Radiolucent pressure sensors - for mammography applications

Mammography is widely used today, where the purpose of the examination is to detect breast cancer. This is done by taking an x-ray image. To attain as good image quality as possible, the breast needs to be compressed, which is a very painful and uncomfortable experience for most women. Research has shown that the pressure is usually not evenly distributed and most of the pressure often ends up to close to the chest and a big amount over the pectoralis muscles. This causes unnecessary pain for most women and it can therefore be important to measure the specific pressure over more parts of the breast to possibly optimize applied pressure.

This project investigates the fabrication and design of a new type of pressure sensor that can be mounted directly on to the mammography machine. An important property of this sensor is that it is radiolucent, meaning it will not affect the resulting x-ray image taken of the patient's breast.

The sensor measures applied pressure and provides capacitance as an output. The benefits of this sensing mechanism is that it is not affected by temperature changes and works in small ranges. The capacitance is measured between two conducting layers, which are Poly(3,4-ethyleneddioxythiophene) (PEDT), seen in figure 1. As pressure is applied on the sensor, the non-conducting materials compress and pull the PEDT layers closer to each other. This results in an increase in measured capacitance. By calibrating the capacitance to the applied pressure on the sensor it is possible to know what pressure is actually applied. In figure 1, the two PEDT layers actually consists of 3 "stripes" of PEDT. The result of this is that a matrix system containing 9 sensors.

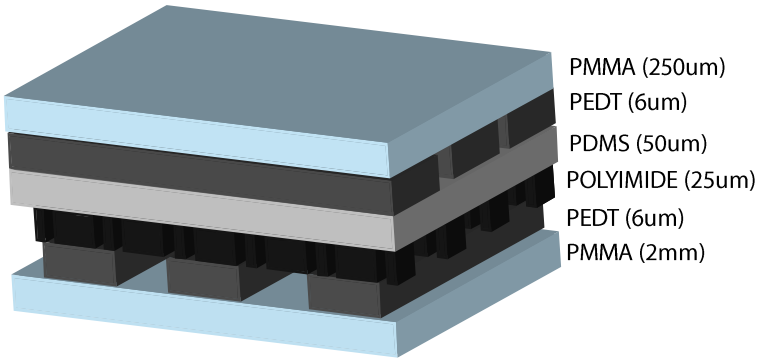

Figure 1. Overview of the pressure sensor, the capacitance is measured between the two conducting PEDT layers.

The fabrication of the pressure sensor was performed in clean-room facilities, and an overview of the sensor can be seen in figure 1. It consists of 6 layers, the three bottom layers and three upper layers were made separately and then put together. The lower and upper part consists of Polymethyl methacrylate (PMMA) which is a transparent and stiff plastic. The upper PMMA part is much thinner, for the reason to increase resolution. Resolution in this case refers to when pressure is applied at a point, it should not affect close individual sensors in the matrix.

PEDT is a polymer which is very robust and highly conductive. This polymer can be coated onto several materials and is the conducting material that the capacitance is measured between. Polydimethysiloxane (PDMS) is a type of silicone rubber that has many applications. PDMS is very elastic and has unique flexibility properties. That characteristic is vital in the sensor since this is the material that deforms. Between the PDMS and the lower PEDT layer, a Polyimide layer is present and has been patterned, as seen in figure 1. This structure will take in the soft PDMS and make sure that it does not spread over the sensor. Thus, this design increase previously mentioned resolution.

The results showed that the pressure sensor was not visible in mammography screening, neither through image processing tools, nor by looking at it. In a mammography examination the pressure varies between 0-35kPa, and the sensor worked well in these ranges. It could be possible to use the

pressure sensor in other applications as well. The output signal of the sensor might have to be changed (e.g. if the sensor needs to adapt to a measurement system), therefore more research is needed when it comes to what property the sensor will have when changing the thicknesses of the different layers.