Multiphysics analyses of the effect of package on the performances of PMUT transducers

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ABSTRACT

The application of piezoelectric materials in "smart" microdevices is continuously increasing, with different possible uses of both "direct" (conversion of mechanical energy into electric energy) and "indirect" effect. The latter is applied for actuating purposes, e.g. in the case of micropumps [1]; "direct" effect is now widely used for energy harvesting, namely for obtaining an electric power by exploiting some freely available mechanical energy [2].

In the case of MEMS, some recent developments in microfabrication techniques allowed for the introduction of layered structures with thin films of piezoelectric materials (namely, PZT or AlN). After a thorough examination of piezoelectric mechanical properties for thin layers, it is possible to provide a comparative table in terms of "Figure Of Merits" (FOM). In that way, one can select the best material for each possible application, with the use of both direct and indirect effects.

The ultrasound transducers (PMUT) are piezoelectric structures which are actuated with the purpose of emitting and receiving ultrasonic waves [3]. The complete simulation of the device's behaviour can be obtained by considering multiple coupling between different fields: electro-mechanical coupling for piezoelectric model; acoustic-structural coupling for understanding the efficiency in the emission and in the sensing phase. The model is complicated by the fact that the PMUT devices are usually packaged, so the interaction between the surrounding medium does not involve directly the vibrating diaphragm only but the package as well.

This paper is focussed on the development of a fully-coupled model in order to carry out parametric studies on the effect of package geometry on the PMUT operation. This has been done with reference to axisymmetric models, with the main purpose of reducing the computational burden. This is perfectly suited for the emission of waves from circular diaphragm in circular package; conversely the sensing phase would require a full 3D model, whose specific features are thoroughly discussed in this paper. The achieved results have represented a useful guidance in the design of a PMUT prototype, that has been finally subject to experimental tests. The measured data are in good agreement with the numerical predictions.

REFERENCES

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