Panasonic 3D ToF Depth Sensing Camera Module

Panasonic MN34906 Time-of-Flight Image sensor and Flood Illuminator in the Vivo Nex Dual Display

IMAGING report by Stéphane ELISABETH
Physical Analysis by Nicolas RADUFFE
May 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 Panasonic MN34906 and the Flood Illuminator found in the Vivo Nex Dual Display.

- This report is focused on the analysis of the 3D depth-sensing camera, comprising the near-infrared (NIR) ToF camera module, and the flood illuminator. Relying on Panasonic’s knowledge of Charge Coupled Device (CCD) image sensors, the MN34906 has the smallest known pixel size for any ToF image sensor made with a CCD process on the market. Indeed, with a very low number of metal layers, Panasonic was able to produce a very cost-efficient image sensor with enough resolution and accuracy for a consumer application. Coupled with a standard flood illuminator based on vertical cavity surface emitting laser (VCSEL), the system has a very small form factor GS approach.

- This report analyzes the complete 3D depth sensing camera, provided along with cost analysis and price estimation for the module. It also includes a physical and technical comparison with other 3D sensing systems, such as the Infineon/pmd ToF image sensor in the Lenovo Phab 2 Pro, and the Sony BSI ToF image sensor in the Oppo RX17 Pro. The comparison looks at system integration, the NIR camera module and the illuminator architecture.
Vivo Nex Dual Display Teardown
Summary of the Physical Analysis

NIR Camera Module Assembly:
  - Dimensions:
  - FSI
  - Optical Features:
  - Wire bonding on Rigid PCB
  - CCD Technology

NIR ToF Image Sensor Die:
  - Process:
  - Electrical Connection:
  - Placement in the package

Flood Illuminator Module Assembly:
  - Dimensions:

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

Vivo Nex Dual Display solution 3D sensing Assembly — Camera Module & Flood Illuminator ©2019 by System Plus Consulting
3D ToF Camera Module Cross-Section

Physical Analysis
- 3D ToF Module
  - Flood Illuminator Module
    - Overview
    - Cross-Section
  - NIR VCSEL Die
    - Views & Dimensions
    - Die Process
    - Die Cross-section
  - NIR ToF Image Sensor
    - Overview
    - Cross-Section
    - NIR ToF Image Sensor Die
      - Views & Dimensions
      - Delayering & Process
      - Die Cross-section
VCSEL Die Overview & Dimensions

- Die Area:
- Pad number:
  - Wire bonding:
  - Material:
  - Diameter:
- Emitting Array:
- Emitter Number:
  - Cavity Area:
  - Cavity Diameter:
3D ToF Camera Module – Sensor Die Overview & Dimensions

- Die Area:
- Nb of PGDW per inch wafer:
- Pad number:
  - Connected:
- Pixel Array:
- NIR ToF Image Sensor resolution:
  - Pixel Area:
  - Pixel Size:
Sensor Die – Die Delaying – Pixels

Physical Analysis
- 3D ToF Module
  - Overview
  - Cross-Section
- Flood Illuminator Module
  - Overview
  - Cross-Section
- NIR VCSEL Die
  - Views & Dimensions
  - Die Process
  - Die Cross-section
- NIR ToF Image Sensor
  - Overview
  - Cross-Section
- NIR ToF Image Sensor Die
  - Views & Dimensions
  - Delayering & Process
  - Die Cross-section

Physical Comparison
Manufacturing Process Flow
Cost Analysis
Related Reports
About System Plus
Sensor Die – Die Cross-Section – Photodiode

Figure 1. (a) Pixel structure that consists with P-type substrate, photodiode is not separated in deep region. (b) Pixel structure of SDP, photodiode is completely separated.

Table 1. Characteristics summary of stacked deep photodiode

<table>
<thead>
<tr>
<th></th>
<th>Conventional photodiode</th>
<th>Stacked deep photodiode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photodiode depth</td>
<td>4.7μm</td>
<td>10μm</td>
</tr>
<tr>
<td>QE (850nm)</td>
<td>16%</td>
<td>30%</td>
</tr>
<tr>
<td>MTF (850nm at Nyquist frequency)</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Dark current 60 °C</td>
<td>17ele/sec</td>
<td>17ele/sec</td>
</tr>
<tr>
<td>Read out voltage</td>
<td>4.6V</td>
<td>4.7V</td>
</tr>
</tbody>
</table>

Source: H. TAKAHASHI et al., IEEE, 2015, Symposium On VLSI Tech.
# Vivo vs. Oppo vs. Lenovo – NIR Camera Module

## Table of Camera Module Specifications

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Lenses Number</strong></td>
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<tr>
<td><strong>Spacer Number</strong></td>
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<td></td>
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<tr>
<td><strong>FOV (°)</strong></td>
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<tr>
<td><strong>Module Height (mm)</strong></td>
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<tr>
<td><strong>Filter thickness (µm)</strong></td>
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<tr>
<td><strong>Substrate</strong></td>
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<tr>
<td><strong>Image Sensor Assembly</strong></td>
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Pixel Array Circuit Process Flow

- n-type buried Layer

Manufacturing Process Flow
- Global Overview
- NIR Sensor Die Front-End Process
- NIR Sensor Process Flow
- NIR Sensor Fabrication Unit
- NIR VCSEL Process Flow
- NIR VCSEL Fabrication Unit

Cost Analysis
Related Reports
About System Plus
### NIR Camera Module – Pixel Array Front-End Cost

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<th>Medium Yield</th>
<th>High Yield</th>
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<td>Clean Room Cost</td>
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<tr>
<td>Equipment Cost</td>
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<tr>
<td>Consumable Cost</td>
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<tr>
<td>Labor Cost</td>
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<tr>
<td>Yield losses Cost</td>
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</table>

**Pixel Array Front-End Cost**

The **front-end cost** for the Pixel array Die ranges from according to yield variations.

The largest portion of the manufacturing cost is due to the
## Flood Illuminator – NIR VCSEL Front-End Cost

### Wafer (Epitaxy + Metal Layer)

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

- wafer with epitaxy
- Clean Room Cost
- Equipment Cost
- Consumable Cost
- Labor Cost
- Yield losses Cost

### Front-End Cost

The **front-end cost** for the NIR VCSEL ranges from...

The largest portion of the manufacturing cost is due to the...
### Complete System Price

<table>
<thead>
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<th>Low Yield</th>
<th>Medium Yield</th>
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<td>Wide Angle Cost</td>
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<tr>
<td><strong>Tri-Cam System Price</strong></td>
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We estimate that [redacted] realizes a gross margin of [redacted] on the 3D ToF Module. The gross margin results in a final component price ranging from [redacted] for the 3D ToF Module, which results in an [redacted] Tri-Cam cost ranging from [redacted].

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

**REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING**

**IMAGING**
- Sony’s 3D Time-of-Flight Depth Sensing Camera Module
- Huawei Mate 20 Pro’s 3D Depth-Sensing System
- Mobile Camera Module Comparison 2019
- Orbbec’s Front 3D Depth Sensing System in the Oppo Find X
- STMicroelectronics’ Near Infrared Camera Sensor in the Apple iPhone X
- Apple iPhone X – Infrared Dot Projector
- Lenovo Phab2Pro 3D ToF Camera

**MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT**

**IMAGING**
- 3D Imaging & Sensing 2019
- VCSELs - Technology, Industry and Market Trends
- Consumer Biometrics: Market and Technologies Trends 2019
- Status of the Camera Module Industry 2019 – Focus on Wafer Level Optics
- Status of the CMOS Image Sensor Industry 2018

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