OUTLINE

- Introduction to SICK AG
- Product Portfolio
- VCSELs for LiDAR
- Challenges
INTRODUCTION TO SICK AG

SICK AT A GLANCE (2018)

SICK – worldwide one of the leading manufacturers of sensors and sensor solutions for industrial applications.
INTRODUCTION TO SICK AG
PRESENCE WORLDWIDE

Subsidiaries and representative offices
Agencies

Production
Regional Competence Centers
Development
INTRODUCTION TO SICK
WIDE PRODUCT RANGE

- Analyzer solutions
- Automation light grids
- Detection and ranging solutions
- Distance sensors
- Dust measuring devices
- Encoders and inclination sensors
- Fluid sensors
- Gas analyzers
- Identification solutions
- Magnetic cylinder sensors
- Motor feedback systems
- Opto-electronic protective devices
- Photoelectric sensors
- Proximity sensors
- Registration sensors
- Software products
- Safety switches
- sens:Control – safe control solutions
- System solutions
- Traffic sensors
- Ultrasonic gas flow measuring devices
- Vision
2D AND 3D LIDAR SENSORS

- TiM Series
- LMS Series
- LD- and NAV Series

- Short, medium, and long working ranges
- Indoor or outdoor
- High resolution
- Industrial grade

LD-MRS
MRS1000
MRS6000
TIM POWERED BY VCSEL

- TiMxxx: ToF LiDAR sensor, compact size, low power, low cost, **VCSEL powered**
- Sick’s HDDM/HDDM+ technology (High Definition Distance Measurement, a proprietary statistical measurement method)
- ToF LiDAR system design optimizes angular resolution, measurement range, accuracy, etc.
WHY VCSEL VS. EEL (EDGE EMITTING LASER)

- testing on-wafer
- no cleaving and facet coating (no COMD risk)
- simple packaging (SMD, ...)
- circular beam shape
- low temperature sensitivity
- short pulse capability
- low cost

- low brightness
- power scaling difficult

d-ToF LiDAR requires very short optical pulses with very high pulse power!
### VCSEL SPEC

**CHALLENGE: BRIGHTNESS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>$\lambda_{OP}$</td>
<td>nm</td>
<td>845</td>
<td>850</td>
<td>855</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>$T_c$</td>
<td>°C</td>
<td>-10</td>
<td></td>
<td>85</td>
<td>Case temperature during operation</td>
</tr>
<tr>
<td><strong>Emitters</strong></td>
<td>$n$</td>
<td></td>
<td>1</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Emission Area</td>
<td>$\varnothing$</td>
<td>µm</td>
<td>60</td>
<td>75</td>
<td></td>
<td></td>
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<tr>
<td>Divergence</td>
<td>$\alpha$</td>
<td>°</td>
<td>20</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope Efficiency</td>
<td>SE</td>
<td>mW/mA</td>
<td>0.8</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>l x w</td>
<td>mm x mm</td>
<td>3 x 2</td>
<td>Optimized thermal conductivity</td>
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Pulse operation:
- Pulse duration: 1 – 10 ns
- Pulse current: 0.7 – 1.2 A
- Max duty cycle: 0.75 %
- Maximum average current: 5 mA
- Maximum voltage drop over diode: 17 V

**Issue:**
Large emitter diameter contrast to beam quality and divergence due to limited internal current spreading!
## VCSEL SPEC

### CHALLENGE: RELIABILITY

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**Reliability**

| Symbol | FIT | 60 | Confidence level: 60% |

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VCSEL RELIABILITY: VERIFICATION EXAMPLE

144 DUTs, t=10.7kh, $E_a=0.35\text{eV}$, CL=60% $\rightarrow$ **116 FIT**

Test condition: 0.7A, 5ns pulse, 660ns repetition, 85°C
### VCSEL SPEC

#### CHALLENGE: PULSE POWER

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**more pulse power needed!**

**pulse current of >5A possible? (@0.1% dc)**
2D LIDAR → 3D LIDAR

3D LiDARs with many layers require many VCSELs...
MANY THANKS FOR YOUR ATTENTION.
This presentation was presented at EPIC Meeting on VCSELs Technology and Applications 2019

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