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Award Description

The Frost & Sullivan Award for Product Innovation of the Year is presented each year to the company that has demonstrated excellence in new products and technologies within their industry. The recipient company has shown innovation by launching a broad line of emerging products and technologies.

Research Methodology

To choose a recipient of this award, the analyst team tracks all new product launches R&D spending, products in development, and new product features and modifications. This is accomplished through interviews with all the market participants, and extensive secondary and technology research. All new product launches and new products in development in each company are compared and evaluated based on degree of innovation and customer satisfaction. Companies are then ranked by number of new product launches and new products in development.

Measurement Criteria

In addition to the methodology describe above, there are specific criteria used to determine final competitor rankings in this industry. The recipient of this award has excelled based on one or more of the following criteria:

- Significance of new product(s) in their industry
- Competitive advantage of new product(s) in their industry
- Product innovation in terms of unique or revolutionary technology
- Product acceptance in the marketplace
- New product value-added services provided to customers

2007 North American Gyro Sensors Product Innovation of the Year Award Award Recipient: InvenSense, Inc.

The Frost & Sullivan 2007 North American Product Innovation of the Year Award in the field of gyro sensors goes to InvenSense, Inc. in recognition of its development of an advanced integrated, dual-axis (X and Y axes) MEMS (microelectromechanical systems) rate gyro, which leverages an innovative electrostatic drive technique, bulk micromachining, wafer-scale packaging, and mixed-signal ASIC design to enable the realization of rate gyros for large-scale, cost-sensitive applications. InvenSense has designed its gyros to be of sufficiently economical cost and compact size, and yet be able to provide the level of performance and functionality required, to enable gyro sensors to be significantly used in high-volume consumer electronics applications (such as digital still cameras, and mobile phones), where such gyros afford these handheld products enhanced motion-based sensing capabilities.

Introduction

Santa Clara, Calif.- based InvenSense, Inc. was founded in 2003 by Steven Nasiri, the company's president and CEO, who is a veteran of the MEMS sensor industry and seasoned entrepreneur. Nasiri has extensive expertise in MEMS design, fabrication, and packaging for manufacturability. He developed the novel product concept of the MEMS gyroscope and the low-cost, high-volume fabrication process known as, "Nasiri-Fabrication". These efforts have led to the filing of the four core patents for the InvenSense, including the dual-axis gyro design and the vertical MEMS

fabrication process. These patents are now responsible for the development of world's first integrated dual-axis gyroscope which is the company's flagship product and being shipped in millions of units to major OEM companies around the world. He has been a co-founder and early stage executive at several Silicon Valley MEMS sensor companies, including SenSym (acquired by Honeywell), NovaSensor (GE), Integrated Sensor Solutions (Texas Instruments)(TI Sensors and Controls is now known as Sensata Technologies), and ISS-Nagano GmbH. Nasiri has spearheaded the deployment of over 50 sensors and MEMS-based product families, representing cumulative shipments exceeding 100 million units. He has authored over 40 patents issued and pending.

InvenSense is dedicated to developing high-performance motion sensing solutions that meet the challenging size and cost requirements of the mobile consumer electronics market. The company's efforts have resulted in dual-axis gyros with integrated electronics that are designed to surmount key challenges to incorporating inertial sensors in handheld consumer products. Target applications for InvenSense include: image stabilization in digital cameras and camera phones; gesture-based applications such as 3D mice and television remotes to navigate content; user interface navigation and gaming for mobile handsets, game decks; and location-based services for portable navigation devices (PNDs) and mobile phones.

Major investors in InvenSense include Qualcomm Ventures, Artiman Ventures, and Partech International. InvenSense's integrated dual-axis gyros have been designed into a number of high-volume consumer applications, encompassing digital still cameras, portable navigation devices and 3D remote controllers. Moreover, Sanyo Electric Co., Ltd. and other digital camera makers have selected InvenSense's gyro for use in its new generation of digital still camera models that offer image stabilization features.

Technology Overview

Various sensing technologies are used in gyro sensors, including piezoelectric, ring laser, fiber-optic, spinning mass, and capacitance. MEMS gyros, which can allow for reduced size and cost, are typically vibratory devices that use vibrating mechanical elements (a proof mass) to sense rate of rotation. Vibratory gyros are based on the transfer of energy between the two vibration modes of a structure, due to Coriolis acceleration (which arises in a rotating reference frame and is proportional to the rate of rotation). Tuning fork gyros contain a pair of masses that are driven to oscillate with equal magnitude, but in opposite directions. When rotated, the Coriolis force creates an orthogonal vibration that can be sensed using various sensing techniques.

There are key challenges in building a low-cost, high-performance gyro, which is not susceptible to factors that can impact a gyro's performance, such as manufacturing variations, packaging, linear acceleration, or temperature. Designing a MEMS gyro is more challenging than designing, for example, a MEMS pressure sensor or

accelerometer, since the MEMS gyro is essentially two high-performance MEMS devices integrated into one device: a self-tuned resonator in the drive axis; and a micro-g sensor in the sensing axis. The magnitude of the Coriolis force sensed in the MEMS gyro is orders of magnitude lower than that for a high-volume MEMS accelerometer. Moreover, largely owing to design and packaging constraints, micromachined or MEMS gyros have not achieved the cost point that would enable such gyros to achieve their market potential and expand into diverse consumer electronics applications.

Innovative Features

InvenSense's integrated dual-axis gyro sensor products are geared toward providing the size, functionality, performance, and cost point required to truly enable the incorporation and proliferation of MEMS gyros in new markets/applications (i.e., consumer electronic devices). The company's MEMS gyros and other inertial sensors, which offer a very small footprint are designed to be readily integrated as key motion (e.g., rate of rotation) sensing components in a diverse range of products (i.e., consumer handheld devices).

InvenSense's MEMS capacitance tuning fork gyro design addresses the challenges of achieving a gyro with key functionality at a size and price point that can spearhead the use of such gyros in high-volume consumer electronics applications. The use of bulk silicon material can allow for a larger proof mass and can be more efficient to manufacture compared to a surface micromachined gyro that uses polysilicon.

Compared to competing MEMS rate gyros, InvenSense's dual-axis gyros are designed to provide advantages in terms of the parameters of size and cost. Moreover, the company's bulk silicon gyro can be more robust than surface micromachined gyros, since it can accommodate a larger proof mass.

InvenSense has achieved a dual-axis rate gyro with a silicon die size of less than 3 x 3 mm. The company's patented out-of-plane resonating structure is the cornerstone of their gyro's design, designed to have a greater ability to serve cost-sensitive applications.

InvenSense's gyros also benefit from wafer-level packaging, providing a fully functional device at the silicon die level. Wafer-level packaging is achieved by combining the MEMS and ASIC (application specific integrated circuit) wafers using a proprietary, patented wafer bonding technology. The wafer bonding process provides electrical connections between the CMOS (complementary metal oxide semiconductor) and MEMS wafers, which also establishes a hermetic seal between the two wafers. The integration of the finished MEMS structures with a standard, off-the-shelf CMOS ASIC can avoid the pitfalls associated with integrating MEMS and CMOS processes (which could occur in the surface micromachining approach).

Furthermore, in contrast to resonating rate gyro sensors, InvenSense's gyros do not require expensive hermetic packaging to achieve the appropriate operating pressure or isolation form environmental influences (such as moisture). The integration of the drive, sense, and signal conditioning electronics at the wafer level can minimize stray capacitance and inductance. This level of integration also can minimize the need for external components in an application, allowing for a streamlined design and facilitating cost and size benefits.

In addition, InvenSense's product road map includes a six-axis Motion Processing Unit™ (MPU™), sensing all six degrees of freedom using its gyroscope and accelerometer technology, providing for more intuitive and comprehensive motion sensing capabilities. The six-axis MPU will provide dynamic motion to benefit applications in mobile phones or other consumer electronic handheld devices. Such applications could include location-based services (where the MPU would provide dead reckoning for better position tracking), image stabilization, user interface control, gaming, and power management. In very large quantities, the goal is to have an IMU, or dual-axis gyros, priced at sub-$1.00 per axis.

Smaller, low-power, less expensive MEMS gyros have key potential for use in consumer electronics applications. For example, in camera image stabilization applications, small form factor gyros can help ensure high-quality pictures by detecting and controlling hand jitter. As digital still cameras increase in pixel density and optical zoom range, subtle hand movements can result in poor image quality, especially in low-light settings. InvenSense's integrated small form factor dual-axis gyros are enabling MEMS gyros to replace piezoceramic gyro sensors, which have been used in camcorder or camera image stabilization and which reportedly could be fragile and vulnerable to temperature drift.

Moreover, camera phone images tend to be of low resolution and are susceptible to blurring as a result of hand jitter. Cameras with higher resolution and optical zoom and auto focus capabilities will be vulnerable to blurred images. The small size of camera phones and their densely packed electronic circuitry has tended to prohibit the integration of the existing image stabilization solutions that are used in digital still cameras. InvenSense's gyros can possess the size, power, and cost characteristics that meet the needs of camera phone manufacturers.

In handheld devices, such as mobile phones, InvenSense's integrated dual-axis gyros can allow for more intuitive, gesture-based functionality, such as scrolling, text entry, improved GPS navigation, or gaming. The company's gyros serve as "smart user interfaces" that provide mobile systems with a higher degree of motion and gesture comprehension, enabling them to provide enhanced intelligence and user interaction, and an improved user experience.

The company's compact, cost-effective gyros could also, for example, facilitate using handheld electronic devices for pedestrian navigation or location-based services. Such services can include emergency assistance, pedestrian navigation/tracking, and

mobile commerce (e.g., using a mobile phone to search for a restaurant or other points of interest). Such pedestrian navigation and location-based services require a global positioning system or terrestrial tracking technology. Moreover, in such applications gyros can provide information about direction of motion, which, along with information form accelerometers, can aid in pinpointing the user's location and in accurately tracking the user's position and movements when a GPS signal is compromised or unavailable.

InvenSense's integrated dual-axis gyros have been designed into digital still cameras and camera phones for image stabilization, GPS devices for dead reckoning, and 3D peripherals (e.g., 3D mice, TV remote controllers, game controllers). There are many digital still cameras that incorporate the company's integrated dual-axis gyros that are on the market today.

InvenSense's IDG-300 integrated dual-axis MEMS gyros are suitable for diverse consumer and industrial applications (e.g., IMUs, handheld GPS navigation devices, radio-controlled helicopters, toys and game devices, robotics and power tools, antenna positioning remote control, and so on) has a factory-set full-scale range of +/- 500 degrees/second, a low offset voltage, integrated low-pass filters, integrated reset switches for high-pass filters, 3 V supply operation, 5000*g* shock tolerance low cross-axis sensitivity, and superior vibration rejection over a wide frequency range.

The company's IDG-1000 integrated dual-axis gyroscope, designed for demanding consumer applications, such as image stabilization systems for camcorders, cameras, or camera phones, has a factory set full-scale range (30 degrees/second in the standard configuration), 3V supply operation, a sensitivity of about 33mV (degrees/second), nonlinearity of +/- 1% full scale, and weighs about 0.14g.

In addition to producing motion sensors, InvenSense develops complete application solutions to enhance product functionality while expediting adoption and time to market for product manufacturers. It's BlurFree™ image stabilization technology uses the gyroscope with specially designed imaging algorithms which provides superior image quality for digital cameras and camera phones. The gyroscope accurately tracks the movement of the camera caused by the natural hand shake of the user and the BlurFree™ software corrects the blur caused by this motion. The results are sharper pictures that are typical of more expensive mechanical image stabilization systems. For GPS applications, InvenSense's StrayFree™ dead reckoning technology provides an autonomous and highly accurate navigation solution when a GPS signal is corrupted or unavailable for handheld and portable navigation devices (PNDs).

InvenSense embodies the strengths and capabilities that allow a young company to effectively and rapidly carve out opportunities in key market segments that benefit from enhancements and advancements in gyro technology. The company has designed its MEMS rate gyros with an eye toward addressing key high-volume applications.

Moreover, a key part of InvenSense's strategy has been to create and provide MEMS gyros that provide the size, functionality, and price point required to truly generate new market an application opportunities for gyros. InvenSense's success demonstrates how a sensor company can be positioned to succeed in the marketplace by making key (e.g., design and packaging) improvements in sensor technology, which enables the sensor to address key needs in significant market segments (e.g., in the consumer electronics area there are key opportunities for more compact, low-power, and cost-effective gyro sensors).

InvenSense also illustrates the value of having management and personnel who have deep technological expertise and who understand how to design and make sensors for key, potentially high-volume applications. The level of MEMS expertise that InvenSense's founder and staff possess enables them to truly understand challenges in creating smaller, less expensive integrated gyros and to be able to address such challenges.

Moreover, InvenSense reveals how a sensor company with considerable technology expertise and a dedicated, diligent entrepreneurial spirit can create key opportunities in the sensors industry. The company has reportedly garnered over $20 million in total funding. Manifesting the effectiveness of such an approach and mind-set, InvenSense, in early January, reported having secured $11 million in Series B funding. Qualcomm Ventures participated in the round, along with existing investors Artiman Ventures and Partech International. The funds will finance InvenSense's high-volume production map for its integrated dual-axis gyro and the completion of new product development for the handset arena. The infusion of new capital will also allow InvenSense to build a broader infrastructure to handle the demands of very high-volume production and to widen its market reach and range of applications served.

Conclusion

In summary, InvenSense, Inc. has earned Frost & Sullivan's Award for Product Innovation of the Year in the field of gyro sensors in recognition of its achievement in developing an advanced, highly compact, functional, and cost-effective MEMS integrated dual-axis gyro solution, which is helping to open up new market opportunities for MEMS gyros in rapidly growing consumer electronics applications.

About Best Practices

Frost & Sullivan Best Practices Awards recognize companies in a variety of regional and global markets for demonstrating outstanding achievement and superior performance in areas such as leadership, technological innovation, customer service, and strategic product development. Industry analysts compare market participants and measure performance through in-depth interviews, analysis, and extensive secondary research in order to identify best practices in the industry.

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