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Flip chip MEMS microphone package with large acoustic reference volume

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Abstract

MEMS microphones must be further miniaturized for use in mobile devices. So we developed packaging technologies for MEMS microphones using flip chip technology instead of wire bonding. The first two generations have the sound hole in a ceramic interposer at the bottom side of the package. Now a new flip chip microphone package with the sound hole on the top side has been developed. The new package technology combines a large acoustic reference volume for good signal to noise ratio with small size. Compared to other microphone packages the sensitivity is improved by 3 dB. The front volume is small to avoid resonances in the acoustic frequency range.

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Keywords: Microphone; MEMS; Packaging; Flip Chip; CSMP; sharpEar

1. Introduction

For consumer products electret microphones have been the standard for several decades [1]. These microphones were also used in the first decade of mobile communication. Now electret microphones are more and more replaced by MEMS microphones. There are two main reasons for this technology leap: First, MEMS microphones are smaller than electret microphones. Second, their sensitivity is not affected by high temperatures, so they can be assembled by automatic soldering. In most cases MEMS microphones are soldered directly on the main PCB of the mobile device.

The sound port can be either on the top side (opposite the PCB) with a rubber sealing ring between the microphone top side and the case of the device sealing the acoustic path. Or the sound port is on the bottom (PCB)

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side of the component with a hole in the PCB, a solder ring between microphone and PCB and a rubber sealing ring between the opposite side of the PCB and the case sealing the acoustic path. In this paper a new highly miniaturized MEMS microphone package with top sound port is presented.

2. MEMS Microphone Packaging

For most MEMS microphones currently available wire bonding is used for the electrical connections inside the package. In figure 1 such wire bonding type microphone packages are shown. Transducer chip and ASIC are die bonded on an interposer made of PCB material. Bonded wires realize the electrical connection from transducer to ASIC and from ASIC to interposer. The package is closed by a lid. The sound port can be either on the top side of the component in the lid or on the bottom side in the interposer.

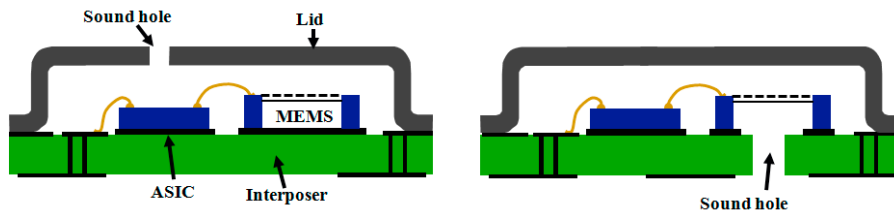


Fig. 1. Wire bonding type MEMS microphone package. Left: sound port on top side in the lid. Right: sound port on bottom side in the interposer.

2.1. Flip chip MEMS microphone package with sound port on bottom side

For the use in mobile devices MEMS microphones must be further miniaturized. The size of transducer and ASIC chipset is already quite small, the main part of the component volume results from packaging. A milestone on the path towards miniaturization was the step from wire bonding to flip chip packaging [2, 3]. In figure 2 on the left side our flip chip package is shown. Transducer chip and ASIC chip are side by side flip chip bonded to a ceramic interposer using SnAgCu solder balls with a diameter of 100 μ m. The package is closed by lamination of a polymer foil which is removed at the component edge by laser ablation. After metallization of the package top for HF-shielding the components are singulated by dicing. This package was named “chip size MEMS package (CSMP)”.

The second generation of CSMP also has the sound port in the ceramic interposer [4]. As shown in Figure 2 right now the two chips are stacked. The ASIC is mounted in a cavity in the ceramic substrate, the transducer chip on top of the ASIC. The stacked chip arrangement allows a further miniaturization of the package down to 2 x 2 mm².

The sound port of both CSMP packages is in the ceramic interposer. The acoustic reference volume is inside the MEMS chip.

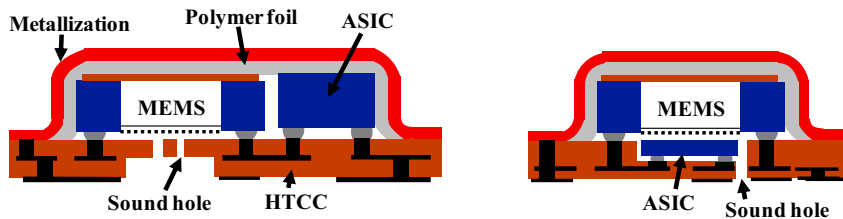


Fig. 2. Flip chip MEMS microphone package with sound port on bottom side. Left: Chips side by side. Right: stacked chips

2.2. Flip chip MEMS microphone package with sound port on top side

Some mobile phone and headset designs need microphones with the sound port on the top side. So we developed a very small flip chip package with the sound port on the top side [5]. In Figure 3 the newly developed package (patent pending) is shown. MEMS and ASIC chips are flip chip mounted inside a cavity in a high temperature co-fired ceramic (HTCC) substrate. The top side of the package is closed by a metallized polymer foil. The sound port is in this foil above the transducer chip. All the volume in the cavity around transducer and ASIC is used as acoustic reference volume. The technology was named “sharpEar” (sound hole at roof, providing extended acoustic reference).

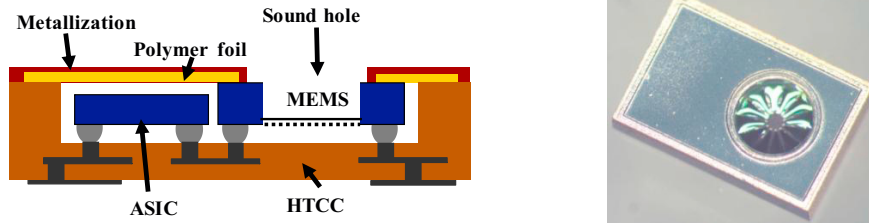


Fig. 3: MEMS microphone package with sound hole at roof and extended acoustic reference (sharpEar). Left: schematic cross section; Right: photo of device.

In figure 4 the packaging process sequence is shown. First a ceramic panel with cavities is bumped by a single ball bumping process. Second ASIC and transducer chip are flip chip bonded into the cavity. Third a polymer foil is laminated sealing on the wall of the ceramic cavity and on the top side of the transducer chip. Fourth, parts of the foil are removed by a laser ablation process. Then the package top is metallized by a sputtering process. The foil on top of the etched hole in the transducer is then insulated by a second laser process. As seventh process step the thickness of the metallization is increased by an electroplating process. No metal is deposited on the insulated part of the foil. In the final step the foil on top of the transducer is removed by a lift-off process to open the sound port.

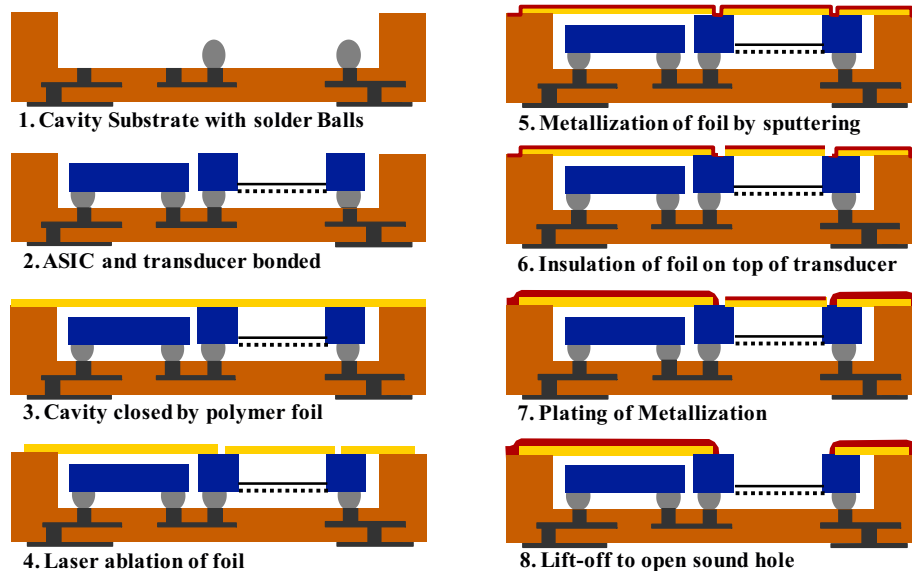


Fig. 4: SharpEar packaging process sequence

2.3. Comparison of the frequency response

The main advantage of the sharpEar technology is the combination of small size with a large acoustic reference volume. In addition an insignificant front volume avoids resonances in the acoustic frequency range.

In figure 5 the frequency responses of MEMS microphones packaged with different technologies are shown. The dotted line shows the frequency response of a conventional packaged MEMS microphone as shown on the left side of figure 1. A large front volume leads to an unwanted resonance at 20 kHz.

The dashed line shows the frequency response of a MEMS microphone in CSMP technology as shown on the left side of figure 2. Due to the very small front volume a resonance in the acoustic frequency range is avoided.

The solid line in figure 5 shows the frequency response of a MEMS microphone packaged with the sharpEar technology. The frequency response is extremely flat in the acoustic frequency range. Due to the extended acoustic reference volume the sensitivity is improved by 3 dB. This leads to an improvement of the signal to noise ratio by about 1.5 dB. The data in figure 5 was calculated using an analogues circuit model as described by Winter in [6] for a chipset from Infineon. The simulations were verified for CSMP by measurements in the acoustic frequency range.

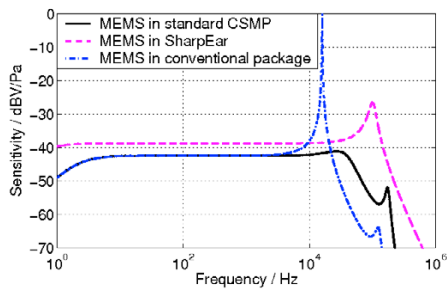


Fig.: 5 Comparison of the simulated frequency response of MEMS microphone packages

3. Summary and Outlook

A new highly miniaturized MEMS microphone package with sound hole on the top side and large acoustic reference volume was developed. Due to a large acoustical back volume the sensitivity is increased by 3 dB compared to conventional packages. A very small front volume leads to a flat frequency response within the acoustical range.

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