**Measures 3D Aerodynamic Flow Fields in Both Controlled Environments and Field Applications**

This micro-electromechanical system or MEMS-based device can measure wall shear stress vectors in 3D aerodynamic flow fields in both controlled environments and field applications. Aviation test equipment is designed to measure wall stress, which is essential to understand and solve aerodynamic drag issues. The global aviation test equipment market is projected to reach a value of over $7 billion by 2020. Only indirect methods, such as hotwires or particle image velocimetry (PIV) field visualization, are available for measuring wall shear stress. These methods require highly controlled testing environments and rely on inferred relations to produce a measurement.

Researchers at the University of Florida have developed a MEMS-based device that is capable of making direct, real-time wall shear stress measurements without secondary measurements or models for validation.

**Application**

MEMS-based device for measuring wall shear stress vectors in both controlled environments and field applications

**Advantages**

- Has a bulk micro-machined floating element, allowing the device to withstand prolonged exposure to various turbulent fluid fields
- Allows for independent measurement of shear stress in two directions, creating a vector measurement of shear forces tangential to the device’s surface
- Requires no prior assumptions about the flow field, allowing for use in highly complex 3D flow fields
- Can be sold directly to users, requiring little initial investment

**Technology**

This MEMS-based device is made of three components: the floating element, serpentine tethers, and capacitive comb fingers. The floating element allows the device to withstand prolonged exposure to various turbulent fluid fields without encapsulation, while the serpentine tethers allow the device to detect wall shear stress in two directions. The floating element is chemically etched into the silicon wafer so the overall device presents a flat surface to the fluid flow. Structures that protrude into the fluid flow field can corrupt the quality of any measured wall shear stress vectors. This device design can be used to test within controlled environments, such as aerodynamic testing facilities, as well as in...
field applications, such as airplanes or drones. Thus, assumptions regarding the testing environment are not required to obtain force measurements, nor are secondary measurements or models required for validation.

Inventors

Mark Sheplak, Ph.D., is an associate professor in the Department of Mechanical and Aerospace Engineering at the University of Florida. Dr. Sheplak earned his bachelor’s degree, master’s degrees and a Ph.D. in mechanical engineering at Syracuse University in New York. He is a member of the AIAA Aerodynamic Measurement Technology Technical Committee and an interim associate editor for JASA Express Letters. His research focuses on the design, fabrication, and characterization of high-performance, instrumentation-grade, MEMS-based sensors and actuators that enable the measurement, modeling, and control of various physical properties.

Casey Barnard Keene, Ph.D., was a graduate student in the Department of Mechanical Engineering at the University of Florida. He earned his Ph.D. in mechanical engineering from the University of Florida in 2017 under Dr. Mark Sheplak. He received the Sandia National Labs Campus Executive Fellowship and University of Florida Graduate Student Fellowship. He conducted research on systems to measure aerodynamic wall shear stress in the Interdisciplinary Microsystems Group (IMG) at the University of Florida.

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