Blood Vessel Strain Measurement

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Project Abstract:

This project involves the fabrication, characterization and viability investigation of microfabricated compliant gauges for measuring 100% dilational strain in a blood vessel. These gauges will be used in a research setting to provide continuous data acquisition of strain during pressure testing in harvested vessels. The strain gauges could be used to study the formation of Abdominal Aortic Aneurysms (AAA) in a rat animal model.

2-D and 3-D visualizations of abdominal aortic aneurysms are shown in Figure 1. Ultimately, implantation of a strain measurement device in *in vivo* medical devices such as stents would allow real-time monitoring of problematic conditions in blood vessels, decreasing the mortality rate through preventive monitoring.

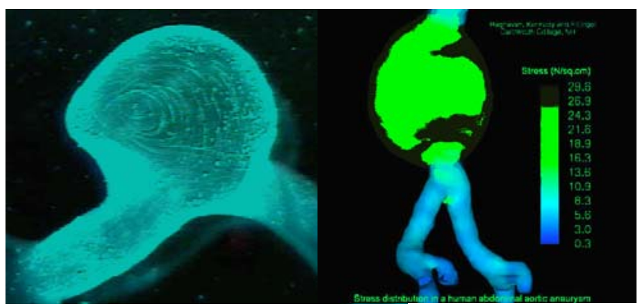

Figure 1: Left pictures shows 2-D visualization of AAA; Right pictures shows 3-D visualization with stress gradients.

The strain gauge design involves a Polydimethylsiloxane (PDMS) cuff that surrounds the blood vessel, as shown in Figure 2. The PDMS cuff must be thin in order to reduce vessel constriction, while still able to withstand 100% strain. To increase the compliance of the cuff, stress relief cuts are made in the PDMS as shown in Figure 3. The manufacturing process, as shown in Figure 4, involves making an SU-8 mastermold on a glass wafer substrate. PDMS is poured over the mastermold and then excess PDMS is removed. After curing, the PDMS substrate with relief cuts is ready for patterning.

Piezoresistive materials are patterned on the compliant PDMS substrate, such that the electrical resistance of the device changes as it strains with the blood vessel. Silicone-based carbon conductive ink patterned on the cuffs displayed good adhesion to the PDMS substrate and preliminary data shows that the electrical resistance of the device varies linearly with strain for strains up to ~70%. For patterning PDMS with the ink, different manufacturing processes, including microcontact printing, were explored. Similarly, the piezoresistive properties of gold patterned on PDMS are being investigated. To create the desired gold traces on the PDMS, a shadow mask was placed over the PDMS substrate during a gold evaporation process.

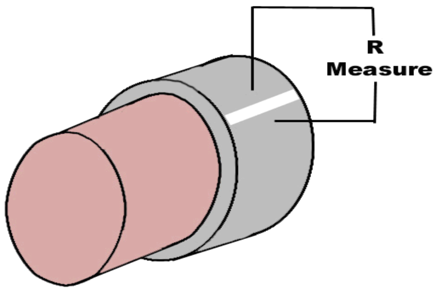

Figure 2: (a) PDMS cuff shown in grey surrounds vessel shown in pink. Electrical characteristics of the cuff change as it expands with vessel. (b) PDMS cuff with interleaved metal traces and stress cuts to increase cuff compliance.

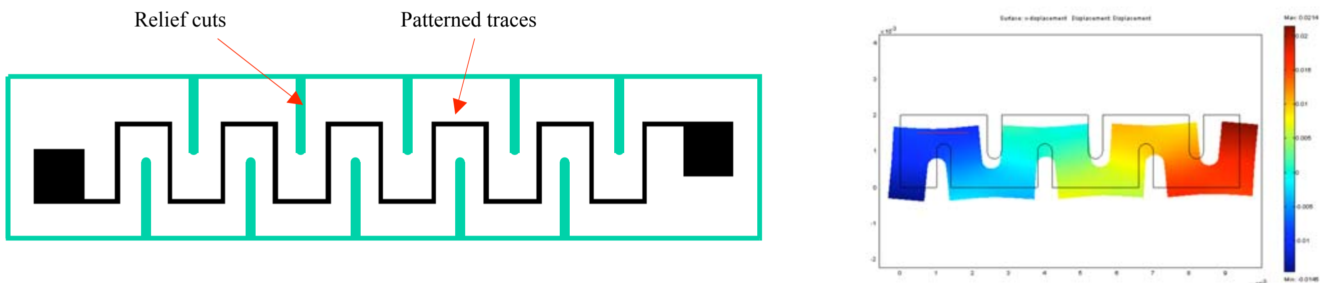

Figure 3: Stress relief cuts are voids intentionally made to increase the compliance of the PDMS cuff or band.   The patterned traces are made of conductive ink or gold.   FEM simulation of strain from centerline.

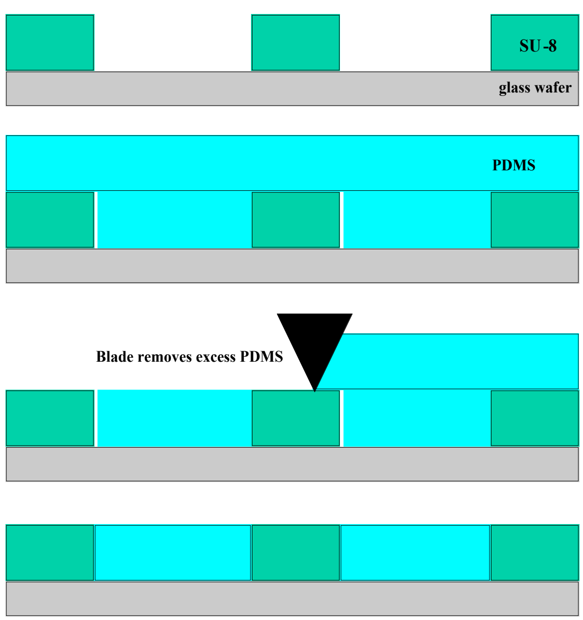

Figure 4: Process steps for using SU-8 mastermold to create PDMS bands with stress relief cuts.

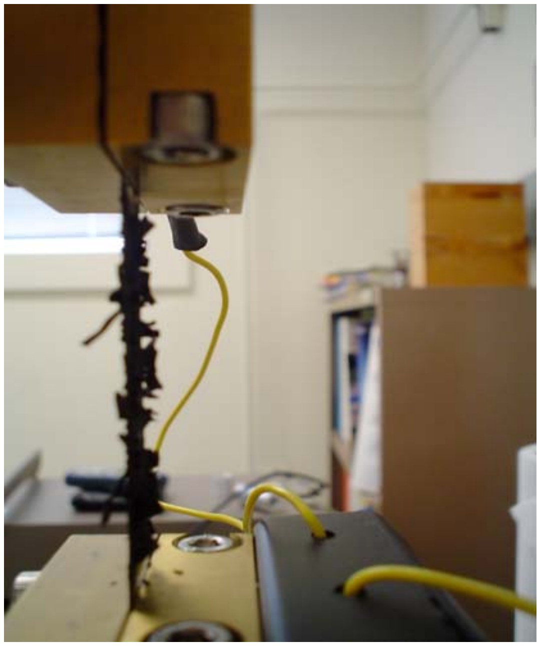

Figure 5: Device under test in MTS machine and resistance and force-displacement data from pull tests.