High precision 3D printing (HP3DP) – freeform optics for VCSEL applications

B. Stender, W. Mantei, A. Krupp, Y. Dupuis, J. Wiedenmann, F. Hilbert, R. Houbertz

Multiphoton Optics GmbH, Würzburg (Germany)

3D printing from the sub-100 nm to the cm scale with highest precision
Nano – Micro - Macro
Fraunhofer Spin-Off in 2013.
16 (20↑) staff plus 2 associates (JPN, USA).

Products High Precision 3D Printer LithoProf3D®
Prototyping & Engineering
High Precision 3D Printing (HP3DP): Principles

single voxels  \[ W \propto I \]

2PA

Axial dimension (a.u.)

Gaussian intensity profile

lateral dimension (a.u.)

regions of absorption

photoresist

simple adjustment by laser power & focussing objective & material

fine

medium

coarse

structures

Realtime

200 µm
HP3DP: Optics Manufacturing

**Scalability**

Nano | Micro | Meso | Macro
---|---|---|---

**Shape**

Spherical | Freeform | Arrays

Ø 2 mm
2003 – 2008
LD-PD coupling
MM WG

Passive Alignment only (up to 12 cm)

conventionally

new approach

42 Gb/s (6 ch in 2007)

200 µm

data rate vs. BER

7 Gbit/s @ app. BER 10^{-9}

V_{pp} = 385 mV, I = 8 mA
T_{a} = 27 °C May 28, 2008

Freeform Optics on Chip Level Packaging (PIC – fiber)
Freeform Optics for LED application

Miniaturization of LED illumination systems & influencing the light output distribution

Point source LED Chip w/o printed optic
- TO-18 header
- Bonding wire
- LED Chip (Ø 25 µm)

Point source LED Chip w/ printed optic
- w/o printed optic
- w/ printed optic

Radiation pattern w/o printed optic
- Radiation pattern w/ printed optic

All measurements at 5 mA:
- $\Phi_V$ & $\Phi_e$ measured with integrated sphere
- $I_V$ & $I_e$ measured in a distance of 10 cm

<table>
<thead>
<tr>
<th></th>
<th>$I_V$ (mcd)</th>
<th>$\Phi_V$ (mLm)</th>
<th>$\Phi_e$ (µW)</th>
<th>$I_e$ (µW/sr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/o printed optic</td>
<td>8.6</td>
<td>14.3</td>
<td>94.0</td>
<td>35.0</td>
</tr>
<tr>
<td>w/ printed optic</td>
<td>28.2</td>
<td>24.7</td>
<td>212.0</td>
<td>108.4</td>
</tr>
</tbody>
</table>

Polymer Optics ➔ enhanced light outcoupling of chip
⇒ shaping & focussing
Freeform Optics for Edge Emitters

Emission area: 3.5 x 1.2 µm²

fast axis: 43°
slow axis: 18°

_intensity [a.u.]

19°
slow axis:
17°
Freeform Optics for Edge Emitters

Threshold (mA) | Efficiency (W/A)  
---|---  
pre | post | pre | post  
20 | 21 | 0.18 | 0.22

- All laser dies work after printing process.
- Lens influences threshold & efficiency.
- Lens influences far field positively.
- Far field depends on positioning of lens.

Polarization
Comparing laser dies w/ and wo/ printed lenses

Catastrophic optical damage (COD)

Life-Time (and running...)

Up to MW/cm²
Reference Customers, Partners, Networks
This presentation was presented at EPIC Meeting on VCSELs Technology and Applications 2019

HOSTED BY

SONY

GOLD SPONSOR

PIXAPP
Photonic Packaging Pilot Line

SILVER SPONSOR

PASSION

BRONZE SPONSOR

depPIX

EU initiatives funded by www.photonics21.org