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 — 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