Goodix’s Ultra-Thin Optical Under-Display Fingerprint

Latest generation of sensors using micro-optics

SP20552 - Imaging report by Stéphane ELISABETH
Lab. analysis done by Nicolas RADUFE

April 2020 – Sample

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Executive Summary

- This full reverse costing study has been conducted to provide insights on technology data, manufacturing cost and selling price of the Goodix Latest Generation of Under-Display Fingerprint.

- With more than 120 designs in several flagships on the market, Goodix this year offers a new version of the fingerprint sensor. It’s called the ultra-thin in-display optical fingerprint sensor, and it uses a micro lens design instead of optical lenses. The sensor is located on the front of the device, directly under the glass display and the organic light emitting diode (OLED) material.

- This report focusses on analyzing the optical sensor and its integration under the display. The sensor is manufactured from a Front-Side Illumination CMOS Image Sensor (FSI-CIS), with an on-chip Near InfraRed (NIR) filter, collimator and Micro Lens Array (MLA). The component also includes features to provide a small gap between the CIS and the OLED material.

- Since the last version of the device, Goodix made several changes at the optical level but also at the integrated circuit (IC) level. Indeed, the sensor doesn’t require any additional circuits besides the sensor IC. Power management and signal processing rely on the main board chipset.

- This complete analysis of the optical fingerprint module includes analyses of the sensor die and the optical part, along with cost analysis and price estimation for the module. It also includes a physical and technical comparison with the previous generation of the sensor from Goodix. Finally, a cost comparison is included with Goodix’s previous fingerprint sensor with an optical lens.
OnePlus 7T Pro 5G McLaren Teardown

- Dimensions: 162.6 x 75.6 x 8.8 mm

- In-Display Fingerprint

- Tri-Camera Module
OnePlus 7T Pro 5G McLaren vs. Oppo Reno 3 Pro 5G Teardown

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- Company Profile & Supply Chain
  - Goodix
  - Supply Chain
  - Smartphone Teardown

Physical Analysis
- Physical Comparison
- Manufacturing Process Flow
- Cost Analysis
- Cost Comparison
- Selling Price Analysis
- Feedbacks
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OnePlus 7T Pro 5G McLaren Fingerprint
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Oppo Reno 3 Pro 5G Fingerprint
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Marking:

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Summary of the Physical Analysis

Module Assembly:
- Electronic components assembly
- Electrical connections and support:

Module Sensor:
- Sensor die:
- Optical features:
- Electrical connections and support:

Sensor Die:
- Process:
- Placement:

Goodix's Ultra-Thin Optical In-Display Fingerprint Sample
Module Cross-Section

Overview / Introduction

Company Profile & Supply Chain

Physical Analysis
- Synthesis
- Module Assembly
  - Views & Dimensions
  - Overview
    - Cross-Section
- Sensor Die
  - Views & Dimensions
  - Overview
  - Delaying
  - Die Process
  - Die Cross-section
  - Process Characteristics

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  - Cross-Section
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    - Overview
    - Delayering
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    - Process Characteristics

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Die Cross-Section
Die Cross-Section

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- Module Assembly
  - Views & Dimensions
  - Overview
  - Cross-Section
- Sensor Die
  - Views & Dimensions
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  - Die Cross-section
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Die Cross-Section
Fingerprint Goodix 2020 vs. Goodix 2019

<table>
<thead>
<tr>
<th>Version</th>
<th>Distance From the Display</th>
<th>Pixel Size dimensions</th>
<th>Sensing Size (Est.)</th>
<th>Sensing Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodix 2019</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goodix 2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Fingerprint Goodix 2020 vs. Qualcomm Ultrasonic Sensor

<table>
<thead>
<tr>
<th>Version</th>
<th>Technology</th>
<th>Distance From the Display</th>
<th>Sensing Size (Est.)</th>
<th>Sensing Area (Est.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualcomm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goodix 2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Optical Back-End Process

- **Sensor:**
  - **Substrate:**
  - **Process type:**
  - **Metal layers:**
  - **Special features:**
  - **Lithography steps:**
Optical Back-End Process Flow (1/3)

- AR Coating
- Lithography #1
- Pattern and Etching
- PR Ashing
Packaging Process

- Fingerprint sensor:
  - Substrate:
  - Support:
  - Special features:

Sensor Module Cross-Section – Schematic
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# Collimator, Color Filter & Microlenses Back-End Cost

<table>
<thead>
<tr>
<th>Back-End</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Room Cost</td>
<td>Cost</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>Equipment Cost</td>
<td>Breakdown</td>
<td>Breakdown</td>
<td>Breakdown</td>
</tr>
<tr>
<td>Consumable Cost</td>
<td></td>
<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>
<tr>
<td>Front-End Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundry Gross Profit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front-End Price</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The **back-end cost** for the circuit ranges from according to yield variations.

The largest portion of the manufacturing cost is due to the

We estimate a **gross margin of** which results in a **back-end price** ranging from

This corresponds to the selling price to Goodix.
## CIS Wafer & Die Cost

<table>
<thead>
<tr>
<th>Front-End Cost</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE: Probe Test Cost &amp; Optical Calibration</td>
<td>Cost</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>BE: Backgrinding &amp; Dicing Cost</td>
<td>Breakdown</td>
<td>Breakdown</td>
<td>Breakdown</td>
</tr>
</tbody>
</table>

**Total Wafer Cost**

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

**Die Cost**

---

**Die Cost Breakdown (Medium Yield)**

- Front-End Cost
- BE: Probe Test, Backgrinding & Dicing Cost
- BE: Yield losses

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

The number of **good dies per wafer** is estimated to range from **[range]** according to yield variations, which results in a **die cost** ranging from **[range]**.
## Component Cost

<table>
<thead>
<tr>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final test &amp; Calibration cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield losses cost</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The component cost is estimated between according to yield variations.

- **Die cost** accounts for of the cost (for medium yield).
- The packaging represents of the total component cost (for medium yield).
- Final test and yield losses represent of the total component cost (for medium yield).
The Goodix RC2603 component is estimated at \[ \text{Component cost} \] of the component cost.

- The CIS component represents \[ \text{Component cost} \] of the component cost.
- Assembly accounts for \[ \text{Component cost} \] of the component cost.

The Goodix TC2403 component is estimated at \[ \text{Component cost} \] of the component cost.

- The LGA component represents \[ \text{Component cost} \] of the component cost.
- The CIS component represents \[ \text{Component cost} \] of the component cost.
- The lens barrel represents \[ \text{Component cost} \] of the component cost.
- The other components of the \[ \text{Component cost} \] of the component cost.
- Assembly accounts for \[ \text{Component cost} \] of the component cost.
Complete System Price

<table>
<thead>
<tr>
<th>Component cost</th>
<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>
<td>Breakdown</td>
</tr>
</tbody>
</table>

**Goodix Gross Profit**

**Component price**

Goodix's ultra-thin optical IN-DISPLAY Fingerprint Sensor
Cost & Price According to Yield Variation

We estimate that Goodix realizes a gross margin of ___ on the system, which results in a final component price ranging from ___ to ___.

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

REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING

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- Synaptics’ Under-Display Fingerprint Scanner Inside the VIVO X21 UD Smartphone

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