temperatures – conditions, where conventional ultrasound transducers tend to fail.

Fraunhofer IPMS has established a process that can deliver small series and pilot productions that enable the development of new customer specific sensor devices (fig. 1).

Principle of operation

The CMUT is essentially a MEMS structure comprising two electrodes facing each other, one of which is fixed and the other is movable. The two electrodes are separated by an insulating layer and a vacuum-sealed gap. CMUTs can operate on transmit and receive mode, by converting electrical energy into acoustic energy or vice versa through the displacement of the movable electrode.

Operating as a transmitter (fig. 2), an electrical potential is applied between the two electrodes, the electrostatic force deflects the movable electrode towards the fixed one. This deflection generates an acoustic wave. In a similar way, CMUTs can also operate in receive mode (fig. 3) when an incoming acoustic signal impacts

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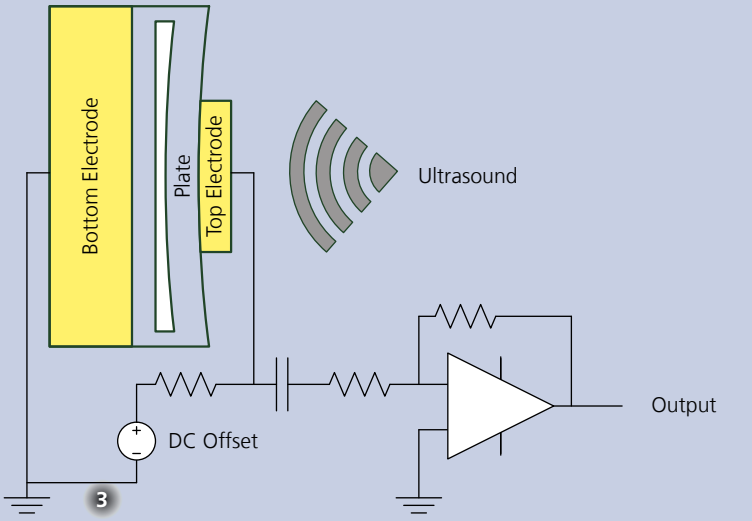

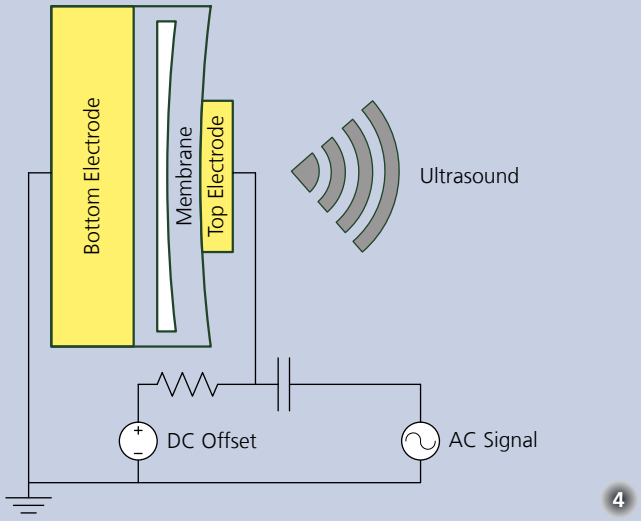

on the movable plate. This impact deflects the movable electrode generating a current between the two electrodes. This electrical current can be sensed and digitally processed to generate an image for further analysis.

CMUTs are free from toxic materials (ROHS II conformity), have a wide variety of resonance frequencies and provide, especially in liquids, an optimal acoustic impedance.

Fabrication

Fraunhofer IPMS utilizes a unique fabrication process for CMUTs, it allows the fabrication of CMUTs as a so-called Back-End-of-Line (BeoL) process module. In particular amorphous metals are used leading to high long-time stability and reproducibility of the devices. Furthermore the CMUT module can be integrated in standard CMOS processes, a unique feature of this technology. Thus, highly integrated CMUTs can be developed and manufactured on a small scale on 200 mm wafers inside the institute's own clean room.

The final application defines the requirements for the operating frequencies, voltages, sensitivities, etc. A variable range of specifications can be met.

Besides singular devices for distance measuring or acoustic spectroscopy 1D or 2D arrays are feasible.

Technical properties

- Frequency range 1 MHz – 50 MHz
- Fractional bandwidth >100% of resonant frequency (in water)
- Array types: 1D, 2D , Annular, Rectangular and combinations
- Number of elements per array: 2 – 128 (or more if required by application)
- Array element dimensions: 100's of micrometers to millimeter range
- CMUT shape: circular

Applications

- Acoustic spectroscopy
- Medical imaging
- Medical therapy (HIFU)
- Short-range distance measuring
- Nondestructive testing
- Ultrasound microscopy

3 *CMUT in receive operation mode.*

4 *CMUT in transmit operation mode.*