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SIMPLIFIED, ROBUST THREE-AXIS ACCELERATION SWITCH

Introduction

This invention presents a major advance in detection and quantification of sudden acceleration events. A research team at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL), Adelphi, Maryland, has designed and fabricated an acceleration threshold sensor that dramatically lowers operational power needs and generates a data stream less cumbersome than today's commercially available accelerometers. The capabilities represented by the ARL invention could realize new opportunities in the fight against traumatic brain injury (TBI) and improve existing systems for air bag deployment, drop-detection in electronic equipment, and many others.

Accurately characterizing linear and rotational forces experienced by participants in high-risk sports – such as these college football players at left – would assist significantly in prevention, diagnosis ,and return-to-action decisions. (Image source: U.S. Navy)

Concept

Accelerometer data is gaining interest in a growing number of fields, such as the military, sports, and other hazardous endeavors. A common link between each of these is a substantial risk for TBI. Each year there are an estimated 1.5 million cases within the U.S., resulting in more than 50,000 deaths. Among service personnel, DoD has reported more than 150,000 brain injuries since 2000 alone. TBI is caused by linear and rotational shocks to the brain. Such forces are likely to be encountered during head impacts and can result in neural and vascular damage. Accurately characterizing these forces would assist significantly in prevention, diagnosis, and return-to-duty decisions. Most field measurements involve instrumented helmets. This is not ideal since helmets are designed to absorb energy and mediate impacts. Acceleration sensed at this level does not accurately reflect true injury potential. A device fixed directly to the head or skin would provide more realistic data.

Current TBI sensing systems are too bulky for such an application; however, the ARL invention is compact (only 5mm by 5mm) and could easily be attached directly to a person's body. Moreover, its normally off switch design greatly reduces power consumption and streamlines the amount of data generated.

Invention Overview

- *Compact, low-power sensor measures acceleration in x, y, z axes*
- *Uses scalable MEMS fabrication processes well-known to industry*
- *Large number of potential applications in a variety of industries*
- *TRL 4 – Assembled sensors verify operational principles and fabrication techniques devised and used successfully to construct several devices*
- *Laboratory data available*
- *Builds on previous 3-axis acceleration switch designed by Army Research, Development and Engineering Center (patent pending)*

Doing Business with ARL

- *ARL is a leader in partnering with domestic firms*
- *Successfully developed and implemented innovative tools to ease the technology transfer process*
- *Tools include Patent License Agreements (PLAs); Cooperative Research and Development Agreements (CRADAs); Test Services Agreement (TSA); and others*
- *Visit www.arl.army.mil for more information*

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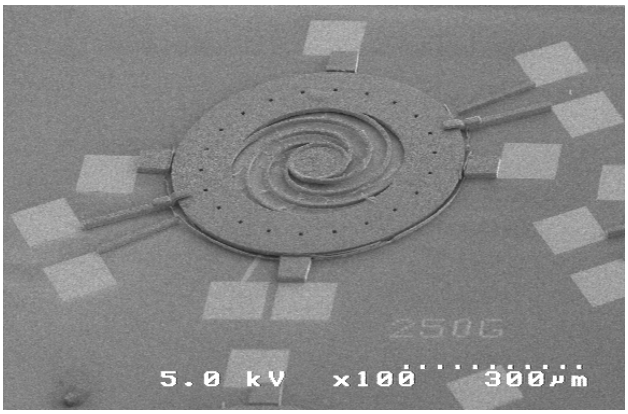
Features/Capabilities/Intellectual Property

The first acceleration-measuring machine was assembled in 1783, and since then, these devices have found useful missions throughout industry, in engineering, biology, construction, medicine, navigation, transportation, and consumer electronics. Tiny accelerometers do exist, but power supply and data processing required for extended use make them incompatible with evolving TBI monitoring strategies.

The ARL acceleration threshold sensor (a.k.a. an acceleration switch) represents a greatly improved option. Power consumption and data generation are minimized potentially by orders-of-magnitude because the switch is normally in a quiescent state, activated only when a shock event occurs. Acceleration switches are nothing new, but the ARL invention is superior to the current marketplace in several important ways. It measures acceleration along three axes simultaneously, and it has a method of electronic readout that reduces the I/O requirements via an on-chip resistor network that ties multiple sensors together. Other features/ capabilities/intellectual property offered by this invention include the following:

- Digital output with no A/D conversion needed
- True angle-sensing in x-y plane to +/- 10 degrees
- IP includes detailed MEMS method of manufacture and assembled device
- Builds on the first three-axis acceleration switch, developed by ARDEC (patent pending)



MEMS-fabricated ARL acceleration threshold sensor with spiral springs and individual x/y/z contacts (Image source: ARL)

Potential Markets/Applications

The compact size and capability of the ARL invention translate to potential applications in diverse fields:

- TBI event detection in military, athletics, children's car seats
- Airbag deployment
- Drop detection for damage prediction/assessment of sensitive equipment
- Low power robotic directional bump sensor
- Landing and other inertial event detection for “smart dust” sensor nodes
- Military munitions target detection, target impact, and reduction of UXO

Key Advantages & Benefits

- *Small, 5mm x 5mm geometry*
- *Customizable acceleration range from 30g up to 300g*
- *Orders-of -magnitude potential reduction in power consumption and data generation*
- *Digital output with no A/D converters needed*
- *Inventor team available to work with commercialization partner*

Contact Information

This technology was developed by ARL. It is now available for licensing and CRADA opportunities.

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