MEMS PRODUCTS AND MEMS TECHNOLOGIES FOR AUTOMOTIVE APPLICATIONS AT INFINEON

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Abstract: Sensor products and the corresponding fabricating technologies represent a challenging field within semiconductor development. The article will give you an overview of Infineon sensors and shows the development of the required technologies.

The product portfolio can be described with two major sensing principles, magnetic sensing with Hall sensors and GMR Sensors and "moving mass sensing" with Gyrometers, accelerometers and pressure sensors.

On one side the technology is based on bulk micromaching integrating the piezoresistive resisors. On the other side, BiCMOS technologies with integrated Hall elements, GMR elements and integrated micromechanical devices are used. A focus within the development of these technologies and products is to assure robustness, high yield and automotive quality within automotive specifications.

An outline of the principal development flow of such a technology development will be given. A prerequisite to provide quality is to use a well known and qualified process base and the IP pool of an established fab.

In case of SMM Devices this process base is a 0,5µm BiCMOS process. Within qualification DOE's provide a deep device and technology understanding.

The summary shows the corresponding fields of application and products

Infineonovi MEMS izdelki in tehnologije za uporabo v avtomobilski industriji

Kjučne besede: senzorji, avtomobilski senzorji, MEMS, senzorji GMR

Izvleček: Senzorji in njim pripadajoče tehnologije predstavljajo zanimivo področje znotraj razvoja polprevodnikov. V prispevku podajamo pregled nad Infineonovimi senzorji in pregled nad razvojem ustreznih tehnologij.

Delovanje senzorjev temelji na dve osnovnih principih: magnetno zaznavanje (Hall in GMR senzorji), oz. zaznavanje z gibajočo se maso (žiroskopi, merilniki pospeška in merilniki pritiska).

Na eni strani je tehnologija osnovana na mikrojedkanju substrata za izdelavo piezo uporov. Na drugi strani pa BiCMOS tehnologija omogoča integrirane Hall elemente, GMR elemente in integrirane mikromehanske komponente. Končni cilj razvoja tovrstnih tehnologij je zagotoviti robustnost, visok izplen in kakovost, ki zadovoljuje stroge zahteve avtomobilske industrije.

Podali bomo primer razvoja ene takih tehnologij. Pogoj za doseganje visoke kvalitete je uporaba znanih in kvalificiranih procesov ter znanja in izkušenj proizvodnje.

V primeru SMM komponent je osnova 0.5um BiCMOS proces. V povzetku naštejemo ustrezne izdelke in možnosti uporabe.

1. Infineon Sensors

The Infineon Technologies sensor product portfolio can be described within two main sensor principles, magnetic sensors and mechanical sensors.

Today most of the magnetic sensor are realized with a simple n-doped well integrated in a 0,5µm BiCMOS logic process.

This base technology is operating with 5 to12V and produced with a 2 to 3 layer metallization on 8 inch wafers

Due to the construction of the n-well resistor and the Hall Effect the sensor is sensitive perpendicular to magnetic fields. The advantage of this approach is the easy integration in existing basic logic technologies, which allows a great diversity of applications and interfaces.

A new and promising technology for measuring magnetic field is the GMR (Giant Magnetic Resistor) technology. The resistance of the layer stack is sensitive to magnetic field components in plane to the sensor.

The advantage of this effect is a higher sensitivity for higher resolution or reduced application / packaging requirements. This technology is integrated in a 0,25µm logic technology. This technology is in ramp up.

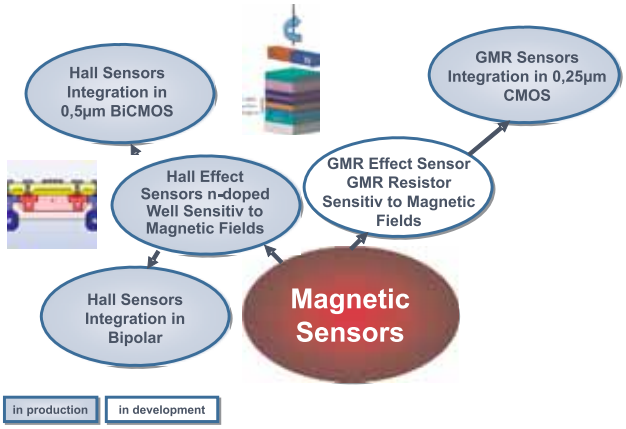

Fig 1: Magnetic Sensors

For mechanical sensor within Infineon Technologies, the inertia sensors are produced with a BMM (Bulk Micromachining) technology with no integration of logic circuitry. This technology allows access to Mono-Silicon cantilevers and beams. The movement of the beam is detected on one side with piezoresistive resistors placed in the stress maximum of the beam. This concept is applied for pressure sensors and acceleration sensors.

Demonstrated in the TPMS product (Tire Pressure Monitoring System) a membrane pressure sensor and cantilever acceleration sensor can be realized on the same chip in one production flow.

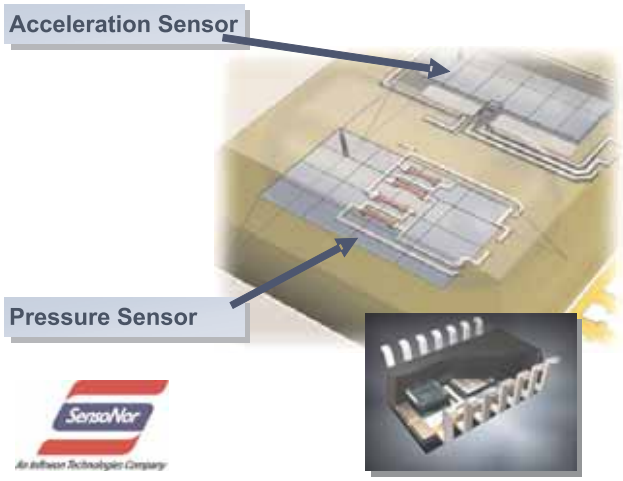

Fig 4: BMM TPMS Sensors

On the other side the signal can be realized with measuring the capacitive signal between the two moving electrodes. This concept is applied for the Gyrometers.

Overall mechanical sensors allow sensing of multiple physical parameters. For example Pyrho-Arrys with detecting temperature differences below 1°C or microphones with HIFI quality in µm dimensions.

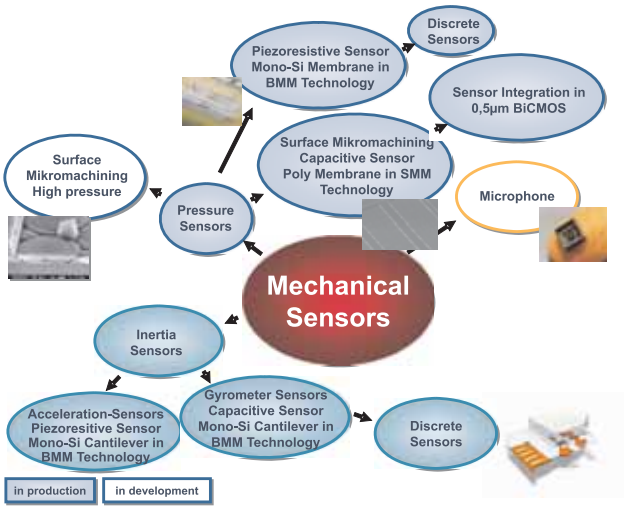

Fig 2: Mechanical Sensors

The application of these technologies within the product portfolio is described in the following overview

Fig 3: Product Portfolio

2. SMM Pressure sensor technology

The technology of the SMM pressure sensor is described in more detail within the following chapter.

Bases of the technology is a well known 0,5µm state of the art BiCMOS technology which is already in production. The process flow of the technology consists of different process modules. The base process providing vertical NPN's, lateral PNP's, 5V CMOS, Poly resistors and Poly-Poly Capacitors can be expanded by adding process moduls and such adding devices.

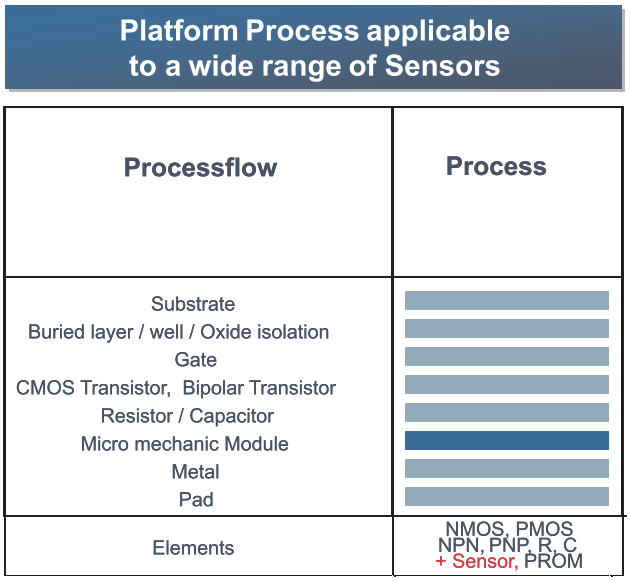

Fig 4: Processflow SMM Pressure Sensors

In this way the Hall probe, vertical PNP's, PROM devices and high voltage devices up to 30V have been added. In the same way a module for fabricating the pressures sensor has been added.

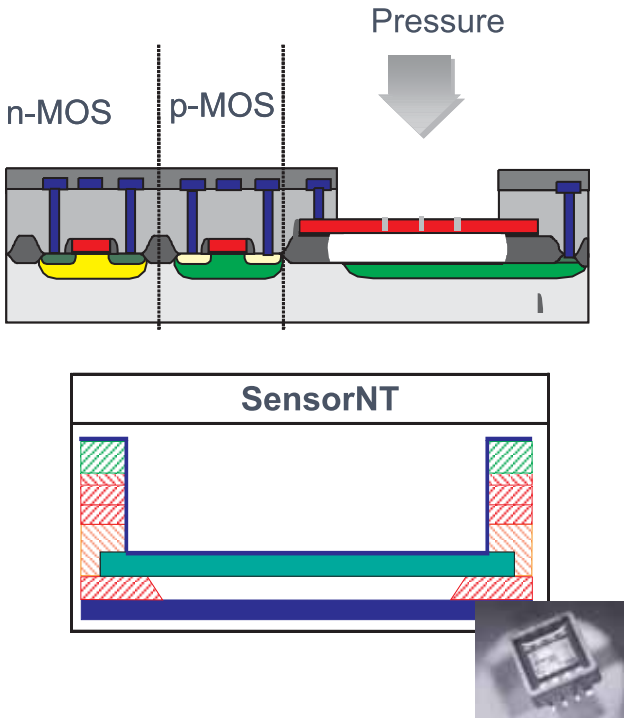

Fig 5: Sensor concept

This module consists of a sacrificial layer, providing the cavity after having been etched; it consists of a Poly silicon layer working as a membrane; it consists of the cavity sealing process and last not least it consists of the final passivation of sensor and circuitry. All this steps are done in a standard CMOS fab with no extra equipment or special processes.

After completing the process the sensor consists of a 0,8µm Polysilicon membrane. The cavity hight is 0,3µm with an inside pressure of <2hPa and a maximum bending of the Poly membrane of about 20nm.

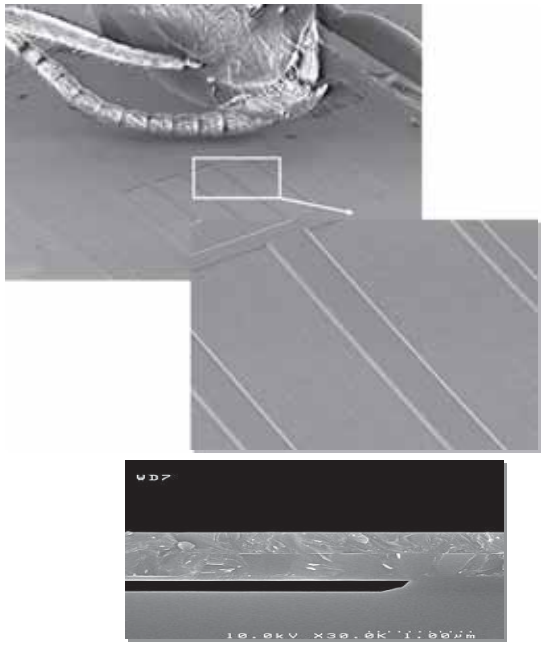

Fig 6: Cross Section SMM Presssure Sensor Device

2 sensor arrays and 2 non movable reference arrays are arranged in a wheatstone bride. Each array consisting of 42 independent pressure sensor cells.

The pressure sensor product is applicated for 0,1bar to 3 bar with 1% overall accuracy. The accuracy is achieved with on chip signal conditioning

This sensor is used for side airbag detection and motor management

Figure 5: SMM Pressure sensor applications

3. Technology Development, Example SMM Pressure Sensor Technology

The technology development process is controlled by project management and during ramp up by a dedicated ramp up team.

The technology development team provides the unit processes, the process integration the process flow and the equivalent devices for controlling process and device parameters.

The product development team provides the product design, the test engineering and the logistics during development.

For a parallel development of technology and product a test chip design has to be done.

The analyses departments provides physical analyses, stress tests, simulations and parameter extractions

The qualification department provides process and product qualification.

After the release of technology and product the responsibility is handed over to the fab which takes care for yield and quality.

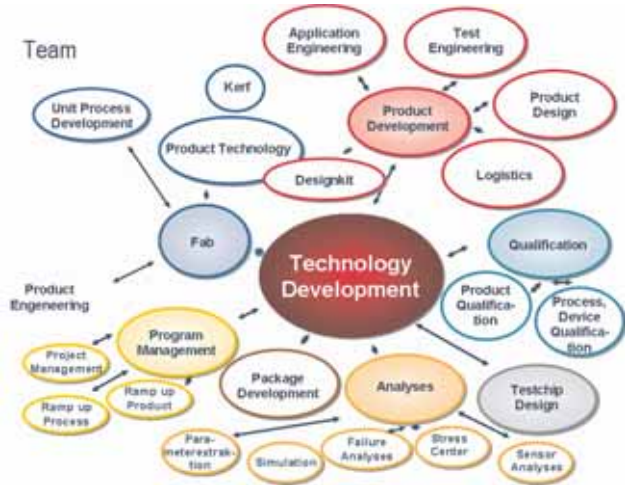

Fig 6: Technolgy development process, involved teams

The main targets of the development are:

Qualification of the technology, verifying the technology robustness in terms of variations in the fabrication process and of course a stable yield.

The most important development tools to archive this are simulation, FMEA (failure methods and effect analyses) and process window evaluations.

The simulation of the Sensor Device is mainly done with FEM and must result in a model applicable within the product development. For the model is based on process parameters, this allows an in depth understanding of the product performance and it allows a fast analysis of deviations.

The FMEA Method is a method for classifying all risks in a cross functional team. Measures taken for device or process can be tracked by the team and the problem solving is documented.

Below, a short overview of the development process and its deliverables are given.

Fig 7: Overview development process

The project starts with the process and product idea. If the target of the development is the development of a new platform technology the technology may be done parallel to the product development

The deliverables at this status are:

- Consolidated project plan
- Technology and development concept created
- Feasibility proven
- Target specification of devices fixed
- Risk analysis done

The freeze of the process flow can be done when the stability of the process is proven and no major changes are necessary. It enables the production of engineering samples.

The deliverables at this status are:

- Feedback from pilot product including package
- Final process flow for qualification
- Preliminary device characteristics and Design Rules
- Process window results on critical parameters
- Early Hardware reliability results available

The developed process is released in agreement with the involved partners and with the final qualification of process and product.

The deliverables at this status are:

- Device characteristics and Design Rules finished
- Process flow Construction analysis finished
- Technology documentation finalized
- Production Robustness proven
- Qualification finalized, Qualification Report & Record available.

Within the qualification a complete technology qualification has to be done once per technology or process line and a product qualification has to be done for each product or product family

A technology qualification consists of:

- Devices qualification (e.g. drift at bias / temperature stress)
- Dielectrics qualification (e.g. time to breakdown)
- Metallization qualification (e.g. maximum current densities, electromigration stability)

The result of the technology development process is a Technology Platform established for Application in Products with:

- A qualified and standardized process line with process flow and equipment recipes for production
- The necessary device library, design documents and tools for product development
- The equivalent kerf

4. Summary

The Technology portfolio of Infineon provides MEMS processes for products in automotive applications.Magnetive sensing with Hall sensors and GMR sensors "Moving Mass Sensing" with Gyrometers, Accelerometers and Pressure sensors.

The Technology Development provides Technologies for automotive products Platform Technologies result in stable quality Standard Development flow result in robust processes

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