Integrating a fingerprint sensor under a smartphone's cover glass

As you may have noticed, the fingerprint sensor integrated in a smartphone is usually placed on the backside of the smartphone or inside the home button. Why is it that way and why can't the sensor just be placed under the cover glass instead you may ask? This article will show how a capacitive fingerprint sensor can be integrated under glass and how the reliability of said technology can be improved.

When the smartphone companies develop a new phone, the design is an important feature. The design is one of the deciding factors the consumers consider when they are choosing which model to buy since the smartphone is not only used as a phone, but also as an accessory. You might have noticed that Samsung's model Galaxy S8 has a screen that covers the whole front of the phone. While the design of the screen looks very good, the fingerprint sensor was placed at an awkward position on the back of the phone. Why couldn't the sensor just be integrated in the home button located under the glass? The answer to that question is that most fingerprint sensors in smartphones measures capacitance which is dependent on the distance between your finger and the sensor in where the cover glass is usually quite thick. To be able to do capacitive fingerprint sensing under glass, the distance between the sensor and the finger must be minimized.

From the sensor die which performs the measurements, there need to be electrical connections to the phone. Usually this is done with wire bonding (Figure 1 b) in where tiny wires are used as interconnections. Since these wires are very thin they need to be protected, and this is usually done by applying a mold compound on top of the sensor die that covers the wires. However, this mold compound will add height on top of the sensor which will decrease the capacitive strength. Instead of wire bonding, through-silicon vias (TSV) (Figure 1 a) can be used as interconnections. The TSV is a type of vertical electrical connection that can pass through the sensor die in where no additional height is added on top of the sensor die. It is only recently that TSVs are available for mass production. By using TSVs, compared to using wire bonding as interconnections, the capacitive strength between the sensor die and the finger can be increased due to shorter separation distance. However, since TSV structures are both more complex as structures and have a more complex manufacturing process compared to wire bonding, reliability can be an issue.
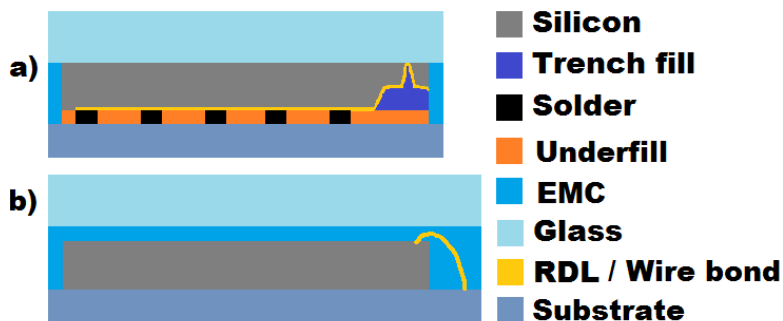

Figure 1: Stack-up comparison between two types of fingerprint sensor packages under glass. a) Showing a TSV solution where the connections from the sensor die go through the die. b) Showing an overmolded wire bond solution where wires are used as interconnections. Note that the distance between the sensor die and the top of the glass is shorter in the TSV solution.

The reliability of the interconnects can be tested by exposing the sensor for a cycling temperature between -40 °C and 120 °C for several hundred cycles. This test will simulate a few years of normal phone usage. The TSV consists of many different layers with many different coefficients of thermal expansion (CTE). Some of these layers include a conducting copper layer and polymer layers which protect the copper layer. As the temperature cycles, all the layers will expand at different rates in which stress will be built up in the copper layer. Worst case scenario is that this copper layer will detach from the sensor die which will lead to premature failure of the sensor. Both simulations and cross-section analysis on TSV structures with different polymers show that the stress which is built up in the copper layer can be reduced by choosing polymers with low CTE. In that way, the sensor will have a longer life time. Next time you buy a smartphone you can notice that if the fingerprint sensor is located under a physical home button or on the backside, tiny wires are connecting the sensor to the phone while if the sensor is located under glass, the sensor is most likely connected by TSVs. Isn't it really cool, right?

Gustaf Onsbring
LTH