

# Implantable Left Ventricular Pressure Sensor



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Heart failure, which is caused by the heart failing to pump enough blood to the body, affects about 2% of adult population and is a main cause of death. Left ventricular pressure is a significant parameter needed for the clinical diagnosis of heart diseases. Constant monitoring of LV pressure in patients can provide early warnings before acute heart failure occur, thus reducing the need for hospitalization and also lowering mortality rates.

The MEMS capacitive pressure sensor has the features of ultra small size, low power-dissipation and absolute pressure sensing. The capacitor is fabricated on a CMOS die, along with the circuits to measure the capacitance. The integration of the capacitor and circuits leads to high-precision measurement. This device aims to measure the left ventricular end diastolic pressure of the heart, the normal range of which is 3-12 mmHg, and for patients with heart failure, this value is usually above 12 mmHg but less than 30 mmHg, which means that the heart pressure value is only a small fraction of the atmospheric pressure. Using proper formulas, the capacitance can be non-linearly related to pressure. However, within the variance of targeted heart pressure, the capacitance varies linearly with respect to heart pressure, making the device a linear system.

The fabrication process is illustrated in figure 1. Cross-sections are shown here. There are 4 metal layers in a CMOS die, which are separated by oxide layers and connected by vias. The gap in (4) highlighted by a red circle is the area that forms the capacitor. In the first step (2), oxide etch is done from the top surface to the metal layer that will eventually be etched away to form the capacitor. In the second step (3), the exposed metal layer will be etched by wet etching, except that the adhesion layers will stay intact, and form a gap between them. Then in (4), the boundary of the gap will be sealed using two distinct depositing techniques. The top part of the structure will now bend due to the pressure difference on both sides, and therefore this makes a pressure sensor.

(The project is part of a larger collaborative effort on the entire heart pressure sensor system involving ECE graduate students Ahmad Khairi and You Liang Lionel Wong, Robotics Professor Lee Weiss, ICES Professor Phil Campbell and Dr. David Schwartzmann of UPMC.)

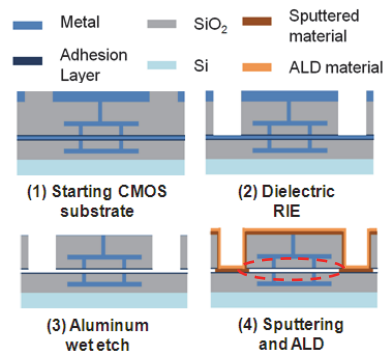


Fig 1: Fabrication process