Embedding Sensing Capabilities in an FDM-Printed Object

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Abstract

It is expected that 97 percent of 3D printers sold by 2019 will be Fused Deposition Modeling (FDM) printers. FDM printers produce parts by printing models from bottom to top in layers of molten plastic—commonly Acrylonitrile Butadiene Styrene (ABS). To date, most all FDM printed parts are static in that they contain no embedded components such as sensors or electronics. Our research demonstrates that it is feasible to produce "smart components" using FDM printing. Specifically, we utilize the elasticity of thin ABS diaphragms to manufacture the first 3D printed, strain-based pressure sensor. The design is a cubic, 3D printed structure with a hollow, conical cavity, closed off by a 1mm or 2mm thick diaphragm. During the printing process, a strain gage was placed at the center of the diaphragm, either within the diaphragm or on its interior surface. Successfully produced prototypes exhibited a limited leak rate, acceptable sensitivity, limited hysteresis and drift, and repeatability. When sealed with 100% acetone, the diaphragms' leak rates were dramatically improved by ~50x compared to unsealed 3D printed sensors. Pressure testing revealed that 1mm diaphragms deformed ~10x more than 2mm diaphragms. Additionally, 1mm sensors with a strain gage secured at the diaphragm surface responded to pressure linearly for an operable range of 0 to 7psi. Suspending a second strain gage inside the cavity allowed for a half-bridge circuit configuration, which improved the sensors' resistance to drift induced by temperature changes. The ABS diaphragms also showed no signs of elastic hysteresis or nonlinear buckling. Finally, when exposed to consecutive pressure sweeps from 0 to 5psi, the sensors yielded repeatable recordings. This work demonstrates a concept previously overlooked—exploiting the intrinsic properties of FDM prints with embedded electronics.

Biography

Garrett McGrady is a rising third-year Grawemeyer Scholar and one of two students from the University of Louisville to receive a 2018 National Goldwater Honorable Mention. His research background includes six years of experience in three different labs at UofL, including neuroscience, atmospheric science, and microelectromechanical systems. Garrett is returning from a co-op rotation at the Johns Hopkins Applied Physics Laboratory, where he worked on research in deep learning neural networks, and he is currently completing his second co-op rotation at Raytheon Missile Systems. Outside of research, Garrett is serving his second year as the Services Vice President of the Speed School Student Council. In 2017, he developed and launched the *SSSC Service Coalition* brand—an effort to support local schools' STEM clubs by providing them with student volunteers from Speed School.