PATENTS

Draper encourages its personnel to challenge the constraints of the past and present and to create solutions for tomorrow.

The Laboratory, which was formed to contribute to scientific research and technological development, has a tradition of technical innovation. The disclosure of inventions is a critical step in documenting Draper personnel's creative efforts, and is a requirement under Laboratory contracts (and by an agreement that all employees sign). Draper values the creativity of its engineers that leads to a patent award. The established patent policy is intended to direct attention and recognition to these innovative individuals and their accomplishments in science and engineering.

Millions of US patents have been issued since the first patent in 1836. Almost 1,000 Draper patent disclosures have been submitted to the Patent Committee since 1973; half of which were approved by Draper's Patent Committee for further patent action. As of December 31, 1998, a total of 371 patents have been granted for inventions made by Draper personnel. Fourteen patents were issued for calendar year 1998.

On average, Draper's Patent Committee typically recommends seeking patent protection for 50 percent of the disclosures received. This percentage is higher than one would commonly find in other organizations, be they industry or academia, and is further evidence of Draper's concern for and encouragement of creative work. An issued patent is distinguished and clear recognition by a critical and qualified third party, namely the US Patent Office, of novel and creative work. The Draper engineers who were granted patent awards in 1998 should be justly proud of receiving this recognition.

The patent chosen for this publication, *Temperature Insensitive Silicon Oscillator and Precision Voltage Reference Formed Therefrom*, is an excellent example of Draper engineers developing creative solutions to solve what was thought to be the limits of the past. The following pages contain an overview of the technology covered in the patent, followed by the official patent abstract issued by the US Patent Office.

1998 Patents Issued

In addition to the featured patent, the following pages contain a list of all other patents issued by the US Patent Office to Draper engineers during the 1998 calendar year.

Monolithic Micromechanical Tuning Fork Angular Rate Sensor by Paul Greiff

Patent No. 5796001, Issued 18 August 1998

A monolithic, micromechanical tuning fork gyroscope is fabricated from a unitary silicon substrate using etch stop diffusions and selective anisotropic etching. A non-etched silicon structure is suspended over the selectively etched pit. The non-etched silicon structure includes at least first and second vibratable structures. Each vibratable structure is energizable to vibrate laterally along an axis normal to the rotation sensitive axis. The lateral vibration of the first and second vibratable structures effects simultaneous vertical movement of at least a portion of the non-etched silicon structure upon the occurrence of angular rotation of the gyroscope about the rotation sensitive axis. The vertical movement of the non-etched silicon structure is sensed, and a voltage proportional to the movement is generated, for providing an indication of angular rate of rotation detected by the gyroscope.

Comb-Drive Micromechanical Tuning Fork Gyroscope with Piezoelectric Readout by Jonathan J. Bernstein and Marc S. Weinberg

Patent No. 5767405, Issued 17 June 1998

A microfabricated, tuning fork rate sensitive structure and drive electronics in which vibrational forces are communicated through a set of meshing drive and driven finger electrodes associated with each of two vibrating elements. The vibrating elements are supported in a rotatable assembly between first and second support electrodes that are in turn suspended by flexures for rotation about an axis passing through the flexures and through a point midway between the vibrating elements. Additional masses are formed onto the vibrating elements to improve overall sensor sensitivity. Sense electrodes for detecting capacitive changes between the support beams and the substrate are positioned on the substrate beneath each end of the support beams. In an alternative embodiment, piezoelectric sense capacitors are disposed on the flexures for detecting rotation of the support electrodes. Drive electronics are connected between the driven fingers of the vibrating elements and the drive electrode fingers that mesh with them to cause vibration. Excitation is provided between the support electrodes and the sense electrodes. Any change in signal resulting from rotation of the assembly and the resulting variation in capacitance between the support electrodes and the sense electrodes or within the piezoelectric capacitors is sensed as a measure of inertial rate. A torque loop may be additionally formed using the sense electrodes in order to re-torque the assembly to a neutral position in a torque-to-balance loop.

Process for Bonding a Shell to a Substrate for Packing a Semiconductor by Steve T. Cho

Patent No. 5837562, Issued 17 November 1998

A process is developed for manufacturing a vacuum enclosure for a semiconductor device formed on a substrate with leads extending peripherally. Assembly of the enclosure is compatible with known batch fabrication techniques and is carried out at pressures required for optimal device operation. In a first embodiment, an intrinsic silicon shell is sealed to the substrate via electrostatic or anodic bonding with the leads diffusing into the shell. In a second embodiment, a thin interface layer of silicon or polysilicon is deposited on the substrate prior to electrostatic bonding a glass shell thereon. In a third embodiment, tunnels are formed between a lower peripheral edge of the shell and the substrate, allowing leads to pass thereunder. The tunnels are sealed by a dielectric material applied over the enclosure.

Monolithic Micromechanical Vibrating Beam Accelerometer with Trimmable Resonant Fequency by Paul Greiff

Patent No. 5760305, Issued 2 June 1998

A monolithic, micromechanical vibrating beam accelerometer with a trimmable resonant frequency is fabricated from a silicon substrate that has been selectively etched to provide a resonant structure suspended over an etched pit. The resonant structure comprises an acceleration-sensitive mass and at least two flexible elements having resonant frequencies. Each of the flexible elements is disposed generally collinear with at least one acceleration-sensitive axis of the accelerometer. One end of at least one of the flexible elements is attached to a tension relief beam for providing stress relief of tensile forces created during the fabrication process. Mass support beams having a high aspect ratio support the mass over the etched pit while allowing the mass to move freely in the direction collinear with the flexible elements. Also disclosed is a method for fabricating such an accelerometer. Further disclosed is an alternative embodiment of the aforementioned accelerometer characterized by a low profile, and alternative planar processing methods for fabrication of these and other embodiments.

Process for Micromechanical Fabrication by Paul Greiff

Patent No. 5725729, Issued 10 March 1998

An improved process is developed for fabricating micromechanical devices having movable members, such as gyros and accelerometers. A starting wafer includes an oxidized silicon wafer that has been wafer bonded to a second silicon wafer that has a thin N layer on a P substrate. The wafer is patterned, doped, and etched in a series of process steps that include the deposition of epitaxial layers to configure

critical device dimensions and geometry. Metallizations are deposited for electrical/electronic interconnections. The process includes an ability to integrate on-chip electronics on the silicon substrate. Alignment difficulties and thermal mismatch associated with prior art processes are minimized.

Tunneling Sensor with Linear Force-Rebalance and Method for Fabricating the Same by Jonathan J. Bernstein

Patent No. 5752410, Issued 19 May 1998

A tunneling sensor is disclosed having a pair of force rebalance capacitors that are used in a push-pull relationship so as to provide a rebalance force that is a linear function of applied rebalance voltages, which leads to an output voltage that is linearly related to input acceleration. The tunneling sensor comprises a plate electrode that is formed from and attached to a silicon substrate by a pair of torsional flexures, which provide an axis of rotation for the plate electrode. A pendulous mass is formed on a first end of the plate electrode, and a tunnel-effect contact is formed on a second end of the plate electrode. A pair of torque rebalance bridge electrodes are formed on the substrate so as to span the plate electrode. A tunnel-effect tip is formed on the substrate so as to be proximate the tunnel-effect contact and in line with the rotational path that the tunnel-effect contact takes when the plate electrode is rotated.

Capacitive In-Plane Accelerometer by Paul Greiff

Patent No. 5817942, Issued 6 October 1998

An accelerometer is developed having one or more flexure stops for increasing the stiffness of the flexures when the accelerometer is subjected to relatively high acceleration. A wrap-around proof mass is suspended over a substrate by anchor posts and a plurality of flexures. In one embodiment, the proof mass has a rectangular frame, including top and bottom beams extending between left and right beams and a central crossbeam extending between the left and right beams. Proof mass sense electrodes are cantilevered from the top, bottom, and central beams and are interleaved with excitation electrodes extending from adjacent excitation electrode supports. Each of the flexure stops includes a pair of members extending along a portion of a respective flexure. Also described is a three-axis accelerometer triad device and a dissolved wafer process for fabricating the devices described herein.

Beat Frequency Motor Position Detection Scheme for Tuning-Fork Gyroscope and Other Sensors by Paul Ward and Anthony Kourepenis

Patent No. 5747961, Issued 5 May 1998

A tuning fork gyroscope has an in-plane position sensitive pick-off to which an AC or AC+DC bias is applied. Intermodulation is exploited to produce beat-notes between the applied frequency and the motor frequency at amplitudes proportional to motor amplitude, but unaffected by error sources such as spurious substrate charge accumulation. The beat-notes are used to control motor amplitude without the effects of charge accumulation.

Micromechanical D'Arsonval Magnetometer by Jonathan Bernstein and Marc Weinberg

Patent No. 5731703, Issued 24 March 1998

A micromechanical D'Arsonval magnetometer is developed for sensing magnetic fields at low frequency with high sensitivity for operation near the resonant frequency of a micromechanical structure comprising a movable proof mass supported by torsion flexures, a conductive winding formed on the movable proof mass, at least one bridge electrode spanning the movable proof mass, a source for electrically biasing the movable proof mass relative to the bridge electrode(s), and a drive for electrically driving the conductive winding. Magnetic fields in the plane of the proof mass perpendicular to an axis of rotation formed by the torsion flexures interact with current passing through the conductive winding so as to torque the proof mass about the axis of rotation, whereby the resulting rotation is sensed through capacitors formed between the proof mass and the bridge electrode(s). The current invention micromechanical D'Arsonval magnetometer can be operated either open or closed loop. An open-loop embodiment allows the proof mass to twist solely under the influence of the magnetic fields, while a closed-loop embodiment restrains the proof mass motion. The loop can be closed by constructing additional electrodes or by using the existing bridge electrode(s) for both sensing and rebalancing.

GPS Transfer Initialization by Richard L. Greenspan and Joseph M. Przyjemski

Patent No. 5739786, Issued 14 April 1998

A GPS transfer initialization system for initializing a mobile unit from a base unit includes a GPS receiver in the mobile unit for receiving a GPS signal, including a time register, a frequency register, and a GPS reference oscillator for generating a GPS carrier signal of a first frequency; a mobile transmitter/receiver circuit on the mobile unit responsive to the GPS carrier signal, for generating and transmitting a transfer carrier signal of a second frequency that is a multiple of the first frequency; a base transmitter/receiver circuit on the base unit including a GPS calibrated frequency and time reference for providing a GPS calibrated signal of a third frequency; an error detection circuit for comparing the GPS calibrated signal and the transfer carder signal to generate a frequency error signal determined from the difference between them and representative of the error in the frequency of the GPS reference oscillator; and an error correction circuit responsive to the GPS calibrated frequency and time reference and to the error detection circuit for generating and transmitting the GPS time and error signal; the mobile transmitter/receiver circuit including an initializing circuit responsive to the GPS time and the error signal for adjusting the time register and frequency register to the correct GPS time and frequency.

RF Balanced Capacitive Vibration Sensor System by Paul Ward and William Kelley

Patent No. 5808198, Issued 15 September 1998

An RF balanced capacitive vibration sensor system includes a carrier generator for generating an RF carrier and an inverted RF carrier; a voltage tunable capacitive vibration sensor responsive to one of the carriers; a reference capacitor responsive to the other of the carriers; a summing device for combining the outputs from the sensor and reference capacitors; a controller device for adjusting the amplitude of the carriers to tune the capacitance of the sensor to that of the reference capacitor; the sensor modulating one of the carriers with a vibration modulation signal representative of a sensed vibration; an RF amplifier device responsive to the summing device for amplifying the modulated carrier from the sensor; and a detector device, responsive to the modulated carrier from the RF amplifier, for detecting the modulation signal representative of the sensed vibration.

Net-Shape Ceramic Processing for Electronic Devices and Packages by William L. Robbins (Draper), John S. Haggerty, Dennis D. Rathman, William D. Goodhue, George B. Kenney, Annamarie Lightfoot, R. Allen Murphy, Wendell E. Rhine, Julia Sigalovsky

Patent No. 5834840 and 5801073, Issued 10 November 1998

An electronic device package is provided, consisting of reaction bonded silicon nitride structural and dielectric components and conductor, resistor, and capacitor elements positioned with the package structural components. The package consists of a ceramic package base characterized by a dielectric constant less than 6, of reaction bonded silicon nitride, or a heat spreader material. An electrical conductor is positioned on, embedded in, or attached to the package base for making electrical contact to an electronic device supported on the base and in preferred embodiments, a resistor is attached to the package base. The invention also provides package sidewalls connected to the package base, preferably of reaction bonded silicon nitride, and at least one electrical conductor extending to an outside surface of the package sidewalls for making electrical contact to an electronic device supported by the package base. The reaction formed electronic device packages of the invention provide the ability to support high device signal frequencies, high device operational temperatures, and high environmental temperatures, due to the characteristics of the package materials. The reaction formed electronic device packages of the invention may be produced with a nitriding process during which the overall package structure exhibits minimal shrinkage. As a result, the reaction formed electronic device packages of the invention may be shaped to finished dimensions before the nitriding process with complicated and tight-tolerance geometries of package structural, conducting, resistive, and capacitive components.