VCSEL in Smartphone - Comparison 2019

Technology and Cost Comparison

LED report by Sylvain Hallereau
March 2019 – version 1
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Executive Summary

Today up to 3 VCSEL dies can be integrated in a smartphone. 3D recognition with the flood illuminator, the dot projector and a time of flight for the proximity sensor are based on VCSEL laser components. Already integrated in the flagship smartphone, these functions will quickly become widespread in all smartphones causing a sharp increase in demand for VCSEL.

This comparative review has been conducted to provide insights into the structures, technical and design choices of these component at the center of innovative functions. We analyzed and compared 4 Dot Projectors, 4 Flood Illuminators and 2 Time of Flight systems, extracted the VCSEL dies and performed full physical analysis.

We present technological and economical comparisons of 10 VCSEL dies integrated by the main smartphone actors, Apple, Xiaomi, Huawei, Oppo, Lenovo in their flagship smartphones and the Intel RealSense. All the functions needing VCSEL are studied, Dot Projector, Flood Illuminator, Proximity sensor (Time of Flight). The components of the 3 main suppliers, Lumentum, Philips Photonic and ams (Princeton Optronics) are in the report.

Integration of the VCSEL in the smartphones are showed in the report. We base our analysis on full teardowns of the VCSEL dies to unveil the technological choices made by the different manufacturers. We also estimated the different participants in the supply chain. The combination of the two allowed us to simulate the cost of these different components.

This report contains a complete cost analysis and a cost estimation of the VCSEL. Finally, it features an exhaustive comparison between the studied samples, highlighting the similarities and differences and their impact on cost.
## VCSEL – Device Players and Functions

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<th>VCSEL Manufacturer</th>
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<th>Mobile Manufacturer</th>
<th>Solution Integrator</th>
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<td>Oppo</td>
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<td>Structured light</td>
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Company Profile – ams

VCSEL highlights

- **Traditional VCSEL players** but much smaller than Lumentum, Finisar or II-VI as they are a pure VCSEL player.
- Initially engaged in telecom and datacom applications, the company has rapidly shifted to other applications including material processing, security and surveillance cameras and now focuses on 3D sensing.
- **The recent acquisition by ams** in 2017 has further strengthened the position of Princeton Optronics in the 3D sensing area. This complements synergies with **Heptagon** acquired by ams in 2016 which specializes in illumination modules for sensing applications.
- In order to make the most of increasing volume opportunities for VCSELs for consumer applications from 2019 onwards, **ams has recently invested $100M into a VCSEL manufacturing line in Singapore.**
- Like Lumentum, ams has developed a virtual IDM model with IQE and AWSC in addition to internal manufacturing capacity. ams also has a 15% stake in HLJ and might use the company as a preferred partner.

Supply chain highlights

Source: Yole Développement
STMicroelectronics ToF - Package Opening

Overview / Introduction

Company Profile & Supply Chain

Market Analysis

VCSEL Integration
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Intel RealSense - VCSEL Lens Modules Cross Section

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VCSEL Lens Module Cross section.
Field of view of 72%
Philips Photonics - VCSEL Die – Cross-Section

Philips Photonics

- VCSEL Die
  - Cross-Section

SEM View

VCSEL Cross-Section – SEM View

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Princeton Optronics – Lenovo Phab2PRO - NIR VCSEL Die View and Dimensions
Princeton Optronics - VCSEL Front-End Cost

Wafer (Epitaxy + Metal Layer)

Front-End Cost

The table shows the front-end cost breakdown for different components and processes involved in the manufacturing of VCSELs. Each column represents a different cost component, including wafer, epitaxy, clean room, equipment, consumables, labor, and yield losses.
DOT Projector VCSEL Comparison

<table>
<thead>
<tr>
<th>Dot Projector VCSEL</th>
<th>Die Area (mm²)</th>
<th>Cavity Array (mm²)</th>
<th>Cavity Number</th>
<th>Cavity Area (µm²)</th>
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<td>Apple Iphone X</td>
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<td>Huawei Mate 20 Pro</td>
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**REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING**

**PACKAGING**
- SP19424 - Huawei Mate 20 Pro’s 3D Depth-Sensing System
- SP18438 - Mantis Vision’s 3D Depth Sensing System in the Xiaomi Mi8 Explorer Edition
- SP18437 - Xiaomi Mi 8 Explorer Teardown
- SP18434 - Orbbec’s Front 3D Depth Sensing System in the Oppo Find X
- SP18404 - Intel RealSense D435_en relecture
- SP18383 - STMicroelectronics Proximity & Flood Illuminator iPhone X - Version 2
- SP17376 - iPhone X - Heptagon - DOT Projector
- SP17326 - STMicroelectronics ToF Sensor iPhone 7 Plus
- SP17305 - Lenovo Phab2Pro - Google Tango project - Time of Flight

**MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT**

**ADVANCED PACKAGING**
- VCSELs – Technology, Industry and Market Trends 2018
- 3D Imaging & Sensing 2018

**ADVANCED PACKAGING**

**PATENT ANALYSIS - KNOWMADE**

**ADVANCED PACKAGING**

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