## Program

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00</td>
<td><strong>NEMO - a powerful tool for micro-optics in Europe</strong></td>
<td>Hugo Thienpont (VUB)</td>
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<td></td>
<td>NEMO - the European Network on Micro Optics, an overview</td>
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<td></td>
<td>NEMO Industrial User Club (IUC)</td>
<td>Tomasz Nasilowski (VUB)</td>
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<tr>
<td>9.40</td>
<td><strong>NEMO's service centres 1 - capabilities and services to industry</strong></td>
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<td></td>
<td>Centre for modelling of micro-optical components</td>
<td>Norbert Lindlein (FAU)</td>
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<td>Centre for fabrication of micro-optical systems</td>
<td>Jürgen Mohr (FZK)</td>
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<tr>
<td>11.00</td>
<td><strong>NEMO's service centres 2 - capabilities and services to industry</strong></td>
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<td>Centre for measurement of micro optical components and new measurement tools</td>
<td>Malgorzata Kujawinska (MWUT)</td>
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<td>Centre for assembly &amp; packaging of micro optics</td>
<td>Peter van Daele (UG)</td>
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<td>Centre for reliability &amp; standardization issues</td>
<td>Oliver Kraft (FZK)</td>
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<tr>
<td>13.15</td>
<td><strong>Food Chain in Micro Optics 1: Fibre sensors</strong></td>
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<td>Fibre sensors for strain &amp; temperature measurement</td>
<td>Tomasz Nasilowski (VUB)</td>
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<td>Simulation, Fabrication and Characterization of new fibres for sensor applications</td>
<td>Waclaw Urbanczyk (WRUT)</td>
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<td>14.10</td>
<td><strong>Food Chain in Micro Optics 2: Micro Lenses</strong></td>
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<td>Use and advantage of micro lenses in imaging applications</td>
<td>Jacques Duparre (IOF)</td>
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<td>Simulation, fabrication and characterization of micro lenses and lens arrays</td>
<td>Heidi Ottevaere (VUB)</td>
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<tr>
<td>15.30</td>
<td><strong>Application fields of micro optics</strong></td>
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<td>Optical interconnects at the PCB level</td>
<td>Peter van Daele (UG)</td>
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<td>Diffractive and sub-wavelength micro-optics for light management</td>
<td>Martin Salt (HEPT)</td>
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<td>Infrared micro optics</td>
<td>Peter Muys (LROE)</td>
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<tr>
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<td>Emerging applications in Micro Optics</td>
<td>Olivier Parriaux (CNRS-TSI)</td>
</tr>
<tr>
<td>16.50</td>
<td><strong>Summary &amp; conclusions IUC</strong></td>
<td>Tomasz Nasilowski (VUB)</td>
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Assembly and packaging of micro optical systems

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Pentti Karioja, VTT, Finland
Ulrich Gengenbach, FZK, Germany

Packaging of optical and opto-electronic components very often makes up the largest portion of the cost of the final component. This is not only caused by the fact that alignment issues are much more critical when playing with optical inputs and outputs in addition to electrical input and output, but also due to the lack of standardization. In electrical packaging, much of the packages and the processes to be used is standardized and is identical, no matter what functionality the electrical component has. This is not the case for optical or opto-electronic components, where packaging is largely determined by the functionality. As an example one can take the case of fiber-pigtailing a laserdiode: in the case of a VCSEL, the process, technology, package,… is completely different from the case for an edge-emitting laserdiode.

Just as in the case of the electronic industry, several levels are defined within the optoelectronic assembly and packaging world. The IPC identifies 4 levels in its roadmap “Optoelectronic Assembly and Packaging Technology”:

- Level 0 (uncased device): Lasers, LEDs, photodiodes, fibres, micro-lenses, waveguide chips, etc. are basic devices needed for optoelectronic modules and systems.
- Level 1 (packaged device): When devices have some features added, such as, a laserdiode is encapsulated in a hermetic TO can or a fibre is equipped with a micro-lens or ferrule, we are dealing with packaged devices. At this level, issues such as alignment and sealing are envisaged. Solutions might be based on existing technologies, such as, soldering of metallised micro-optical components.
- Level 2 (modules): Module level is reached when several functional devices or components are integrated in a single package. Good examples of optoelectronic modules are fibre optic transmitters, wavelength multiplexers/ demultiplexers, splitters and couplers,… This level of assembly requires a much more robust level of assembly (accuracy about 1 to 2 um) and a different level of sealing, as the facets of optical waveguides should be protected. New tools for handling these micro-optical sub-assemblies and mounting technologies, probably based on Flip-Chip technologies should be deployed or adapted.
- Level 3 (board-level): The final interface of the optical module towards the outer world will, in most cases, be an optical fibre.

The presentation will also present the capabilities of the NEMO NoE in these different levels of packaging and integration.
Centre for assembly & packaging of micro optics

Peter Van Daele (Univ. Gent, B)
Pentti Karioja (VTT, SF)
Overview

• Introduction
• Levels of Packaging
• Processes
• NEMO Capabilities
• Conclusions
Introduction

Processing yields naked chips

• difficult to characterise, handle and use
• subject to environmental influences

Packaging is the car around the engine
Introduction

• Packaging electronic components
  – protect against environmental influences (passivation)
  – only electrical contacts
  – no accurate alignment needed
  – thermal housekeeping

• Packaging optical & optoelectronic components
  – Optical coatings
  – optical “contacts” : fibre alignment & micro-optics
  – temperature control
  extreme accurate alignment needed
  up to 80% or 90% of the total cost!
Introduction

Does this looks cheap?
Introduction

- Packaging electronic components

To cope with large I/O:
- DIP: Dual-in-Line Package
- PGA: Pin Grid Array
- SOP: Small Outline Package
- QFP: Quad Flat Package
- LCC: Leadless Chip Carrier

Functionality has limited influence on packaging
Introduction

• Packaging optical & optoelectronic components

Functionality determines packaging

- Fiber pigtailting
- Edge emitter
- VCSEL
Overview

- Introduction
- Levels of Packaging
- Processes
- NEMO Capabilities
- Conclusions
Levels of packaging

1. **Device**
   naked chip, tested or not tested

2. **Component**
   assembled chip and possibly locally encapsulated

3. **Module**
   chips, components integrated into a functional unit

4. **System**
   modules integrated into a functional unit
Processes

- **Die bonding:**
  - to fix Chips
  - electrical contact
  - alignment

- **Wire bonding:**
  - electrical contacts to package pins
Out of requirement to cope with large I/O:

– all contacts on the outer edge
  • smaller chips smaller surface less space
– demand for increased I/O

Flip-Chip technology
High density Au Flip-Chip

Pitch 12.5 μm

Diameter 6.25 μm
Processes

- What can Flip-Chip do for Optoelectronics?

LASERDIODE

70-100 μm

epoxy

OPTICAL FIBER

core

< 10 μm

125 μm
• Flip-Chip controls height of active layer
Processes

Coupling flip-chip mounted edge-emitting laser-arrays to optical fibers
Mode mismatch

Optical fiber

Tapered section

Active area

laserdiode
Overview

• Introduction
• Levels of Packaging
• Processes
• NEMO Capabilities
• Conclusions
NEMO Capabilities

- Assembly & Integrated related Design & Modeling
- Materials tailoring
- Optical, surface, mechanical, thermal character.
- Fabrication techniques
- Packaging
  - Substrate (Ceramic, Polymer, PCB, SC, …)
  - Bonding
  - Sealing (encapsulation)
  - Assembly
    - Pick & place
    - Microassembly (non standard)
    - Fiber handling
- Reliability testing
  - Vibration
  - Temperature cycling
  - Humidity
  - EMC
  - Leak
- Laser patterning
- CNC
- UV lithography
- Holography
- Dicing
- Precision machining
- Patterning
- Flip-chip bonding
  - Wire
  - Die
  - Dispensing
  - Wafer bonding
  - Bumping
  - Laser
  - Leak
Alignment structures

- Grooves tooled by standard via punching and lamination process
  Fiber alignment accuracy ~±3 µm (vertical to substrate, horizontal to alignment marks)

  V-groove with flexible foils, (SM fiber)  Rectangular groove with steel foils, (SM fiber)

- Grooves made by photolithography using photo-definable paste materials
  Fiber alignment accuracy <±3 µm (vertical to substrate, horizontal to alignment marks)

Application:

62.5/125 µm fibers, vertical tolerance ±1.6 µm
Fiber pigtailing

Passive optical alignment
Multimode fiber
VCSEL / Photodiode
Integrated electronics
Fiber pigtailing

- **Vertical emitting laser diodes**
  - Removable MT-like connector
    - (8 fibers, pitch 250 μm)

1x8 VCSEL-array (λ = 670 nm)
• Coupling to optical layer in PCB’s
ASSEMBLY OF MICROLENS ARRAY ONTO AN LTCC-BASED VCSEL-ARRAY TRANSMITTER

1. Two microlens arrays stacked together by gluing the substrate back-sides with index-matched adhesive
   => double-sided microlens array
2. Double-sided microlens array glued to LTCC substrate
Assembly of microoptical systems

Examples of hybrid microoptical devices

- Fiber switch piezosysteme jena
- Collimator FhG IOF, Jena
- Optical-SMD EPFL Lausanne
- Microoptical duplexer
- Heterodyne receiver

All by Forschungszentrum Karlsruhe - I1M1-

Proximity sensor (first laboratory sample)

Task: Transfer of laboratory fabrication to semi- or fully automatic series fabrication
Assembly of microoptical systems
Passive assembly

Assembly of centering balls

Passive alignment: Self-alignment of ball in etch groove

Etch grooves for centering balls (ø 650 µm)
## Assembly

### Assembly concept

**Passive alignment of components to be mounted on well defined and precisely fabricated stop faces**

### Assembly tasks:

- **Insertion of cylinder lenses into a microoptical board**
- **Mounting of centering balls onto an electronic-optical board**
- **Assembly of microoptical and electronic-optical board**
Assembly

Feeding of components

Example: Tray for micro optical board

Integration of alignment features into design of microoptical board

Design for assembly!

Tray with six microoptical boards
• Modular, high precision assembly machine MIMOSE
  - Cartesian system (x,y,z,∅)
  - workspace 200 x 200 x 70 mm³, 360°
  - repetitive accuracy < 5 µm (resolution 1 µm)
  - payload 5 N
• Feeding of components with standardised 2” - 8” trays (DIN 32561)
• Depending on configuration proprietary or standard tool change system (DIN 32561)
• Various suction grippers and miniaturised adhesive dispensers
• Optional image processing system (DIPLONM)
• Minienvironment (up to class 1000)
Multifunction gripper with multiple suction orifices

- Suction orifices on common vacuum supply
- Suction orifice 1: Gripping for shearing of lenses from wafer
- Suction orifice 2: - Gripping of lenses after reversal
  - Gripping of centering balls
Equipment

Multifunction gripper with multiple suction orifices

Example: Mounting of centering balls onto electro-optical board

Etch grooves for centering balls (ø 650 µm)

Electronic-optical board

Passive alignment: Self centering of ball in etch groove

Gripper

Tray with electronic optical boards
Equipment

Adhesive Dispenser

adhesive dots on a wafer
Wafer bonding: SUSS MA6

1st wafer

2nd wafer with adhesive dots

after alignment UV curing of the adhesive
Hermetic encapsulation

Photonics sub-assembly based on LTCC board

Hermetic fiber feedthrough by the use of solder glass preform

Kovar frame, solder reflow sealing to LTCC using integrated resistance heating element or reflow oven

Kovar lid, sealing with laser

Encapsulated & pigtailed LTCC module BGA-assembled on PCB
Conclusions

Packages allow components to be used
- Wide range of possible packages & techniques
- Optimise technologies for optical packaging
- Costs are extremely high

Much research still to be done
Look around and be creative!!