Integration of Small Transducers in Commercial Products

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Abstract: Miniaturization of electronic devices requires smaller components as well as higher level of integration. Whenever audio is involved, as in mobile phones, it is exactly the acoustics components that offer the largest challenge in this respect. There are physical limitations to how small those components can be made, and with present methods of integration, even the smallest acceptable size is still too large. Progress in material research is expected to offer new possibilities for solving problems in further integration of components, e.g. microphones. In the development of silicon microphones new materials and processes are utilized already. Decreasing size of components and systems makes the problem of vibration coupling through structures more severe. Furthermore, in smaller components there are a number of physical effects to be counted for, not only in practice but also in numerical simulation models of these systems. An example of this is the effect of viscosity when predicting acoustic performance of the system. Normally viscosity is neglected, but in very narrow ducts, for example, viscosity causes significant effects. Very small components and systems cannot be expected to operate physically as their larger predecessors.

MATERIALS AND STRUCTURES

One challenging area in structural acoustics is related to transducer miniaturization and integration. Generally speaking, the transducers should be small, efficient, and insensitive for their mechanical and acoustical environment. At the same time, there is need for audio transducers which could stand normal reflow soldering process. In mobile phones there are three different audio transducers: microphone, buzzer, ear piece, and hands-free speaker. Advanced materials, transducer concepts, and manufacturing techniques are expected to offer new possibilities for solving problems in further integration of these audio components.

For instance, micromechanical silicon microphones (1,2,3) are very small and they can stand reflow soldering. Even where such microsystems do exist, there are open questions in which way they should be applied in commercial products. Electrical as well as mechanical interfaces are undefined. From structural acoustics point of view, packaging of the microsystem is an essential sector. In multi-module components mechanical contacts should hold and support micromechanical microphone chip. On the other hand, mechanical contacts should isolate microphone membrane from external mechanical vibrations. The packaging of micromechanical components should not be left in shadow of actual component manufacturing (4).

There are physical limitations to how small audio transmitters can be made. To decrease the diameter of the vibrating membrane, the excursion limitation has to be solved. However, small transmitters with such membranes are difficult to manufacture cheaply. One direction in integration of audio transmitters leads to multifunctional transducers. There one transducer operates as an ear piece, a buzzer, and a hands-free speaker. Here the problem is that an efficient buzzer buckles with non-linear manners while an ear piece and a speaker should behave linearly.

Decreasing size of mobile phones increase the direct mechanical coupling between transmitters and receiver. Because there is a demand for lighter products, the supporting structures should be thin and stiff. The structures should also attenuate coupling between audio transducers. Thus used supporting materials and their shape are important parameters.
FLUID FLOW - STRUCTURE INTERACTION

In mobile phones the size of the acoustical cavities for audio transmitter is in same magnitude of order as the transmitter itself. There are also quite a few small conduits between those cavities. Due to viscous nature of the air, flow loses (5) and vortices can be produced when fluid is forced to flow from one cavity to another. Therefore internal shape of audio transducers and related mechanics in mobile phones have to be optimized in order to minimize these loses.

In audio transducers mechanical and acoustical domains are strongly coupled together. To be able to solve this fluid flow - structure interaction problem in miniaturized audio transducers and devices, the viscous effects should be taken into account in applying Navier-Stokes equation. Furthermore, flow velocity and pressure information from finite element simulations can be used to determine acoustical impedance of the mechanical structures for lumped parameter models.

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