

MEMS Packaging - Technological Solutions for a Si-Microphone

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Introduction

Micro Systems and Micro Devices play an important role in today's high tech products. They are used as acceleration sensors for airbag control, as piezo actuators for high resolution print heads, as micro pumps for high precision chemical/medical dispensers or as silicon microphones for smallest hearing aid applications. In order to facilitate the use of such fragile devices, packaging of these structures is a major issue. Due to the cost and yield issues associated with this process step, significant evolution on top of the microelectronic packaging techniques is required. MEMS packaging fulfils a crucial role within the function of the MEMS device. Besides the electrical interconnection, the package provides mechanical protection, media separation or coupling (e.g. pressure), signal conditioning, etc., it must enable the resulting package to be manufactured and assembled at low cost. Also, high reliability requirements even under harsh conditions (e.g. oil sink with extreme temperature differences and aggressive ambient) must be fulfilled in order to be accepted in the market for high tech solutions.

Within the project InFON a packaging technology for stress sensitive MEMS devices has been developed, that allows the cost effective packaging of a silicon microphone. The development of the packaging technology is described in detail from concept development and material selection to manufacturing process development and reliability characterization.

Motivation

Today, microphone packages for mass markets are typically electrete microphones. These microphones are built since decades and the technologies used have reached a high level of maturity and cost efficiency. A schematic is given in Figure 1. The microphones can be used for a wide variety of applications from high end as medical purposes to rather low end as mobile communication. Major drawback is the temperature sensitivity of electrete microphones, causing not only a decrease in performance during product lifetime, but results also in the impossibility to use reflow soldering processes for microphone assembly.

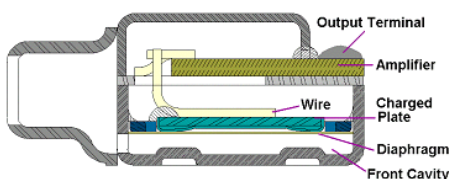


Figure 1: Schematics of an electret microphone (courtesy of Knowles)

Effect is that the high temperature during reflow soldering would cause a discharge of the charged plate and thus the microphone would lose its functionality. This drawback is overcome by single soldering of microphones to the respective motherboard.

Driven by industries demand for surface mountable microphones with high performance and smallest deviations between single devices the development of Si-microphones is pursued. Multiple groups are working on this topic, mostly microphones using premolded packages are described [1], examples for rather microphone-specific packages are a Si-microphone developed by Knowles [2], by Sonion [3, 4]. This provides the background for the work of IZM within the InFON project, where the global goal is the development of cost effective single microphone packages and microphone arrays, resp.. Technological basis of the project is a BICMOS-compatible process for the manufacturing of Si microphones developed by Infineon. [5, 6, 7, Figure 2]

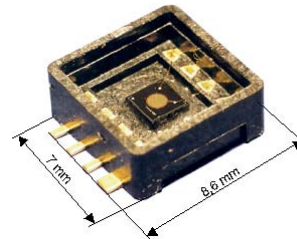


Figure 2: Schematics of a Si microphone in a premolded package (courtesy of Infineon)

Further partners are Siemens Audiologische Technik, SAT and Peiker acoustic, both using the packages for hearing aids [SAT, 8] and speakerphones for automotive use [Peiker, 9]. IZM's task within the consortium is to develop a generic packaging technology, that allows the realization of cost-effective microphone packages for various applications.

Development Challenges

For the packaging of a sensitive MEMS device as the silicon microphone for a mass market application a set of technological and economical demands has to be considered. The key points for this development are:

Minimum influence of the packaging technology on microphone performance (Compliant Packaging),

Maximum miniaturization for hearing aid applications (3,6 x 3,6 x 1,7 mm³ for a single chip module) with a minimum backside volume of 3 mm³,

Generic packaging approach - scalability of the packaging solution related to integrated components –

Realization of single chip, dual chip and array packages within a package family

Process cost is limited by electrete microphone manufacturing cost.

Package compatibility with SMT processes to allow a drop in replacement of electrete microphones

Flexibility of use – packaging should allow the realization of omni-directional as well as bi-directional configuration – i.e. single & double sided sound port

These criteria were the basis for the packaging development for a silicon microphone package within the InFON project.

Packaging Solutions for Single Chip and Array Microphones

In a mutual effort a concept study was performed. This included not only theoretical work but also FEM simulation [10], electrical modelling efforts [11] and first technological evaluations [12]. Selected technology was a COB approach, using a low cost organic substrate as a base material. For die attach a stress decoupling, silicone based adhesive was used, mechanical protection and backside volume for the microphone was realized using metallized polymer cap with optional sound port generated by laser cutting. For device interconnection wire bonding was chosen. A manufacturing process flow for a dual IC package is depicted in Figure 3. All processes were developed using production equipment, allowing an easy technology transfer to the industrial partners within the project.

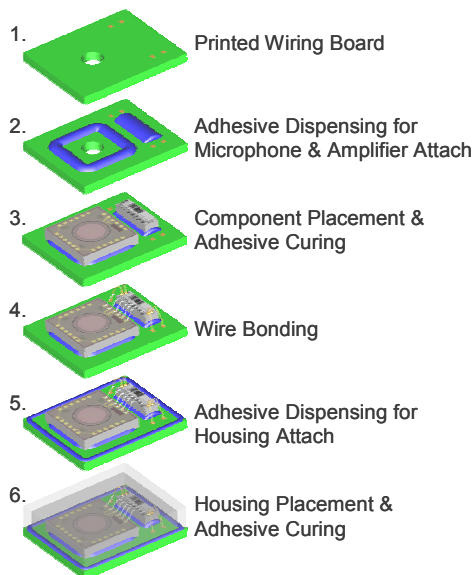


Figure 3: Schematic process flow for the manufacturing of a dual IC package integrating Si-microphone and amplifier

A first series of microphones has been assembled, acoustic performance was tested to be suitable for the demanding hearing aid applications.

Summary & Outlook

Within the InFON project a packaging technology has been developed that allowed the packaging of a stress sensitive

silicon microphone. Using this technology, various package types have been built, single and dual chip packages as well as maximum miniaturized array packages for hearing aid improvement. In Figure 4 and Figure 5 a schematic drawing and an example for such an array are depicted.

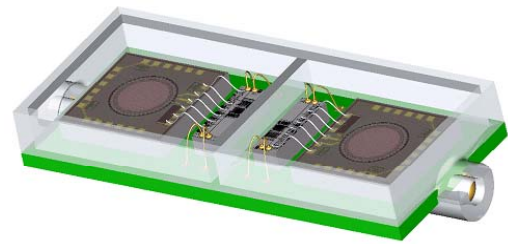


Figure 4: Schematic of a Si-microphone array package

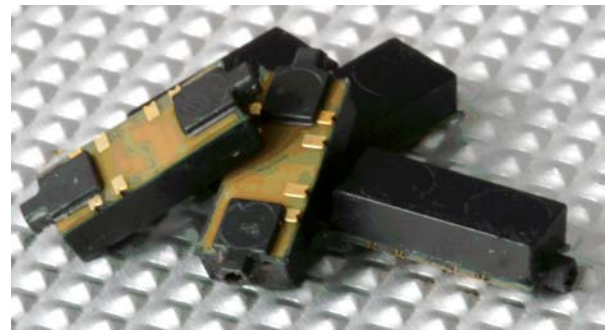


Figure 5: Si-microphone array package realized within InFON

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