Inertial Sensors for Motion Measurement in Safety Systems Applications

a report by
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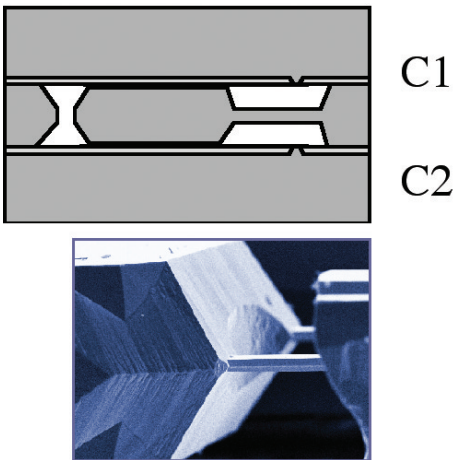
Today, nearly all accelerometers used in automotive applications are silicon micromachined and use a capacitive measurement principle. Silicon, particularly single crystal silicon, is one of the best elastic materials with no plastic deformation at normal operating temperatures. It also provides another excellent overload capability in so far as it does not break until at extremely high overloads. Typically bulk micromachined 1g sensing elements start to break at about 70,000g.

The capacitive measurement principle is simple, in so far as acceleration deflects a proof mass and the deflection is detected as a change in the distance between the electrodes in one or more capacitors. In this way, the capacitive pick-up is direct and we do not rely on phenomena such as piezoresistivity or piezoelectricity.

Depending on the measurement range, there are two basic technologies in use: surface micromachining for high-g applications such as crash sensing, and bulk micromachining for low-g sensing, which normally requires a good zero stability, vibration discrimination and high resolution. Bulk micromachining is superior in low-g and inclinometer applications such as measuring the vehicle body acceleration for electronic stability programs, anti-lock braking systems, traction control systems, electropneumatic brakes or any x-by-wire system. The main reason for this is the large proof mass in combination with a thin spring (low spring constant) shown in *Figure. 1*, resulting in a very sensitive sensing element giving a large signal amplitude out, enhancing accuracy and signal to noise ratio. Another contributing factor is the fact that, in a bulk micromachined element, gas damping can be used to modify the frequency characteristics to optimally measure the required phenomenon and differentiate it from, for example, vibration in the vehicle. Finally, a bulk micromachined element has a limited number of failure modes that are easy to detect, which provides reliability in safety-related applications.

Figure 1: VTI Technologies Bulk Micromachined Capacitive Acceleration Sensing Element



Acceleration or gravity will deflect the proof mass and the cantilever resulting in a change in capacitances C1 and C2.

Advances in Accuracy, Size, Reliability, Testability and Functionality

Silicon bulk micromachined sensors are by no means even near the end of their life-cycle. There are significant new features, such as deep reactive ion etching, coming in the technology, which reduce the size of the elements, increase accuracy, provide more flexibility in the design and enable even three-axis sensing elements. This, together with new advanced packaging technology, will significantly reduce the size of VTI Technologies' accelerometer components and increase the packing density of functions in the next years.

In the past there has been no temperature compensation in VTI's sensor electronics. With temperature compensation the zero accuracy in a 1g–2g accelerometer can be reduced from the present 100mg in -40°C to +125°C by roughly 50%. Further developments will be in multi-axis sensing, sensor diagnostics, including continuous self-test, and interfacing with standard digital protocols. ■

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