nanusens

THE PIONEER OF SENSORS
BUILT INSIDE CMOS

Nanusens opens up MEMS sensor production for ultra-high volume production

Breakthrough novel manufacturing technology builds MEMS within CMOS and breaks the MEMS shrinkage barrier

We live in an analog world with sound, heat, pressure etc. and somehow what happens in it has to converted into a form that our digital electronics devices can understand. It's this awareness that makes the smartphone smart, cars smarter and homes smarter. The key is tiny sensors that detect movement, steps, magnetic fields, etc. These are usually devices called MEMS (Micro Electro Mechanical Systems) with microscopic moving parts that detect the changes in whatever is being measured.

The kick start for huge growth of the MEMS market has been attributed to Steve Jobs changing the mobile phone into a powerful pocket computer with the ability to have more and more sensors included for better and better user experiences. Now sensors are everywhere and MEMS are made in their billions with the market being worth billions of dollars.

However, there is a huge problem for this industry that stops it growing really fast to the trillions. Every type of MEMS sensor has to be designed and made using a dedicated, production process that can take five to seven years to bring to market. It is also hard to ramp up production apart from constructing a second identical manufacturing line. There are no economies of scale available as every process is unique. Moore's Law of electronics continually shrinking does not apply to MEMS as they have effectively hit a barrier at around one micron.

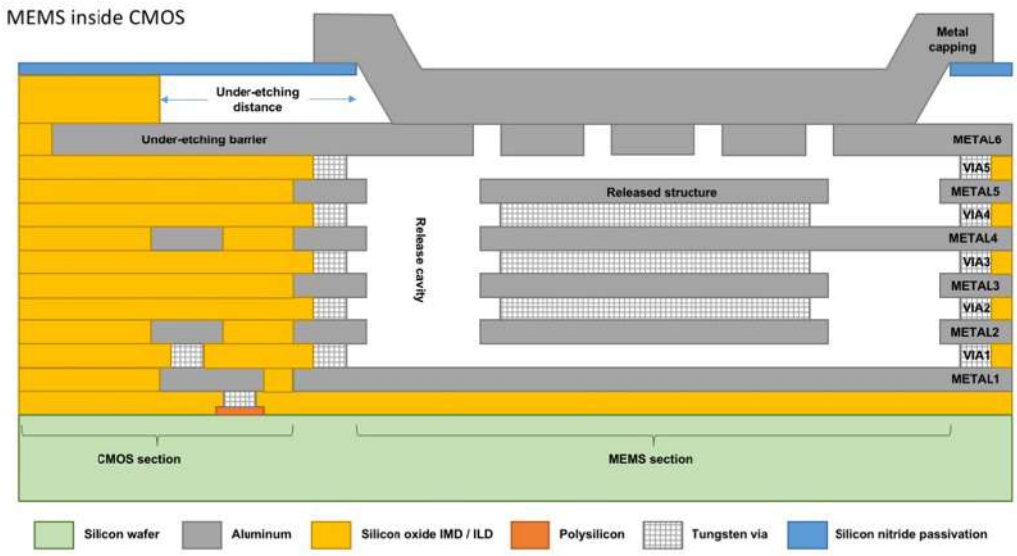
As a result, the demand for MEMS is outstripping supply. More and more devices are being designed with sensors. A smartphone can have over a dozen sensors. Cars need more and more sensors to enable them to become more aware and smarter on the road to self-driving. Building are becoming smart with sensors to optimise heating and ventilation. Health and medical devices use sensors to measure heartrate, respiration, temperature etc. And then there is the vision of the Internet of Things with trillions of smart devices with sensors all interconnected for optimal performance.

This impending shortage of MEMS sensors could become a major bottleneck for device manufacturers. Fortunately, there has been a breakthrough by a British electronics company

that solves this problem by removing the need for specialist manufacturing processes to make MEMS. Instead, Nanusens has created a technique to make MEMS using standard CMOS production techniques so that it can use any fab to make as many MEMS as are required.

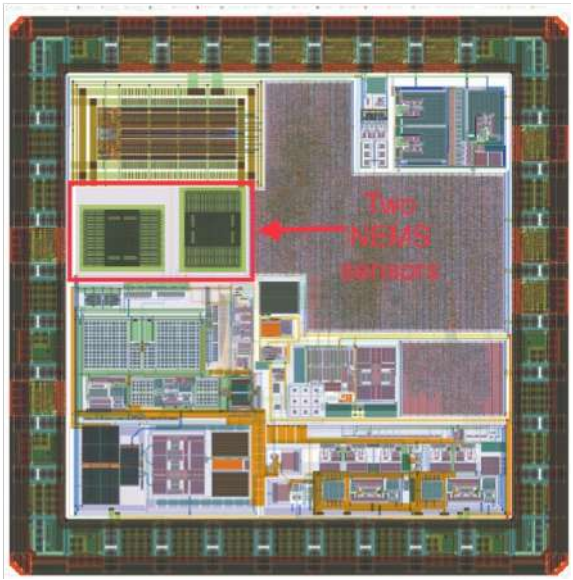
Current MEMS devices consist a chip with the moving parts that form the sensor built on the surface of a silicon wafer, and a second chip with all the control electronics. The second chip is easy to make using standard CMOS processes but the first chip, with the tiny moving mechanical parts, is the part that needs proprietary processing and therefore is the limiting factor that prevents rapid increases in production volumes.

The Nanusens solution is to make both parts in one chip by shrinking the MEMS part so that it can be formed within the layers of the control chip. The MEMS structure is created with metal layers in the same way that a normal CMOS chip is made. The structure is then released by etching away the surrounding silicon dioxide so that it can move freely.



Nanusens shrink MEMS to create nanosensors within the CMOS layers

However, in practice, the released metal MEMS structures distort due to stresses in the metal that are only an issue when the metal is released into the void created. This is because the CMOS process was never designed to release metal layers in this fashion. The team at Nanusens has spent years researching and perfecting MEMS structures that are stable when released. As these structures and variants thereof are quite specific so they can be patented by Nanusens to protect its breakthrough of MEMS-within-CMOS.



The MEMS structures that Nanusens create are ten times smaller than current MEMS

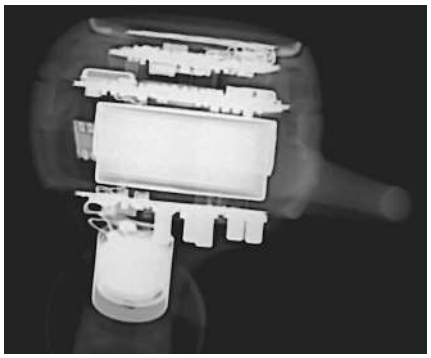
structures effectively taking them from the microscopic realm into the nanoscale making them NEMS (Nano Electro Mechanical Systems). One of these NEMS motion sensor structures measures only 100 by 150 microns and takes up less than ten percent of the chip area with the rest being the control electronics.

Initially, Nanusens will be making devices with just one type of sensor on them with the first being a 2D motion sensor. However, as the sensor structures are so small, it is easy to include several different types of sensor structures on the same chip as the way to make them is identical. As a bonus, the control electronics can be reused so that the overall size of the chip only increases slightly as more sensor structures are added.

Nanusens thus solves the bottleneck of MEMS growth by using standard CMOS production techniques simultaneously solving the limiting factors of cost (now vast economies of scale are available to reduce prices) and volume production (now they can be made in any fab). It also means that Nanusens has smashed the MEMS shrinkage barrier and that NEMS can shrink in the same way as other electronic chips as they are now on the same shrinkage road map of CMOS. Nanusens is currently using 0.18 micron CMOS processes as this is a workhorse, fully debugged and supported node but sees no reason why smaller and smaller nodes cannot be used for future sensors.

Nanosensors free up space in designs

In addition, there are other benefits to this new technology of nanosensors that will particularly appeal to designers of smart devices – particularly portable or wearable products. The final packaged product is much smaller than current equivalents. Current MEMS designs require two chips and, when packaged, the resulting volume is $4mm^3$. The Nanusens NEMS solution is only a single chip so that the package is much smaller at just $1mm^3$. A saving of $3mm^3$ can be tremendously significant in applications where space is at a premium which is why the company's first target market is earbuds.



X ray of an earbud show how densely the components are packed within

Earbuds have two problems that using nanosensors solves. The first is operational life because the small form factor means that batteries are small. The $3mm^3$ saving per sensor replaced enables larger batteries to be used for a longer listening experience. Savings are even greater when several sensors are combined into one Nanusens device.

The other problem is that designers want to put more and more sensors into earbuds but hit the problem of packing them into the already tiny space. Nanosensors remove this barrier so that sensors can be added to improve the operational life of the batteries by enabling the earbuds to detect when they can turn themselves off to save power. For example, a motion sensor detects if they are in the ears whilst a temperature sensor check that they are actually in the ears and not loose in a pocket.

Using Nanusens nanosensors can free up space inside earbuds for larger batteries and more sensors

There is another benefit to shrinking MEMS. Current MEMS structures have feature sizes of larger than one micron while NEMS structures are 0.3 micron as they are made with a 0.18 micron process node. This means NEMS structures are better able to withstand impacts, which is important for use in wearable devices that are often dropped. This greater reliability is because the load mass is much smaller in a NEMS than in a MEMS and a smaller mass does less damage under impact condition. The load mass is suspended on springs and any movement of the load mass is detected using changes in capacitance. In addition, smaller structures are less susceptible to short ranges forces such as Van der Vaal's forces that can hold surfaces together and thus prevent the movement of parts.

Engineering samples made with this technology have already been made and tested. Production samples are due in September 2019 which will be Nanusens first product – a 2D motion sensor. Other sensors will rapidly follow in 2020 as the principle of how the various sensors work is the same and all use the same manufacturing processes.

This also means that Nanusens can combine different sensors on the same chip. It is already in discussion with some leading companies about what combinations of sensors they require for their designs. Albert Chuang, Nanusens Product Manager who is based in Shenzhen, China, added, "Designers are really excited about being able to have multi-sensor solutions in a single tiny package. This opens up whole new opportunities for creating smart devices without the penalty of taking up a lot of space and PCB real estate for numerous discrete sensor packages."

"*If MEMS isn't small enough for you then NEMS should be*," said Stuart Robinson, Director, Handset Component Technologies service at Strategy Analytics. "*Nanusens has taken MEMS*

technology to the next smaller level, developing nanoscale sensors inside the CMOS that can be integrated in the same silicon as the sensor controller. This is not a big deal for some applications but it's a game-changer for small devices that have multiple sensors such as accelerometers, gyroscopes, pressure and humidity sensors. Space-saving sensors leaves more room for other components such as a bigger battery. Every cubic millimetre counts in some devices so Nanusens is onto a winner here."

Nanusens is a VC funded British company that is has opened a new funding round on CrowdCube. It expects this to be the last chance for investors to be able to easily invest in its disruptive technology via CrowdCube before the Series A round later this year for institutional investors. www.crowdcube.com

Author

Dr. Josep Montanyà, CEO Nanusens. More than 14 years working in MEMS design, patent prosecution and semiconductor business.

About Nanusens www.nanusens.com

Nanusens is pioneering sensors built inside CMOS. Nanusens patent-pending technology shrinks MEMS sensors and builds nano-scale sensors (NEMS – Nano Electro Mechanical Systems) along with the control electronics using standard CMOS processes. This creates single chip solutions that are up to ten times smaller than the equivalent multi-package MEMS. The freed-up space can be used for larger batteries for longer operational life battery or additional features. Many different sensors can be built into the same tiny chip to enhance the user experience and differentiate products without taking up more space. Its expertise and pending patents place it as the uncontested leader in this technology that will revolutionise the next generation of sensors.

Founded in 2014 by Dr. Josep Montanyà, Dr. Marc Llamas, and Dr Daniel Fernandez, Nanusens is headquartered in London, England with Research and Development offices in Barcelona, Spain and Shenzen, China. It leverages the research and expertise developed by the founders' previous company, Baolab Microsystems. Nanusens is VC funded by Inveready (www.inveready.com/venture-capital/), Caixa Capital Risc (www.caixacapitalrisc.es/en/) and Dieco Capital (www.dieco-capital.com), and crowdfunding via Crowdcube. Tel +34 935824466 info@nanusens.com

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