Distributed Capacitive Sensor for Sample Mass Measurement

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Previous robotic sample return missions lacked *in situ* sample verification/quantity measurement instruments. Therefore, the outcome of the mission remained unclear until spacecraft return. *In situ* sample verification systems such as this Distributed Capacitive (DisC) sensor would enable an unmanned spacecraft system to re-attempt the sample acquisition procedures until the capture of desired sample quantity is positively confirmed, thereby maximizing the prospect for scientific reward.

The DisC device contains a 10-cm-diameter pressure-sensitive elastic membrane placed at the bottom of a sample canister. The membrane deforms under the weight of accumulating planetary sample. The membrane is positioned in close proximity to an opposing rigid substrate with a narrow gap. The deformation of the membrane makes the gap narrower, resulting in increased capacitance between the two parallel plates (elastic membrane and rigid substrate). C-V conversion circuits on a nearby PCB (printed circuit board) provide capacitance readout via LVDS (low-voltage differential signaling) interface. The capacitance method was chosen over other potential approaches such as the piezoelectric method because of its inherent temperature stability advantage. A reference capacitor and temperature sensor are embedded in the system to compensate for temperature effects.

The pressure-sensitive membranes are aluminum 6061, stainless steel (SUS) 403, and metal-coated polyimide plates. The thicknesses of these membranes range from 250 to 500 µm. The rigid substrate is made with a 1- to 2-mm-thick wafer of one of the following materials depending on the application requirements — glass, silicon, polyimide, PCB substrate. The glass substrate is fabricated by a microelectromechanical systems (MEMS) fabrication approach. Several concentric electrode patterns are printed on the substrate. The initial gap between the two plates, 100 µm, is defined by a silicon spacer ring that is anodically bonded to the glass substrate. The fabricated proof-of-concept devices have successfully demonstrated tens to hundreds of picofarads of capacitance change when a simulated sample (100 g to 500 g) is placed on the membrane.

This work was done by Risaku Toda, Colin McKinney, Shannon P. Jackson, Mohammad Mojarradi, Harish Manohara, and Ashitey Trebi-Ollennu of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP *(see page 1)**. NPO-47690*