Qualcomm 3D Sonic Sensor

Ultrasonic Fingerprint Sensor

SP19465 - MEMS report by Stéphane ELISABETH
LAB. Analysis by Veronique LE TROADEC

July 2019 – Sample
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Executive Summary

- This full reverse costing study has been conducted to provide insight on technology data, manufacturing cost and selling price of the **Qualcomm 3D Sonic Sensor**.

- Either with the Exynos or the Qualcomm Chipset, the Samsung Galaxy S10 series is the first to feature the Ultrasonic Fingerprint Sensor directly under display. The sensor is located on the front of the device directly glued on the OLED material.

- This report focuses on analyzing the ultrasonic sensor and its integration with the display. The sensor is manufactured using LTPS (Low-Temperature Polycrystalline Silicon) technology on glass substrate. Using ferroelectric polymer, the sensor generated and processed ultrasonic waves on the substrate. The component includes also acoustic horn structure in order to focalize the ultrasonic waves.

- Since the last version of the device, Qualcomm managed to realize several changes at the TFT level reusing some mask layers. Also, the QBIC (Qualcomm Biometric Integrated Circuit) has evolved in term of circuit and power handling.

- This complete analysis of the Ultrasonic Fingerprint Module includes analyses of the Sensor die and the ASIC, along with a cost analysis and price estimation for the module. It also includes a physical and technical comparison with the previous version of the sensor in the LeEco LeMax Pro.
By using the Ultrasonic fingerprint sensor, Samsung can provide an almost full front display.
Fingerprint Supply Chain (Estimation)
MEMS & Sensors Market Forecast
Module Extraction

Overview / Introduction

Company Profile & Supply Chain

Physical Analysis
- Module Extraction
  - Module Assembly
    - Views & Dimensions
    - Cross-Section
  - Sensor Die
    - Views & Dimensions
    - Overview
    - Die Process
    - Die Cross-section
  - ASIC Component
    - Views & Dimensions
    - Delayering
    - Die Process
    - Die Cross-section

Physical Comparison

Manufacturing Process Flow

Cost Analysis

Cost Comparison

Selling Price Analysis

Related Reports

About System Plus

Qualcomm 3D Sonic Sensor Assembly
©2019 by System Plus Consulting
Module Extraction – Display Cross-Section

Qualcomm 3D Sonic Sensor Assembly
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Die Overview & Dimensions

- Die Area:
- Pad number:
  - Connected:
- Nb of PGDW per panel:
Die Overview

- Pixel Area:

- PMUT Area:

- Fill Factor:
Die Cross-Section

Die Sensor – Optical View
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Die Sensor – Cross-Section – SEM View
©2019 by System Plus Consulting
Die View & Dimensions

- Die Area:
- Pad number:
The sensor was first integrated under a metal cover back in 2016.

In the Samsung galaxy S10, the sensor is for the first time integrated under display.
Ultrasonic Sensor Front-End Process

- **Sensor Front-End Process:**
  - Substrate:
  - Process type:
  - Metal layers:
  - Polysilicon layers:
  - Special Feature:
    - Lithography steps:

- **Test:**
  - Test type:

*Drawing not at scale*
Ultrasonic Sensor Process Flow (1/4)
Ultrasonic Sensor Front-End Cost

<table>
<thead>
<tr>
<th>Front-End</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>Raw Panel Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean Room Cost</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Equipment Cost</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Consumable Cost</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Labor Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield losses Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sensor Front-End Cost

The **front-end cost** for the Sensor ranges from [ ] according to yield variations.

The largest portion of the manufacturing cost is due to the [ ]
ASIC Wafer & Die Cost

<table>
<thead>
<tr>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
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<td></td>
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</tbody>
</table>

Front-End Cost
BE : Probe Test Cost
BE : Bumping Cost
BE : Dicing Cost

Total Wafer Cost

Nb of potential dies per wafer
Nb of good dies per wafer

ASIC Die Cost

By adding the probe test cost, the bumping and the dicing, the **ASIC wafer cost** ranges from [ ] according to yield variations.

The number of **good dies per wafer** is estimated to ranges from [ ] according to yield variations, which results in the **die cost** ranging from [ ].
Module Assembly Cost

<table>
<thead>
<tr>
<th>Component Cost</th>
<th>Low Yield</th>
<th></th>
<th></th>
<th>Medium Yield</th>
<th></th>
<th></th>
<th></th>
<th>High Yield</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Die cost</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
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<tr>
<td>PCB Substrate cost</td>
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<tr>
<td>ASIC Component Cost</td>
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<tr>
<td>Other Components</td>
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<tr>
<td>Added Value</td>
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</tbody>
</table>

The component cost ranges from according to yield variations.

- The Sensor die represents of the component cost.
- The ASIC component represents of the component cost.
- The Assembly represents of the component cost.
- Other components and PCB substrate represent of the component cost.
Ultrasonic Fingerprint vs. Optical Fingerprint – Qualcomm vs. Synaptics

Component Cost Breakdown (Medium Yield)
- Flex substrate
- Sensor Module cost
- Final Assembly & Test cost
- Other components
- ASIC Component cost
- Final test & Calibration cost
- Others components
- Sensor
- PCB Substrate cost
- Added Value
- Yield losses cost
- Asic Component Cost

The complete system cost is estimated at...
- The Flex substrate cost represents...
- The ASIC Component cost represents...
- The Sensor Module cost represents...
- The other components of the BOM represent...
- The Final Assembly & Test cost represent...
Estimated Manufacturer Price

<table>
<thead>
<tr>
<th></th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component cost</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualcomm Gross Profit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Component price</strong></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

We estimate that Qualcomm realizes a **gross margin** on the Ultrasonic Sensor, which results in a final **component price** ranging from

This corresponds to the selling price for large volume to OEMs.
**Related Reports**

**MEMS & SENSORS**
- Synaptics’ Under-Display Fingerprint Scanner Inside the VIVO X21 UD Smartphone
- FPC’s FPC1268 in the Huawei Mate 9 Pro and Huawei P10 series
- Qualcomm® Snapdragon Sense™ ID 3D Fingerprint

**MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT**
- Status of the MEMS Industry 2019
- Consumer Biometrics: Market and Technologies Trends 2018
- Next-Generation Human Machine Interaction in Displays 2019
Back in 2016, LeEco, a former smartphone design company in China, was the first to integrate an ultrasonic sensor as a biometric fingerprint authentication device. This first integration was under a metal cover at the back of the screen. But the most interesting feature of such a sensor is its possible integration under the display without any additional components. With the integration in the latest Galaxy S10 series from Samsung, Qualcomm has proven that the biometric ultrasonic fingerprint under display is now ready for very high volume production and could compete with capacitive or optical sensors.

Either with the Exynos or the Qualcomm Chipset, the Samsung Galaxy S10 series is the first to feature the Ultrasonic Fingerprint Sensor directly under its display. The sensor is located on the front of the device directly glued onto the organic light emitting diode (OLED) material.

This report focuses on analyzing the ultrasonic sensor and its integration with the display. The sensor is manufactured using Low-Temperature Polycrystalline Silicon (LTPS) technology on a glass substrate. Using ferroelectric polymer, the sensor generates and processes ultrasonic waves on the substrate. The component also includes an acoustic horn structure in order to focus the ultrasonic waves.

Since the last version of the device, Qualcomm has made several changes at the thin-film transistor (TFT) level, reusing some mask layers. Also, the Qualcomm Biometric Integrated Circuit (QBIC) has evolved in terms of circuit and power handling, integrating more high voltage circuits and more on-chip memory.

This complete analysis of the Ultrasonic Fingerprint Module includes analyses of the sensor die and the Application Specific Integration Circuits (ASICs), along with a cost analysis and price estimation for the module. It also includes a physical and technical comparison with the previous version of the sensor in the LeEco LeMax Pro and with the Synaptics’ FS9500 optical fingerprint sensor. Finally, a cost comparison is included with the Synaptics sensor.

**Title:** Qualcomm 3D Sonic Sensor Fingerprint

**Pages:** 127

**Date:** July 2019

**Format:** PDF & Excel file

**Price:** EUR 3,990

**COMPLETE TEARDOWN WITH**

- Detailed photos
- Precise measurements
- Materials analysis
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis
- Selling price estimation
- Comparison with previous version of the fingerprint sensor in the Le Max Pro from LeEco
- Comparison between ultrasonic and optical under display fingerprint
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**Physical Comparison with LeEco Le Max Pro’s Ultrasonic Sensor**
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- Module Cost

**Cost Comparison with the Synaptics FS9500 Under Display Fingerprint**

**Estimated Price Analysis**

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