Huawei’s 3D Depth Sensing System

3D Camera, Flood Illuminator and DOT projector in the Mate 20 Pro

IMAGING report by Stéphane ELISABETH
February 2019 – version 1
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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 Huawei's 3D Depth Sensing System found in the Mate 20 Pro.

• The front optical hub packaged in one metal enclosure features several camera and sensors. The complete systems feature an RGB camera module, a proximity sensor and an ambient light sensor. The 3D depth sensing system comprise the NIR camera module, the flood illuminator and the DOT projector.

• This report will be focused on the analysis of the 3D depth sensing systems. All components are standard that can be found on the market. That includes a GS image sensor featuring 3 µm size pixels and standard resolution of 1.5 megapixel and two vertical cavity surface emitting laser (VCSEL), one for the DOT projector and one for the flood illuminator coming from different supplier. Both, camera and DOT projector uses standard camera module assembly with wire bonding and optical module featuring lenses. In order to provide the structured light features, a WLO is integrated to the DOT projector structure.

• This report analyzes the complete 3D depth sensing system, including a complete analysis of the NIR camera module, and the dot projector, along with cost analysis and price estimation for the system. It also includes a physical and technical comparison with other 3D sensing systems, such as those from Apple in the iPhone X, from Oppo in the Find X and from Xiaomi in the Mi 8 Explorer. The comparison looks at system integration, the NIR camera module and the dot projector architecture.
• All the IR illuminator or sensor are covered with a window with a filtering coating.
Front Sensing Module

DOT Projector Module:
- VCSEL Manufacturer:
- Dimensions:
- Connector:
- DOT Grid:
- Optical Features:

RGB Camera Module:
- Sensor Manufacturer:
- Dimensions:
- Connector:
- Resolution:
- Optical Features:

Flood Illuminator:
- Manufacturer:
- Dimensions:
- VCSEL:
- VCSEL Dimensions:
- Optical Features:

Proximity Sensor Module:
- Manufacturer:
- Dimensions:

Ambient Light Sensor Module:
- Manufacturer:
- Dimension:

NIR Camera Module:
- Sensor Manufacturer:
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- Electronic components assembly
- Electrical Connections and support:

NIR Image Sensor:
- Dimensions:
- Optical Features:

NIR Image Sensor Die:
- Process:
- Electrical Connection:
- Placement in the package:
Summary of the Physical Analysis

**DOT Projector Module Assembly:**
- Electronic components assembly
- Electrical Connections and support:

**VCSEL Die:**
- Process:
- Electrical Connection
- Placement in the package:

**Wafer Level Optics:**
- Process:
- Placement in the package:

**Flood Illuminator Module Assembly:**
- Electronic components assembly
- Electrical Connections and support:

**VCSEL Die:**
- Process:
- Electrical Connection
- Placement in the package:
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Module Overview – Optical View
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Sensor Die Overview & Dimensions

- Die Area:
- Nb of PGDW per -inch wafer:
- Pad number:
  - Connected:
- Pixel Array:
- NIR Image Sensor resolution:
  - Pixel Area:
  - Pixel Size:
Dot Projector Views & Dimensions

Module Overview – Optical View
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Module Front and Cross-Section View – Optical View
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Dot Projector Disassembly

- Lens Area:
- WLO Die Area:
Dot projector Disassembly

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Dot Projector Active DOE – Pattern – SEM View
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Module Overview – Optical View
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Module Front and Cross-Section View – Optical View
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VCSEL Die Overview & Dimensions

- Die Area:
- Pad number:
  - Wire bonding:
  - Material:
  - Diameter:
- Emitting Array:
  - Emitter Number:
    - Cavity Area:
    - Cavity Diameter:

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# Huawei vs. Xiaomi vs. Oppo vs. Apple – 3D Sensing System

<table>
<thead>
<tr>
<th>Company</th>
<th>3D Depth Sensing Designer</th>
<th>Flood illuminator</th>
<th>NIR Camera Sensor</th>
<th>ALS</th>
<th>Proximity Sensor</th>
<th>RGB Camera Sensor</th>
<th>VCSEL Mnf.</th>
<th>Patterning Device</th>
<th>Optics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oppo</td>
<td>![Oppo Logo]</td>
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<td>Xiaomi</td>
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<td>Huawei</td>
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**3D Sensing System**

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Manufacturing Process Flow

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- **Epitaxy**

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<table>
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<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
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<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>BOM: NIR Image Sensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOM: Memory Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passives (Capacitors &amp; Resistors)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lens Module</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Filter &amp; Housing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connector 2x12 Positions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOM: Flex PCB</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

BOM Cost

Assembly Cost

Yield Losses Cost

Component Cost

QTech Gross Profit

Component Price

The component cost ranges from [ ] to [ ] according to yield variations.

- The **Sensor die** represents [ ] of the component cost.
- The **Module Assembly** represents [ ] of the component cost.
- The **Lens Module** represents [ ] of the component cost.
- The **other part** represents [ ] of the component cost.

We estimate a gross margin of [ ] which results in a module price ranging from [ ] to [ ]. This corresponds to the selling price to Oppo.
**DOT Projector – NIR VCSEL Wafer & Die Cost**

<table>
<thead>
<tr>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-End Cost</td>
<td>BE : Probe Test Cost</td>
<td>BE : Dicing Cost</td>
</tr>
<tr>
<td>BE : Probe Test Cost</td>
<td>BE : Dicing Cost</td>
<td></td>
</tr>
<tr>
<td>Total Wafer Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nb of potential dies per wafer</td>
<td>Nb of good dies per wafer</td>
<td></td>
</tr>
<tr>
<td>Front-End Cost</td>
<td>BE : Probe Test &amp; Dicing Cost</td>
<td>BE : Yield losses</td>
</tr>
<tr>
<td>Gross Margin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Die Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Die Price</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By adding the probe test cost and the dicing, the **NIR VCSEL 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 a **die cost** ranging from [ ].

We estimate a **gross margin of** [ ] which results in a **front-end price** ranging from [ ]. This corresponds to the

---

**Die Cost Breakdown (Medium Yield)**
- Front-End Cost
- BE : Probe Test & Dicing Cost
- BE : Yield losses
## Complete System Price

<table>
<thead>
<tr>
<th>NIR camera Sensor Cost</th>
<th>Dot projector Cost</th>
<th>Flood Illuminator Cost</th>
<th>ALS/proximity Sensor Cost</th>
<th>RGB Camera</th>
<th>Optical Hub cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td><strong>Breakdown</strong></td>
<td><strong>Cost</strong></td>
<td><strong>Breakdown</strong></td>
<td><strong>Cost</strong></td>
<td><strong>Breakdown</strong></td>
</tr>
</tbody>
</table>

We estimate that the 3D depth sensing system cost ranging from Low Yield according to yield variation, which results in an optical hub cost ranging from Low Yield.
Related Reports

REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING

IMAGING
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- Mantis Vision’s 3D Depth Sensing System in the Xiaomi Mi8 Explorer Edition
- STMicroelectronics’ Near Infrared Camera Sensor in the Apple iPhone X
- Apple iPhone X – Infrared Dot Projector

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IMAGING
- 3D Imaging & Sensing 2018
- Status of the CMOS Image Sensor Industry 2018
Following Oppo and Xiaomi, two of its major competitors in China, Huawei has introduced 3D depth-sensing hardware in one of its latest flagship phones, the Mate 20 Pro. Unlike Oppo or Xiaomi, which have made some compromises in the performance of their 3D systems, Huawei, with its large sensor coupled with patterned wafer-level optics (WLO), is the closest solution to Apple’s (which relies on high dynamic range and DOE). Huawei’s 3D system includes a DOT projector in a camera module assembly configuration. On the receiver side, the NIR image is captured by a global shutter (GS) near-infrared (IR) camera module.

The front optical hub packaged in one metal enclosure features several cameras and sensors. The complete system features an RGB camera module, a proximity sensor, and an ambient light sensor. The 3D depth-sensing system consists of the NIR camera module, the flood illuminator, and the DOT projector.

This report constitutes a thorough analysis of the Mate 20 Pro’s 3D depth-sensing system. All components are standard and can be found on the market. This includes a GS image sensor featuring 3 µm-size pixels and a standard resolution of 1.5 megapixels, and two vertical cavity surface-emitting lasers (VCSEL): one for the DOT projector and one for the flood illuminator, each coming from a different supplier. The camera and DOT projector use a standard camera module assembly with wire bonding and an optical module featuring lenses. In order to provide the structured light features, a WLO is integrated with the DOT projector structure.

This report analyzes the complete 3D depth-sensing system, including a full analysis of the NIR camera module and the dot projector, along with a cost analysis and price estimate for the system. Also included is a physical and technical comparison with other 3D sensing systems, such as those from Apple in the iPhone X; Oppo in the Find X; and Xiaomi in its Mi 8 Explorer. This comparison examines system integration, the NIR camera module, and the dot projector architecture.

**COMPLETE TEARDOWN WITH**
- Detailed photos
- Precise measurements
- Materials analysis
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis
- Estimated sales price
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    o Wafer and die cost

Estimated Price Analysis: NIR Camera Module, Dot Projector Module and Optical Hub

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