Apple iPhone X – IR Dot Projector

Dot Projector bundle including Heptagon

Imaging report by Sylvain HALLEREAU
December 2017
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Executive Summary

• The Apple iPhone X brings totally new functionality based on the TrueDepth technology. This project is issued from a collaboration including Lumentum for the VCSEL diode and Heptagon for the active DOE and folded optic.

• The iPhone X implements this technology using a Dot Projector. The subsystem features a 30,000 dots projector from Heptagon. We estimate that the Active DOE and the folded optic are manufactured by Heptagon. The electronic package is assembled by an OSAT. The IC driver is designed by Broadcom. The no-grid VCSEL array diode is manufactured by Lumentum. Heptagon performs the assembly of the Dot Projector.

• To provide the 30,000 dots, the VCSEL supplies the IR light and the Folded Optic directs the IR light to the Active Diffractive Optical Element (DOE). Finally, the Active DOE divides the light beam into 30,000 dots of light. The VCSEL is driven in power, beam shape and frequency by an ASIC from Broadcom.

• The report includes technology and cost analysis of the Dot Projector. These analyses provide the technical intelligence necessary to understand this technology.

• A comparison between the Dot Projector and the Intel Real Sense projector and the PMD/Infineon solution are performed.
The Dot Projector module has a ceramic substrate with a separate ceramic block under the VCSEL.
Dot Projector Dimension

Overview / Introduction

Company Profile & Supply Chain

Physical Analysis
- Synthesis
- Teardown
- Ceramic Package
- IC Broadcom
- NIR VCSEL
- Folded Optic
- Active DOE
- Comparison

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

About System Plus

Dot Projector – Global View
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Dot Projector Teardown

The optical block is glued on top of the ceramic substrate.
Dot Projector – AlN Ceramic
NIR VCSEL Die View and Dimensions

Die Area: \(XX\text{mm}^2\)

(\(xx \times xx\ \text{mm}\))

Nb of PGDW per 3-inch wafer: \(XX\)

Pad number: \(x\)

Wire Bonding: \(XX\)
NIR VCSEL Die Cross-Section

Detail active layer after revelation Cross-Section — SEM view

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Folded Optic - Disassembly
Active Diffractive Optical Element - Disassembly
### Broadcom BCM15952 Front-End Cost

The **front-end cost** for the IC ranges from $ to $ according to yield variations.

The largest portion of the manufacturing cost is due to the

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<td>Die Price</td>
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**Front-End Cost Breakdown (Medium Yield)**
NIR VCSEL Front-End Cost per Process Steps

- Overview / Introduction
- Company Profile & Supply Chain
- Physical Analysis
- Manufacturing Process Flow

Cost Analysis
- Synthesis
- Supply Chain
- Yields
- Broadcom BCM15952 Cost
- NIR VCSEL Wafer & Die Cost
- Ceramic Package Cost
- Folded Optic Cost
- Active DOE Cost
- Assembly Cost
- Component Cost

Selling Price Analysis

About System Plus
3D Illumination Module Estimated Manufacturer Price

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- Financial Ratios
- Manufacturer Price

About System Plus

Overview / Introduction

Company Profile & Supply Chain

Physical Analysis

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

- Financial Ratios
- Manufacturer Price
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