ASE: The challenge and importance of MEMS and sensor packaging

Steve Taranovich - January 04, 2017

MEMS and sensor devices have catapulted the Internet of Things (IoT) toward the deployment of billions of sensors in a myriad of applications in electronics technology that will improve the world around us as well as enhance the human condition. In reality MEMS and sensors exist today with incredible capabilities which are continuously being enhanced with more integration. Their physical size is shrinking and the energy needed to power them is ever being lowered.

Smart module and SiP integration will allow the huge deployment of connected devices in the IoT. To enable this, the different solution providers within the value chain will need to work together. A simplified supply chain needs to emerge and system integrators need to develop things like design kits for industry design engineers to evaluate different system configurations before designing a specific module or SiP. ASE Group has a design kit (DK) that will help designers to get a faster time-to-market.

Image courtesy of ASE
Designers can go from prototype to production inside of four months with a development kit like this.

**DK Speed Up Design Cycle Time**

- ASE’s DK could help customers easily verify smart functions with their existing driver module.

An oft-forgotten component of MEMS and sensors is the physical package which mechanically protects the MEMS/sensor and the electrical interconnects, and provides thermal management. Christophe Zinck, senior applications engineering manager at ASE, says that there is much customization in these types of packages for different solutions and new process developments are emerging especially in MEMS; standardization across platforms is not possible. His company will perform an in-depth simulation of a package design and then give that to the customer to evaluate virtually before the package is actually fabricated. The package needs to be considered at the very beginning of a design.

Stress optimization is a critical aspect of the package design for a MEMS/sensor design. Simulations will demonstrate the maximum stresses on a package, look at warpage and see how the package performs when made up of different types of materials (*Figure 1*).
Applications such as consumer products and smartphones sometimes attach sensors to glass. Strong modeling is a must here as well as modeling design interactions that may sometimes leverage existing platforms. Zinck says that optical design for manufacturing (DFM) will have future applications like changing radio frequency with the motion of a hand. A good example of optimum package selection for a particular MEMS device such as an inertial measurement unit (IMU) is shown in Figure 2.

**Figure 1** A warpage comparison of an LGA vs. a WLP package (Image courtesy of ASE)

**Figure 2** Package maximum stress and warpage over temperature are critical factors to a successful IMU solution. (Image courtesy of ASE)

Different packaging technologies and bill of materials (BOM) selection criteria will determine the level of performance that a customer needs (**Figure 3**).
Inertial and environmental sensors have different needs. The customer can choose the best parameters for their individual needs in a package solution. A package is more than just protection. (Image courtesy of ASE)

The growing automotive market

Automotive is a fast growing market for the electronics industry. This sector has far different needs and demands for their MEMS package requirements than most industries. Autonomous vehicle trends are growing and sensors such as cameras, LIDAR, and RADAR will make roads and driving safer with less accidents in this smartphone and texting world. Autonomous vehicles will need lots of redundancy, high integration packaging and more, but smaller packages will be emerging.

ASE’s Zinck thinks that “this market has near-military toughness without the cost of MIL-spec compliance.” Zero ppm in automotive testing may not be possible but it is a mindset. The SiP package is finding favor in this arena for modularization and smaller footprint. Legacy packages are important here as well as AEC-Q100 levels (Figure 4).

Figure 3 Inertial and environmental sensors have different needs. The customer can choose the best parameters for their individual needs in a package solution. A package is more than just protection. (Image courtesy of ASE)

Figure 4 Automotive legacy package solutions include SOP, Unibody, DIP, Chip Pack, Open Cavity SOIC, and LGA. Key technologies for legacy automotive packages are stress isolation, soft die attach (DA), wire bond (WB) on soft DA, and gel coat/fill (needed in an aggressive environment like
MEMS in automotive have needs that had to evolve in packaging in order to enhance integration, size, and performance of these unique devices (Figure 5).

![Automotive MEMS Trends](image)

Figure 5 MEMS package trends in automotive allow better integration of die, low package stress, EMI shielding, smaller board footprint, and more. (Image courtesy of ASE)

SiP packages have their own capabilities and needs in automotive. Shielding, thermal enhancement, stacked die and antenna integration are only a few things that ASE does for their customers in this critical market segment (Figure 6).

![ASE Technologies for SiP](image)

Figure 6 SiP solutions abound in the automotive market to enable shielding, stacking die, bare die solutions, integrated passive components, thermal enhancements and more. (Image courtesy of ASE)

Zinck mentions that in automotive environments like 200 °C, molds will outgas sulphur and attack wires; new failure modes appear at this temperature, but disappear below 165 °C.
A good example of an application in a smart sensor system could be a small hand-held device with light, proximity, and direction sensing, or a body motion sensor array, or even a physiological sign monitoring and reporting device. Design engineers seek enhanced software, greater connectivity, and sophisticated hardware (Figure 7).

**Example of a Smart Sensor System (SiP with sensors)**

- **Application:** Smart handheld (light, proximity, gesture), body motion and physiological sign sensing

![Smart Sensor System](Image courtesy of ASE)

- **Benefit realized:** 80% size reduction and improved optical signal quality by using new package platforms (embedded, LCP lid, QLGA)

**Figure 7** A smart sensor system (SiP containing sensors) has very special needs in packaging.

There are so many optical sensor designs in the market today and one especially growing segment is the wearables sector. There are more and more difficult specs emerging for footprint and device height for wearable applications. The need for more 3D wafer level package (3D WLP) with through silicon via (TSV) will enable further smart integration for MEMS and sensors. 3D WLP is emerging as a key technology for wearable and medical applications as well (Figure 8).

**Sensor Technology – Optical Sensor**

- **Application:** Body motion and physiological sign sensing in Wearable

**Figure 8** Optical sensors have their own special needs in packaging, especially in the growing
wearables arena. The sensor needs to be integrated with passives, power management and other microcontroller die, etc. ASE provides optical signal analysis, firmware co-qualification, system-level testing, and uniquely fitting SiP package designs. (Image courtesy of ASE)

The key challenge here actually does not involve MEMS and sensors packaging itself; instead, the main challenge will be for the outsourced assembly and test (OSAT) community to effectively deliver the most suitable architecture to meet customer module and/or SiP integration needs.

ASE’s group synergy makes it a strong partner with capabilities including ASE assembly and test; ASE materials group; USI supply chain management, system design capability, system level test and more; and ISE Labs for developing test programs, test interface hardware and engineering test services, qualification and reliability testing and failure analysis capabilities. A complete turnkey service that spans engineering design through high volume production.

For more information visit the ASE Group [website](#).

**Also see:**

- [Packaging advances needed to ensure IoT growth](#)
- [Wearables design focuses on packaging](#)
- [Advances make MEMS sensors easier to integrate](#)
- [Sensor conditioning amidst a sea of focus on MEMS and sensors](#)