Working Principle Demonstration of the Dot Projector with Physical Optics Modeling
Dot projector is a key component that enables Apple’s Face ID. The system usually consists of an array of light emitting units, lenses, and beam splitting grating(s). The lens system together with the grating(s) will project and make several duplications of the array source pattern. In this example, we build up such a dot-projector system and demonstrate how it works. With VirtualLab Fusion, we perform both ray and field tracing for the system analysis.
**Modeling Task**

VCSEL array
- model: multi-mode Gaussian (LG00, LG01)
- wavelength: 1 µm
- size: 400 × 400 µm
- no. of VCSELs: 11 × 11
- full divergence angle: 20°

beam splitter
- period: 6.5 µm
- diffraction orders: 7 × 7

* The aspherical lens in the document is designed with Zemax OpticStudio®
Source Modeling

beam splitter
period: 6.5μm
diffraction orders: 7×7

detector plane

aspherical lens

VCSEL array

sketch of the VCSEL array

far field pattern of a single VCSEL

cross section profile along y = 0
Simulation with the On-Axis VCSEL Unit

- The lens collimates the input beam.
- The beam splitter diffracts the collimated beam into different orders.

VCSEL source position: (0, 0)

aspherical lens

beam splitter
period: 6.5 µm
diffraction orders: 7 × 7

detector plane

2.84 mm 500 mm

(+2, +3) order

(-3, -1) order
For off-axis VCSEL unit, the lens collimates the input beam with an angle regarding to the mode’s position.
- The spot pattern is shifted from the on-axis case, with respect to the angle.
The beam splitter duplicates the pattern of the VCSEL array with lateral shifts on the detector plane.
Peek into VirtualLab Fusion

VCSEL model via multimode Gaussian source

configuration of grating in the system

ray tracing visualization

field tracing
Workflow in VirtualLab Fusion

- Set up multimode source
  - Basic Source Models [Tutorial Video]
- Set the position and orientation of components
  - LPD II: Position and Orientation [Tutorial Video]
- Configure the grating component within an optical system
- Configuration of Parameter Run
  - Usage of the Parameter Run Document [Use Case]
VirtualLab Fusion Technologies

Aspherical lens\n
Beam splitter\n
Detector plane\n
VCSEL array\n
Field Solver\n
# Idealized component
## Document Information

<table>
<thead>
<tr>
<th>title</th>
<th>Working Principle Demonstration of the Dot Projector with Physical Optics Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>document code</td>
<td>MISC.0077</td>
</tr>
<tr>
<td>version</td>
<td>1.0</td>
</tr>
<tr>
<td>toolbox(es)</td>
<td>Starter Toolbox</td>
</tr>
<tr>
<td>VL version used for simulations</td>
<td>VirtualLab Fusion Summer Release 2019 (7.6.1.18)</td>
</tr>
<tr>
<td>category</td>
<td>Application Use Case</td>
</tr>
</tbody>
</table>
| further reading | - Design and Rigorous Analysis of Non-Paraxial Diffractive Beam Splitter  
- Design of a High-NA Beam Splitter with 24000 Dots Random Pattern |