

A Next Generation HVM Process Platform for High Performance IMU Devices

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Summary:

We report on our next generation high-volume manufacturing (HVM) process platform for high performance inertial-measurement unit (IMU) devices. While footprint is reduced, it achieves a 40% increase in sensitivity for gyroscope and accelerometer with reduced noise level and improved vibration robustness. New process modules have been implemented and combined to accomplish stable production and application requirements.

Keywords: IMU, MEMS, high-volume mass production, process platform, 30µm Epi, SiRiN

Background, Motivation and Objective

Over the past years, the currently running, HVM proven, process platforms have enabled many successful products [1], but its limitations have become a bottleneck for next-gen IMU devices. Chip size and height constraints in combination with increasing performance demands required an evolution of a new process platform. Since it is not desirable to extend the footprint of a MEMS device, the performance boost in sensitivity is only achievable by significantly increasing the sensor core mass and capacity density. This goal was reached by vertically raising the sensor core mass, combined with other process adaptations. This paper presents the results and challenges of this new process platform development.

Description of the New Method or System

The process platform features a 30 µm thick, low-stress Epi layer and thus a higher aspect-ratio trench for unchanged electrode gaps. This allows for a higher capacitance within the same electrode area, compared to our former 20 µm Epi platform [2]. We also introduce a sacrificial oxide-etch protection using Silicon-Rich silicon Nitride (SiRiN) with a high selectivity, enabling accelerometer designs with very compact anchors, which in turn improve signal offset performance [3]. Furthermore, since wiring traces are no longer underetched, they can be more compact, which makes the parasitic capacitances smaller. To compensate for the conductivity loss of narrow wiring traces, we increased their thickness and doping level. The usage of thick, sacrificial, oxide layers between wiring and functional poly-Si layers enables large gaps for out-of-plane movement of our sensor masses, which

makes the signal detection very robust against external disturbances.

Results

We optimized the new process platform with 50% higher Epi thickness and higher buried topography to achieve a comparable distribution of Epi thickness values after CMP. In fact, as for the previous platform, we still reach a comparable Gaussian standard deviation value over high volumes, as depicted in Figure 1. Simultaneously, increasing the Epi thickness does not lead to compromises in process or design variations, i.e. the critical dimensions or etch loss after trench. Results are comparable to current 20 µm Epi platform settings as exemplified in Figure 2. The spread of drive frequency is kept very small over high statistics and proves capability for HVM. Implementing the insulating SiRiN material required identifying a mass-production-safe gap width between wiring traces to minimize the probability of electrical bypasses. This was achieved using a dedicated test structure (Figure 3), which confirmed that a 2µm gap is sufficient for robust insulation. The new process platform clearly fulfills intended requirements and is ready to launch.

References

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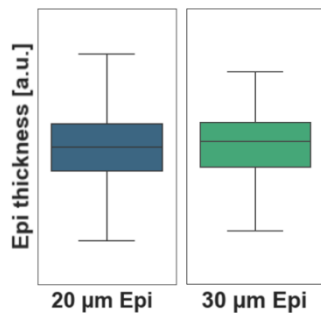


Fig. 1. The EP thickness is evaluated in a test structure, and the data is shown with equal increments. The 30 μm Epi thickness (right) lies well within the targeted thickness range and promises a similar series production capability as the 20 μm equivalent (left).

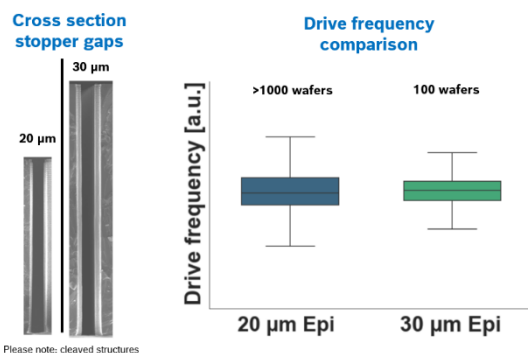
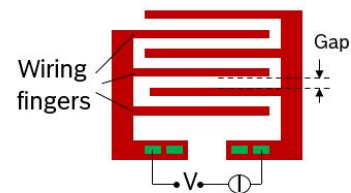


Fig. 2. A SEM cross section of stopper gaps reveals a comparable trench behavior of 20 μm and 30 μm Epi thickness types (left). The achievable etch loss distribution is also comparable (right).



Test wafer data (10V excitation)

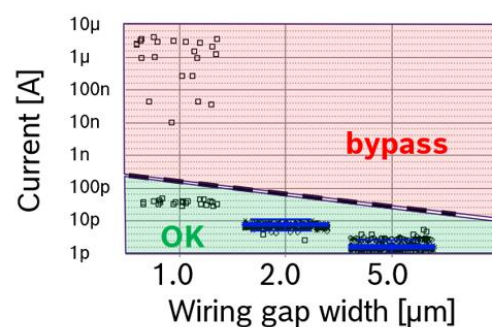


Fig. 3. Test structure (left) to measure the electrical isolation properties of SiRiN. Results (right) indicate that a 2 μm gap is sufficient for insulation.

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