High Frequency Ultrasound Annular Array Based on P(VDF-TrFE) Deposited on Silicon

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Background, Motivation and Objective

Piezoelectric copolymer such as P(VDF-TrFE) are well suited for high-frequency transducer applications (>20 MHz) because of their high bandwidth and their sensitivities are sufficient to provide good quality echographic images. But these performances are highly dependent on electrical connections, i.e. length and type of cables, which can significantly degrade the properties. The use of integrated electronics closer to the piezoelectric element eliminates the spurious effects of the cables (characteristic impedance), but also reduces the size with better performances.
This study presents an innovative technology of high-frequency transducers, based on 3D printing of P(VDF-TrFE) copolymer on a silicon wafer (Irlynx Company). With this technology, the CMOS electronic circuits of an US system could be integrated to deliver a miniature and low-cost system.

Statement of Contribution/Methods

The transducer is an annular array consisting of eight electrodes with equal area (4.9mm²) patterned on the silicon substrate. The P(VDF-TrFE) layer is 3D printed in several steps onto the electrodes to reach a final thickness of 10 µm. The top electrode is deposited on the whole area of the polymer layer. The corresponding chip is fixed and connected on a printed circuit board by wire bonding (fig. 1.a). The P(VDF-TrFE) is poled with an applied electric field of 135 V/µm. Finally, a concave lens, made of polymer with a very low acoustic attenuation is added to the front of the transducer to improve characteristics of the radiation pattern.

Results/Discussion

The electrical impedance measurements in air compared to the results obtained with one-dimensional equivalent electrical circuit (KLM scheme) allow to estimate the electromechanical thickness coupling coefficient (k_t) over 20%. The pulse/echo response of the center element of the transducer, measured at the focal distance of 14mm, has a center frequency of 25.5 MHz, a -6dB fractional bandwidth of 121% and an axial resolution of 24µm (fig. 1.b). Moreover, the radiation pattern shows a depth of field of 1.5mm with a lateral resolution of 100 µm. All elements are successfully tested with a good reproducibility with very low crosstalks. These results show that this technology makes it possible to obtain a transducer with electro-acoustic performances similar to the most efficient transducers in P(VDF-TrFE) available on the market.

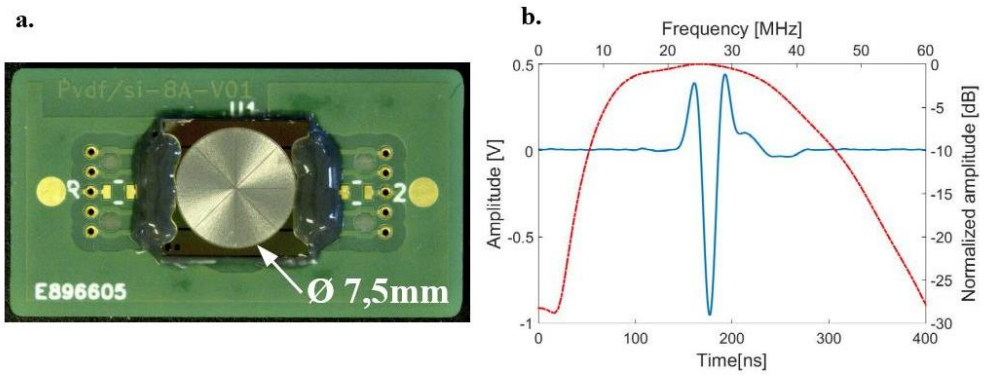

Fig 1 : (a) Photography of the HF annular array and (b) its impulse response at the focal distance in water.