Packaging Challenges for Monolithically Integrated Microsensors

Streiff, Matthias
Sensirion AG,
Laubisruetistrasse 50, CH-8712 Staefa, Switzerland

Abstract

Within a time span of 12 years Sensirion has established itself as an industry leader in microchip based sensing of differential pressure, and flow measurement and control devices for gases and liquids. In particular, Sensirion is now regarded as the industry leader in combined temperature / humidity sensors, with respect to both market share and ability to innovate. This article will focus on humidity sensing, and, in particular, on the packaging challenges that were encountered on the path to a mature product, and on a preview of upcoming generations.

1. Introduction

What makes a successful product? With respect to packaging the original vision was to offer customers products that look like and are assembled like any other standard IC component, i.e. products compatible with standard lead-free SMT processes using standard high volume placement and reflow solder equipment.
Prior to Sensirion's technology, humidity sensors consisted of a sensitive element, discrete read out electronics and a trimming feature to calibrate the system. This resulted in bulky and expensive devices similar to the one shown in Figure 1. Instead, the aim was to develop tiny, inexpensive, readily calibrated, highly stable and reliable components.

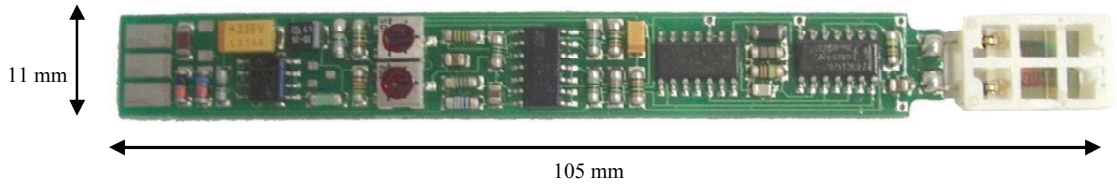

Fig. 1: Typical humidity sensor from the mid 90s.

2. Making the Vision a Reality

Naturally, package technology plays an eminent role in achieving the vision stated in Section 1. However, to accomplish this Sensirion had to refine the following areas concurrently over the past years:

(a) Sensor:

Whereas it is relatively easy to create a first lab grade sensor that is sensitive to humidity, industrial grade sensor stability and selectivity - i.e. being sensitive to humidity only - are not. Nevertheless, they are the prerequisites for a successful product. The best in class specifications met by Sensirion’s humidity sensors are the result of its long-term experience in this area. Furthermore, by integrating the sensitive area and the read out electronics on the same monolithic chip, it was possible to radically reduce the footprint of a single components that is inexpensive, and can readily be tested and calibrated.

(b) Testing:

Semiconductor industry qualification and testing standards are required to reach the reliability levels that a typical customer is asking for.

(c) Calibration:

Usually, this aspect is underestimated, especially with regards to its impact on final product costs. For this reason, most of Sensirion's know-how, experience, and competitive edge, gathered in the past years, are in this area.

(d) Packaging:

The original vision was to offer customers a product that can be handled like and looks like any other standard IC component. I.e. a product with a radically minimized footprint, compatible with standard lead-free SMT processes using standard high volume placement and reflow solder equipment. However, naturally, a sensor chip is not a standard chip. I.e. standard IC packaging processes cannot be used here.
On the one hand, the package has to protect the sensor reliably in harsh environments. That is, the sensor has to comply with tough AEC-Q100 testing conditions that include high temperature operating lifetime (HTOL), temperature cycles (TC), unbiased highly accelerated stress test (UHST), temperature humidity biased (THB), and ESD tests. At the same time, on the other hand, the package has to guarantee high fidelity and low latency for the wanted humidity signal, and has to minimize the impact it has on sensor stability.
Over the years, several dedicated packaging processes were developed that take these factors into account, still at low production costs. Recently, these activities have culminated in starting the production of Sensirion's latest humidity sensor, shown in Figure 4.

3. Humidity Sensor Package Evolution

Figures 2 to 4 show Sensirion's innovation in humidity sensor packaging over the past 10 years.

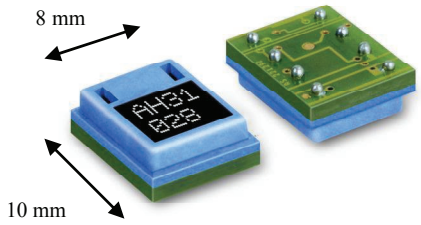

Fig. 2: First product – AH31

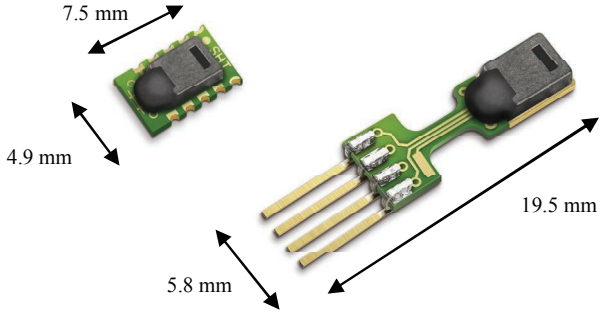

Fig. 3: Present long runner (launched in 2001) – SHT11 and SHT75

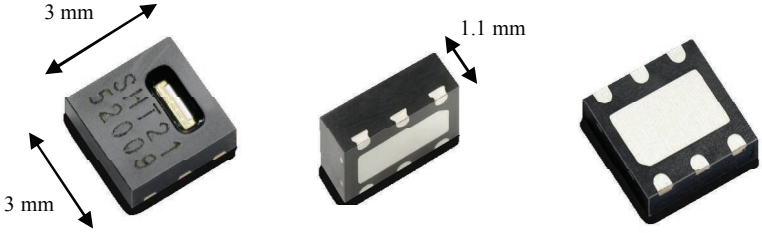

Fig. 4: Latest product (launched in 2009) – SHT21
(please note the change in scale from Figs. 2 and 3)

The very first humidity sensor package, shown in Figure 2, was a ball grid array (BGA) package based on chip on board (COB) technology. The next generation package featured electrical contacts on the sides, or with pins, as shown in Figure 3. It also uses COB technology.

The latest package is shown in Figure 4. It is a dual flat no leads (DFN), which is related to the quad flat no leads (QFN) family of packages. In order to fulfil the packaging requirements stated in Section 2d a proprietary, fully automatic, high volume packaging line had to be developed and custom built in-house. This was needed because standard IC packaging house processes did not meet Sensirion's advanced requirements. A great financial and time effort was put into developing the QFN package along with its manufacturing process. However, it has enabled Sensirion to revolutionize the way humidity is measured.

4. Conclusions

Thanks to Sensirion's latest technology a tiny, inexpensive, readily calibrated, highly stable and reliable component is available now. In this way, accurate humidity and temperature measurements have become accessible to a broad range of customer and are ready to be integrated easily into any thinkable application. Nevertheless, future customer requirements will go further to even smaller sizes and lower costs. In order to address these market needs, Sensirion is presently developing the next generation of humidity sensors.

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References

For more information please visit http://www.sensirion.com.