Hamamatsu Photodiode and Laser in Livox’s Horizon LiDAR

6 channels 905nm pulsed laser and photodiode

SP20559 - Imaging report by Sylvain HALLEREAU
Laboratory analysis by Nicolas RADUFE
June 2020 – Sample
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  - Photodiode package cost
  - Photodiode component cost
- LiDAR Module
  - Complete module price

## Technical and Cost Comparison
- Livox Horizon, LeddarTech Leddar Vu and the Valeo Scala LiDAR.

## Feedbacks

## System Plus Consulting Services
Executive Summary

The LiDAR is manufactured around 4 main components, the pulsed laser diode, the avalanche photodiodes, the opto-mechanical system to sweep the environment in front of the car and the processor.

System Plus Consulting proposes an analysis of the pulsed laser and the photodiode in the Horizon LiDAR by Livox; a Chinese company that sales a LiDAR for automotive ADAS.

The LiDAR sensing module includes a custom six photodiodes array die from Hamamatsu specifically developed for the LiDAR application. The design is particularly optimized to increase the sensibility of the six avalanche photodiodes. The photodiode dies are assembled in a package with 905nm narrow bandpass filter.

The LiDAR uses six edge emitting lasers designed to have three epitaxially stacked emitter. The six laser dies are assembled horizontally with an inclined mirror to send the light perpendicular. The thermal management is performed by a sophisticate substrate.

This report includes a complete technical analysis of the two main optoelectronic components of the Livox LiDAR: the photodiodes and the emitting lasers. The technical analysis is based on optical and SEM pictures of the packaging and the dies. Moreover, thanks to a complete manufacturing process analysis, this report explains the cost and estimates the price for the two components. Finally, it includes a technical and cost comparison with laser and photodiode in the LeddarTech Leddar Vu8 and the Valeo Scala LiDAR.
LiDAR Module Disassembly

- Optic block with the laser and the photodiode components
- Cover Removing

Optic block: Risley prism universal pointing system (RPUPS)

- Company Profile & Supply Chain
- Market Analysis
- Physical Analysis
  - Summary of the Physical Analysis
    - Livox LiDAR Module Assembly
      - Photodiode
        - Package
        - Die
      - EE Laser
        - Package
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  - Livox LiDAR Module Assembly
  - Photodiode
  - Package
  - Die

Manufacturing Process Flow
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About System Plus
Package Views & Dimensions

- Package: TO8 10-pin
- Dimensions: 11.1x 11.1 x 6.2mm
- Pitch: 2 mm

3 glue dots to assemble the IR filter
Photodiode Die Cross-Section – Photodiode

- Summary of the Physical Analysis
  - Livox LiDAR Module Assembly
    - Photodiode
      - Package
      - Die
    - EE Laser
      - Package
      - Die

Die Cross-Section after doping revelation – Optical View
Package Views & Dimensions

- **Package:**
- **Dimensions:**
- **Pitch:**
Edge Emitting Laser Die Overview & Dimensions

Overview / Introduction

Company Profile & Supply Chain

Market Analysis

Physical Analysis
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Manufacturing Process Flow

Cost Analysis

Technical & Cost Comparison

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Edge Emitting Laser Die Cross-Section – Epitaxy Layers
NIR Photodiode – Front-End Cost

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<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>Raw wafer Cost (epi-Si 150mm)</td>
<td>500</td>
<td>100</td>
<td>600</td>
</tr>
<tr>
<td>Clean Room Cost</td>
<td>300</td>
<td>60</td>
<td>400</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>
<td>150</td>
<td>30</td>
<td>180</td>
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<tr>
<td>Yield losses Cost</td>
<td>50</td>
<td>10</td>
<td>60</td>
</tr>
</tbody>
</table>

The front-end cost for the pixel array ranges from $500 to $600 according to yield variations.

The largest portion of the manufacturing cost is due to the raw wafer cost at 20%.
## NIR Edge Emitting Laser Wafer & Die Cost

<table>
<thead>
<tr>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
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</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>Front-End Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE 0: Probe Test</td>
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<tr>
<td>BE 0: Cleaving Cost</td>
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</tr>
</tbody>
</table>

### Laser Wafer Cost

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

### Laser Die Cost

- Summary of the Cost Analysis
- Yields Explanation & Hypotheses
- Photodiode
- EE Laser
- LiDAR Main Optical Components

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**Technical & Cost Comparison**

**Feedbacks**

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**IMAGING**
- Apple iPad Pro LiDAR Module
- LeddarVu8: The first off-the-shelf solid state high-definition LiDAR module from LeddarTech
- Valeo SCALA Laser Scanner

**MARKET AND TECHNOLOGY REPORTS – YOLE DÉVELOPPEMENT**

**IMAGING**
- LiDAR for Automotive and Industrial Applications 2019
- Sensing and Computing for ADAS Vehicle 2020
- 3D Imaging & Sensing 2020
- Sensors for Robotic Mobility 2020
Business Models Fields of Expertise

- Custom Analyses
  (>130 analyses per year)
- Reports
  (>60 reports per year)
- Costing Tools
- Trainings
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