A LINEAR MONOLITHIC RECEIVING ARRAY
OF PVDF TRANSDUCERS FOR TRANSMISSION CAMERAS

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ABSTRACT

Linear receiving arrays with ten transducer elements made of the piezoelectric polymer PVDF were constructed and the performance measured. The single transducers in the monolithic array are defined by standard photolithography and selective poling the remaining metallized 0.7x0.8 mm² spots. The 25µm PVDF foil is glued on to a hard backing to get increased sensitivity. The result we found was a sensitivity of 2.10⁻⁶ Vm²/N and a broad band behaviour from 2 to 12 MHz. The interelement coupling was found to be about -35 dB. The angular acceptance was nearly ideal except narrow minima depending on the backing material.

INTRODUCTION

In pulse echo systems like B-scan imagers ultrasonic transducer arrays made of piezoelectric ceramics, like PZT, are widely used. In order to get broad band behaviour necessary for good axial resolution sophisticated constructions have to be used. Especially good matching to the backing and elaborated width-to-thickness ratios have to be selected. In addition, because of the large impedance mismatch of ceramics to tissue of 30·10⁶ to 1.5·10⁶ kg/m²s, a quarter wave matching layer within narrow thickness and impedance tolerances has to be chosen. These steps are all taken because of the PZT's good properties to transmitting ultrasound.

On the other side, according to Callerame's formula /1/, materials with low dielectric constants are better suited for pure receiving. Such a material, e.g. PVDF with an εᵣ of 8 (2 MHz)
can be used in an ultrasonic transmission camera in which trans­mitting and receiving is well separated. We started to construct receiving arrays capable of reconstructing the diffraction limited resolution offered by the camera. In trans­mission cameras with f/1.5 lenses a resolution of 1.5 mm at 2 MHz is achievable. So we chose the size and the number of the trans­ducers of our arrays to fit in a camera like the SRI camera/2/. This leads to an individual area of the transducers of 0.7x0.8 mm, spaced by 0.1 mm, which is sufficient to sample the offered reso­lution. Because of the low capacity of only 1.6 pF for a single transducer, additional stress has to be layed on the preamplifier electronics.

To find a less difficult way to construct arrays beside slotting ceramics, a monolithic construction with the piezoelec­tric polymer PVDF has been chosen. Monolithic means that the pie­zoelectric foil as a whole is glued to a backing. The foil is covered on one side with the pattern of the transducer, on the other side with the common ground. A slotted foil is conceivable as well but results in a double number of electrical connections. With the 10-transducer-arrays of different construction we mea­sured the receiving properties. Properties to characterize a trans­ducer are absolute sensitivity, broad band behaviour and angular acceptance. Transducers in an array are characterized by their mutual cross-coupling and their homogeneity in sensitivity.

CONSTRUCTION

We used commercial 25 µm and 12 µm biaxially drawn capaci­tor-grade PVDF film as transducer material. This film was vacuum coated by Cr - Ag with a total thickness of 100 nm. After wet­etching the patterns of the transducers, they were selectively poled with an electrical field of about 1 MV/cm for one hour at 100ºC and then were brought back to room temperature under volt­age applied. With a quasistatic measurement /3/ the piezoelec­tric pressure constants $d_h$, $d_{31}$, $d_{32}$ were determined and thus the piezoelectric constant can be calculated by

$$g_{33} = \frac{1}{\epsilon_{33}} (d_h - d_{31} - d_{32})$$

assuming a relative dielectric constant $\epsilon_r$ of 8 (2 MHz). One type of transducers was metallized with Cr-Ag on both sides, then patterned with 0.7x0.8mm electrodes on one and a 0.8mm strip on the other side (type A, Fig. 1). The electrical gold wire contacts were bonded by conductive adhesive. After this the poling was done. Another type of transducers was constructed by selectively poling a 0.8 mm broad metallized strip - Cr-Ag on one side, Al