

The background features a series of overlapping, semi-transparent white geometric shapes, primarily rectangles and trapezoids, arranged in a perspective that suggests depth. Interspersed among these shapes are several small, white, upward-pointing arrows, creating a sense of movement and progress. The overall aesthetic is clean and technical, consistent with a presentation on technology or business.

## Photonics RoadMap for SMEs

VTT: Introduction, approach for photonics integration &  
SMEs in international projects

Pentti Karioja



Business from technology

## VTT Technical Research Centre of Finland

### VTT IS

- the biggest multitechnological applied research organisation in Northern Europe

### VTT HAS

- polytechnic R&D covering different fields of technology from electronics to building technology
- clients and partners: industrial and business enterprises, organisations, universities and research institutes

### VTT CREATES

- new technology and science-based innovations in co-operation with domestic and foreign partners

- Turnover 245 M€
- Personnel 2,700
- 77% with higher academic degree
- 6,200 customers
- Established 1942
- VTT has been granted ISO9001:2000 certificate.

# VTT in brief

Personnel 2700 ■ Turnover 245 M€

## Customer sectors

- Biotechnology, pharmaceutical and food industries
- Electronics
- Energy
- ICT
- Real estate and construction
- Machines and vehicles
- Services and logistics
- Forest industry
- Process industry and environment

## Focus areas of research

- Applied materials
- Bio- and chemical processes
- Energy
- Information and communication technologies
- Industrial systems management
- Microtechnologies and electronics
- Technology in the community
- Business research



## VTT's operations

Research and Development ■ Strategic Research ■ Business Solutions  
■ Ventures ■ Expert Services ■ Corporate Services

# The operating model and the structure

## CUSTOMERS

### STRATEGIC RESEARCH

Management of the self-financed and jointly-funded research

### BUSINESS SOLUTIONS

Management of the contract research

### VENTURES

Commercialisation of research output, venture activities and spin-offs

### EXPERT SERVICES

Consulting services, testing, certification



PARTNERS

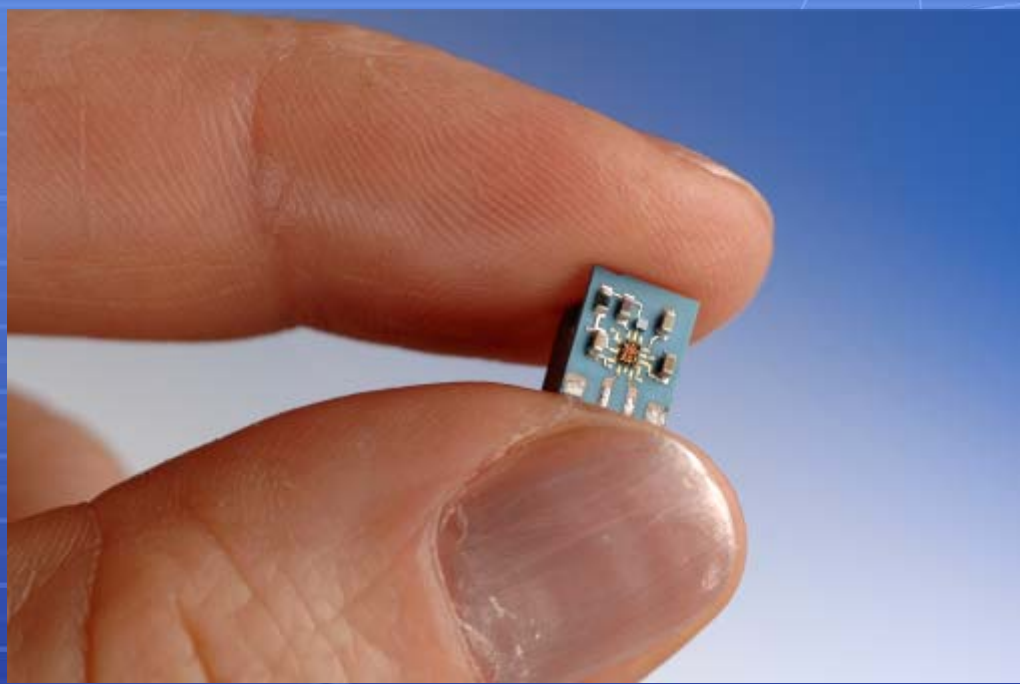
NETWORKING

## RESEARCH AND DEVELOPMENT

Projects  
Competence management  
(6 knowledge clusters and 42 knowledge centres)

Management, support processes

ADVISORY BOARDS

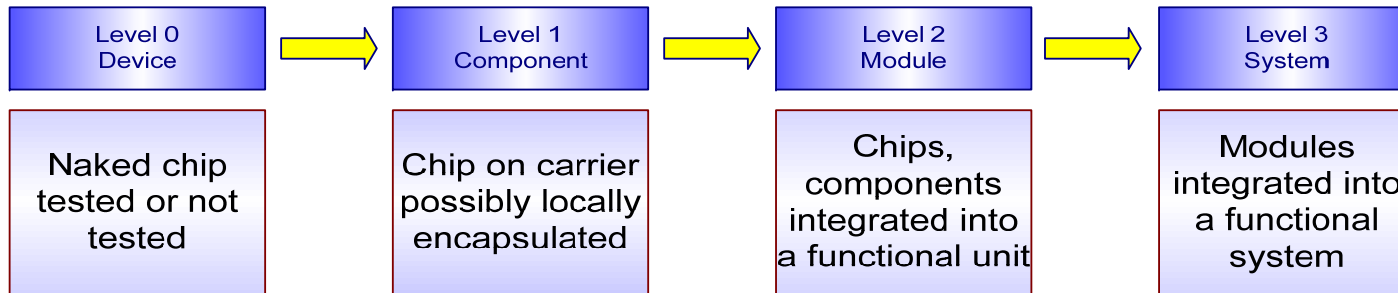
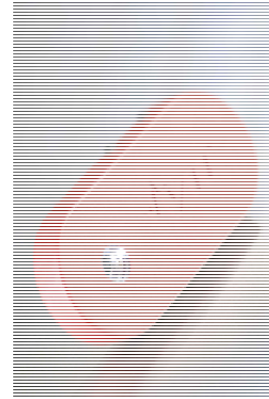
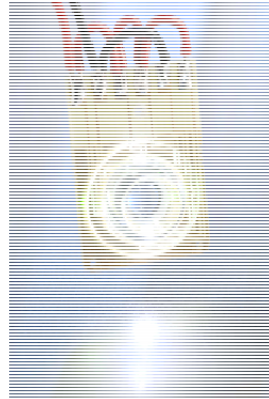
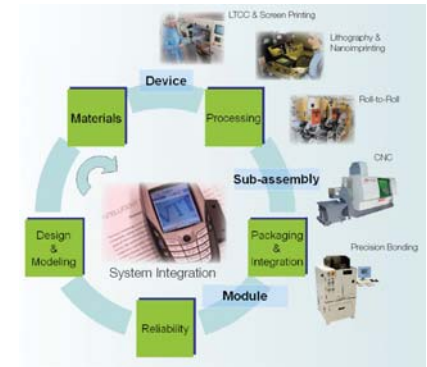


# Optics and Photonics Solutions



Business from technology

# System integrator approach



## MICRONOVA (VTT & TKK)

Clean room	2611 m <sup>2</sup>
▪ class 10	550 m <sup>2</sup>
▪ class 100-1000	875 m <sup>2</sup>
Other lab space	2619 m <sup>2</sup>
Office space	8038 m <sup>2</sup>

Companies

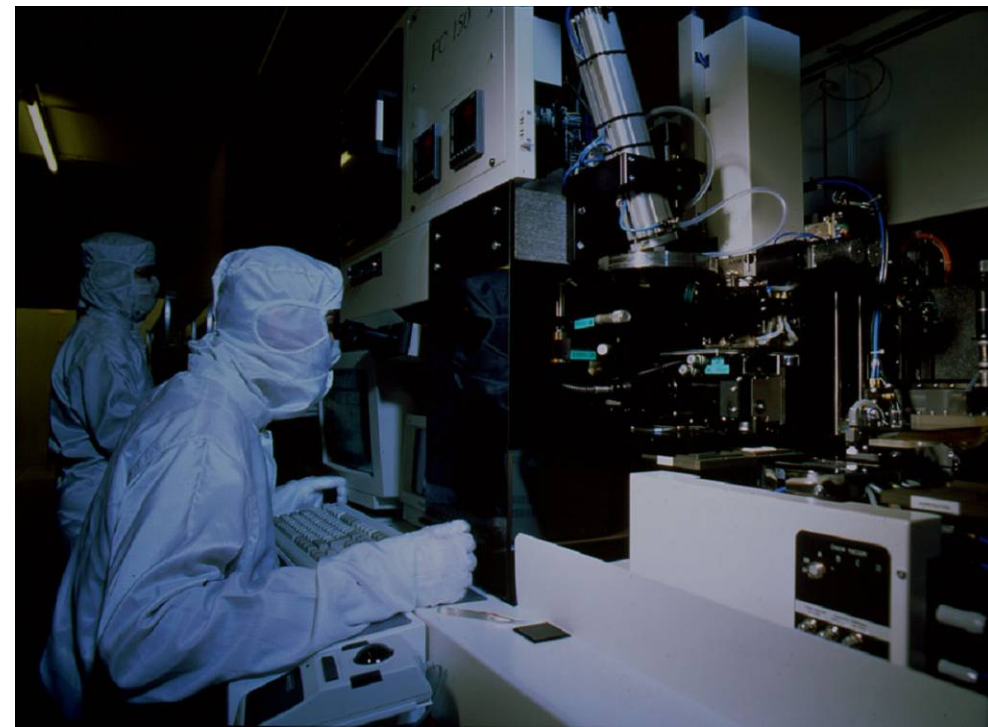
## MICRO MODULE CENTRE

Clean room	600 m <sup>2</sup>
▪ ISO5 (100)	80 m <sup>2</sup>
▪ ISO6 (1000)	80 m <sup>2</sup>
▪ ISO7 (10000)	440 m <sup>2</sup>

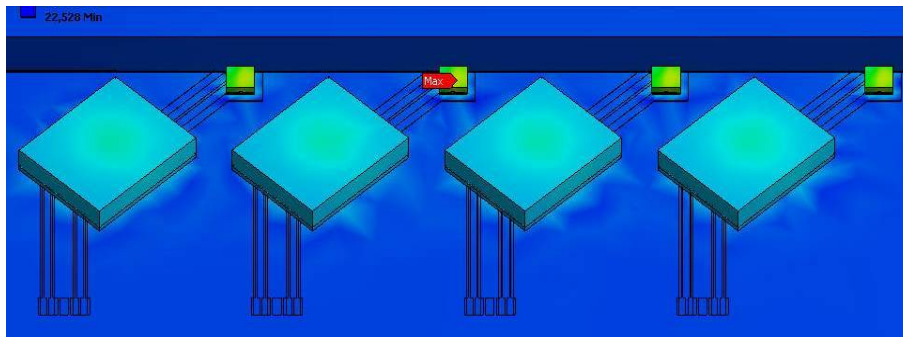
Micro & Nanotechnology Centre (Univ. of Oulu)

Precision Manufacturing Centre (PMC)

Spin-off companies

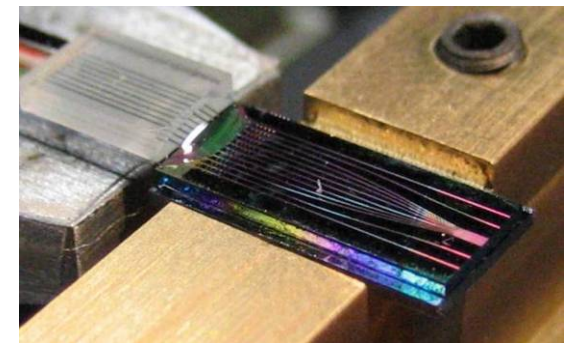
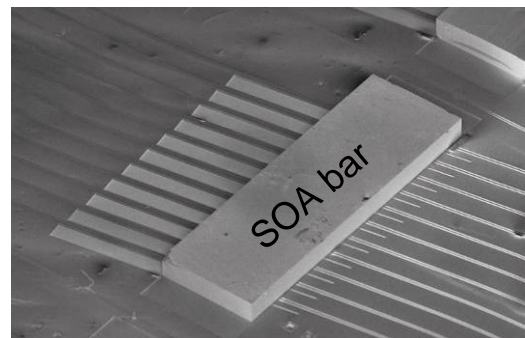
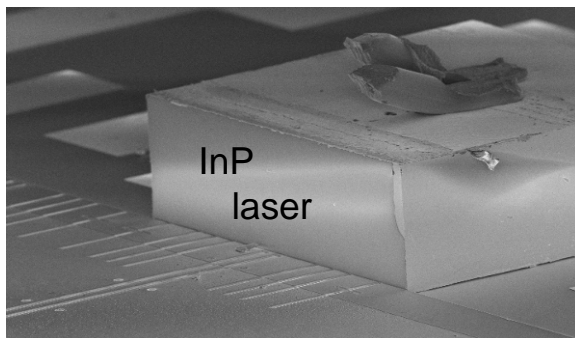


# Integration Platforms

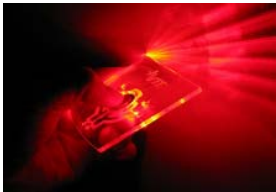
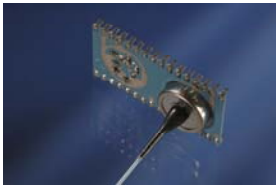
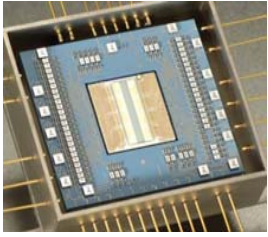


## – Silicon photonics

- Drivers, lasers, amplifiers, modulators and detectors integrated with Au-Au thermo compression bonding.
- Hermetic sealing
- Fiber pigtailed
- Integration of RF-line



## Integration Platforms ... continued



### **Ceramic 3D LTCC high performance system-on-package:**

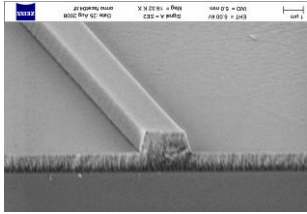
- Excellent thermal management for high-power applications,
  - Small footprint for multi-disciplinary photonics applications,
  - High reliability for harsh environment,
  - High-accuracy and stability
- for fiber alignment, for LED-based lighting, high-speed interconnects & high-performance optical sensors.

### **Plastic optics and integration:** Intelligence merge everything

- Conformal electronics design providing functionalities in 3D,
  - Combined manufacturing technologies, such as, roll-to-roll printing, lamination and injection molding,
  - New materials are challenging the packaging paradigms,
- for user interfaces, displays, illumination and sensors.

Hybrid/heterogeneous integration of optics, mechanics, electronics & sensing, MEMS, fluidics and RF/mm-wave functionalities.

**"More than Moore"**



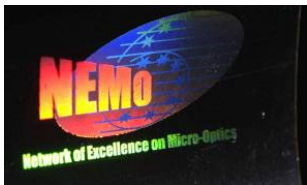
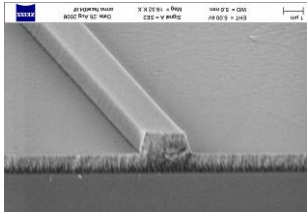
## In-house device technologies

- **MEMS:** Fabry-Perot interferometer, MEMS mirrors, micro-optic devices.
- **Si photonics:** SOI waveguide devices (couplers, splitters, WDM devices), Si nanowires, SiN and silica waveguides on silicon, thermo-optic switches.
- **Polymer devices:** Multimode & single-mode waveguides, nanophotonic structures, micro-optical elements, optical elements.
- **Roll-to-roll:** Diffractive elements, OLED/OPV devices, micro-fluidics structures.

Freedom to choose devices

# MISSION – Paving the way to products

Device portfolio



## MAIN competences:

- **Optical measurement technology:** IR spectroscopy, machine vision, sensor technology.
- **Optical communications:** Si photonics, integration, interconnects.
- **Packaging and integration:** Si, LTCC, polymer platforms & 5-axis CNC and thermal spraying.

## Applications:

- Optical paper instruments
- On-line measurement systems
- (Bio)readers
- Space photonics (sensors & interconnects)
- Photonic sensor solutions
- Lighting (& decoration)
- User interfaces (design)

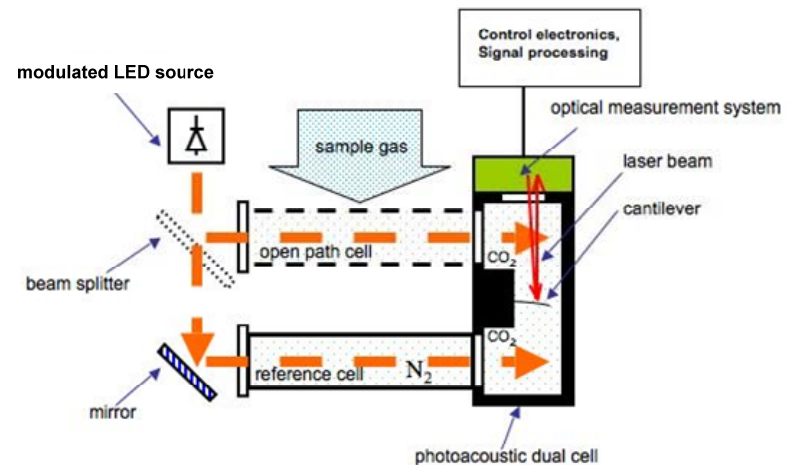
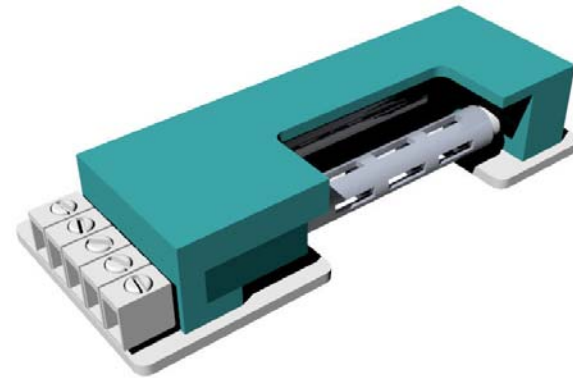
## Products:

- Optical instruments
- Optical interconnects
- Photonic sensors
- Photonics integration

## FP7-MINIGAS

Miniaturized photoacoustic gas sensor based on patented interferometric readout and novel photonic integration technologies

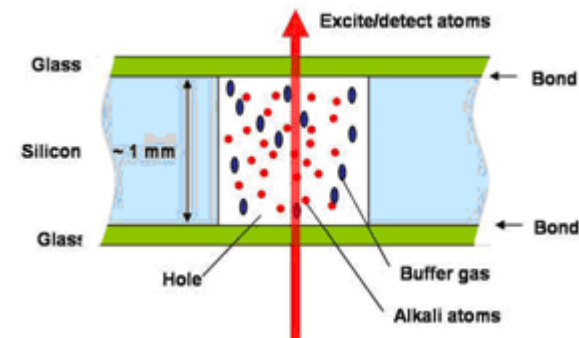
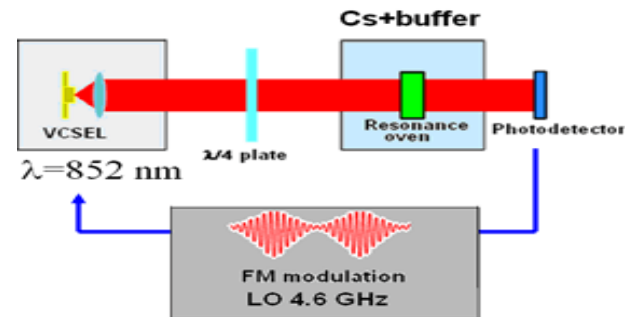
- To build a photoacoustic gas sensor with a volume of less than 5 sq cm, that achieves two or three orders of magnitude better sensitivity than other methods could achieve with a similar size; based on the use of a MEMS cantilever microphone.
- TOTAL budget 2 768 k€
- VTT (coordin.), QinetiQ (UK), Ioffe (RUS), University of Turku (FI), Gasera (FI), Doble (NO), Selex (IT)
- <http://fp7minigas.openinno.fi>



## MAC-TFC

### MEMS atomic clocks for timing, frequency control and communications - MAC-TFC

- To develop and demonstrate all the necessary technology for MEMS atomic clock to achieve an ultra-miniaturized, low-power and ultra-miniaturized cesium atomic clock, presenting a short-term stability of  $5 \times 10^{-11}$  over 1h while operating on the power of an AA battery, with less than 200mW power consumption.
- TOTAL budget 4 842k€
- CNRS (FR), IMT/Université de Neuchâtel (CH), Wrocław University of Technology (PL), Ulm University (GE), CEA-LETI CEA (FR), SAES Getters SpA (IT), ASULAB - Swatch Group (SW), OSA-Swatch Group (SW).
- <http://www.mac-tfc.eu/>





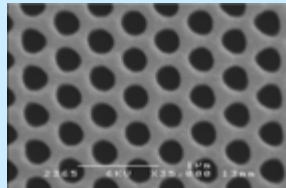
# NAPERRO project 2005–2008

## Development of novel fabrication methods for nanoscale photonics and microelectronics components

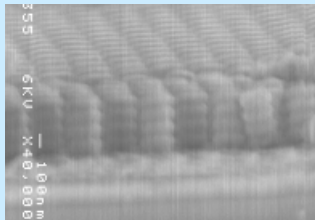


### Wafer-scale manufacturing:

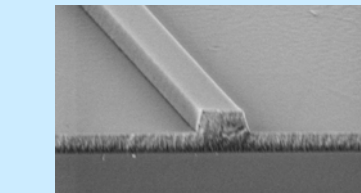
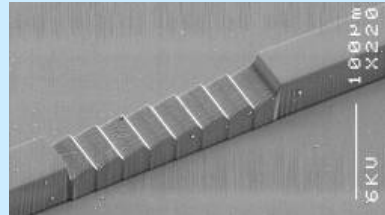
- Nano-imprinting, and Combined imprinting & lithography
- Near-field holographic lithography



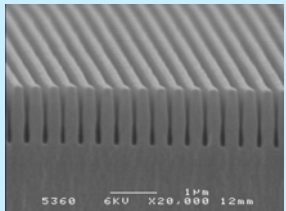
2D photonic crystals



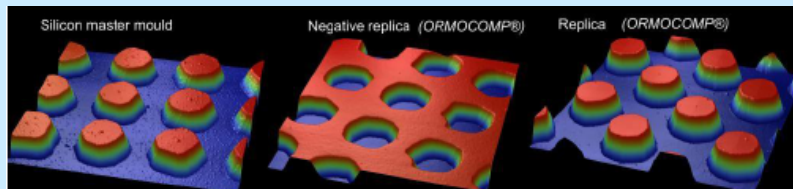
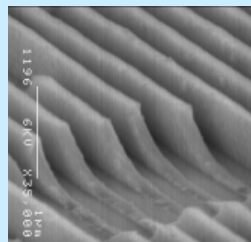
Blazed grating on waveguide



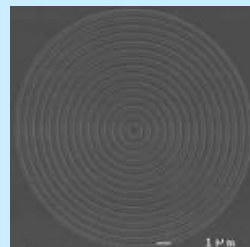
Singlemode waveguide



High-aspect sub-wavelength gratings



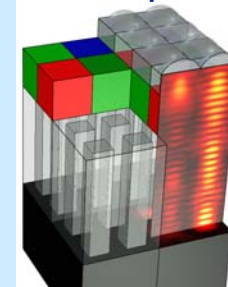
Antireflection gratings



Circular grating

### Optical design & simulation:

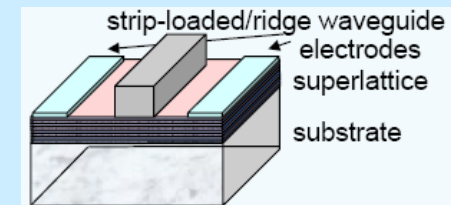
- Plasmonic nanoapertures
- Aperiodic photonic crystals
- Image sensor pixel structures



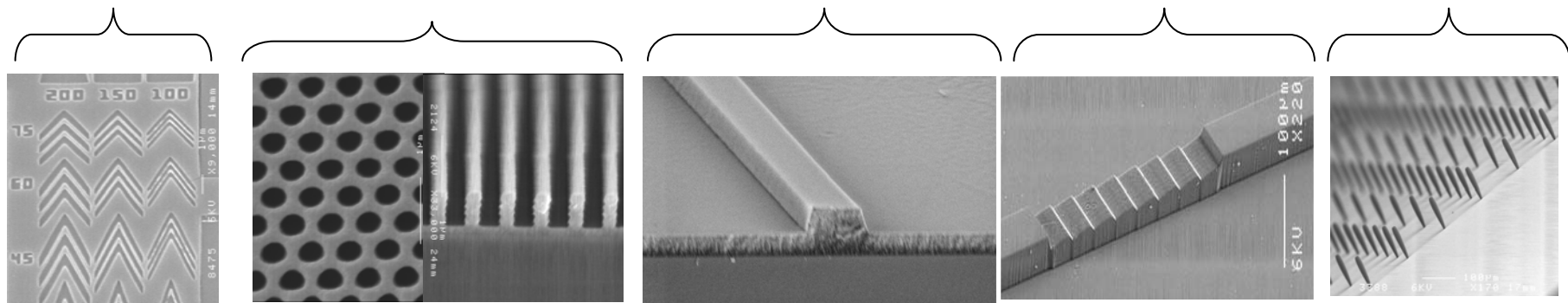
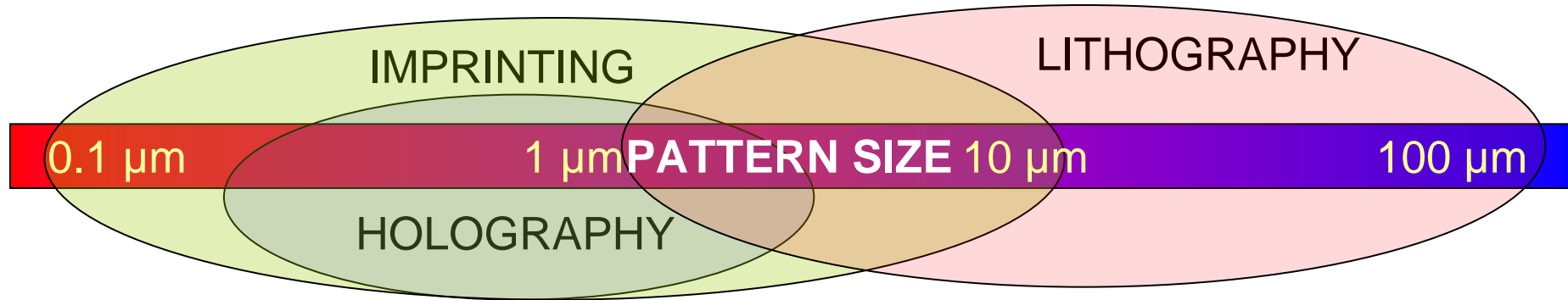
Kuva waveguide model

### Tunable electro-ceramic materials:

- IR shutter by metal-insulator transition
- Electro-optic modulators



# FABRICATION OF POLYMER BASED MICRO- AND NANOPHOTONICS DEVICES



Imprinted test structures

Holographically patterned gratings with different symmetries.

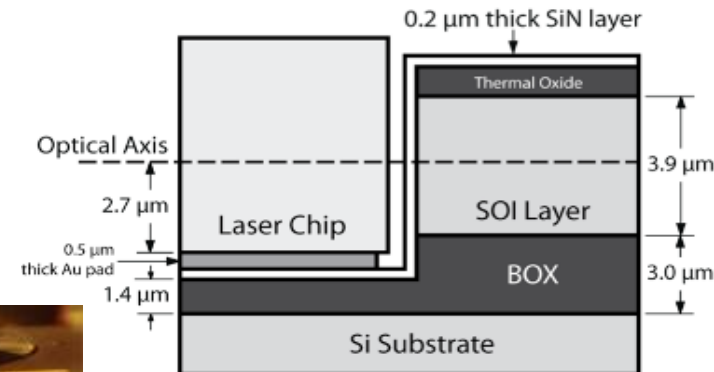
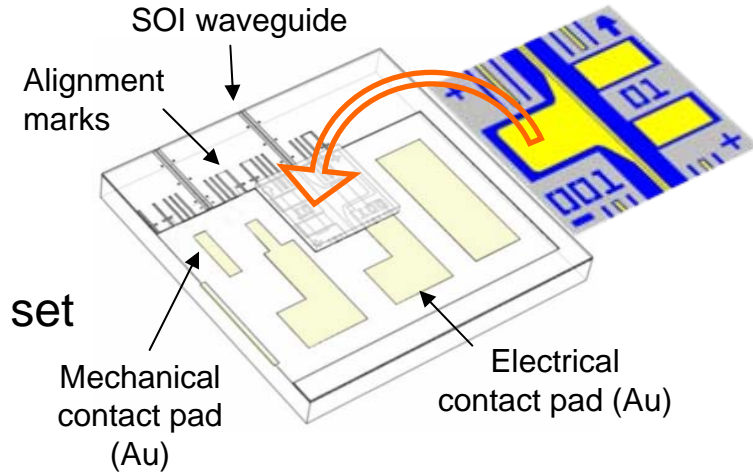
Imprinted single-mode waveguide

Lithographically patterned multi-mode waveguide with Imprinted  $\mu$ -prisms

High aspect ratio vertical Couplers of optical quality Patterned with lithography.

## Thermo compression bonding of LD

- Commercial LD modified with a customised mask set
- Laser specs:  
300 x 300 x 100  $\mu\text{m}$  chip,  
5 mW @ 1520 nm (RMS width 1.3 nm),  
24.3° horizontal & 41.9° vertical div.
- SiN AR coating on SOI
- Au pads on thinned BOX
- Commercial flip-chip bonder (Laurier M9) with nominal accuracy  $\pm 0.5 \mu\text{m}$
- 0.8 N force, 325°C

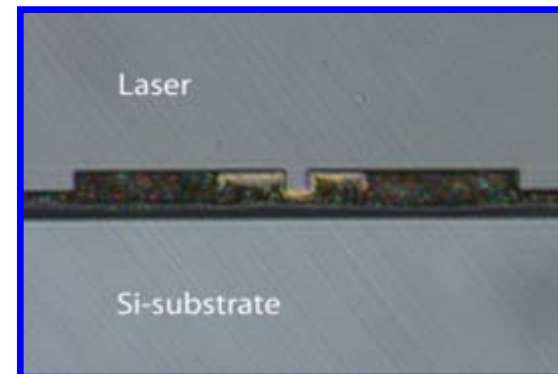
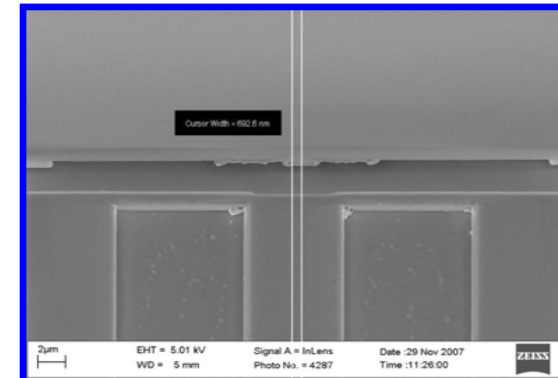
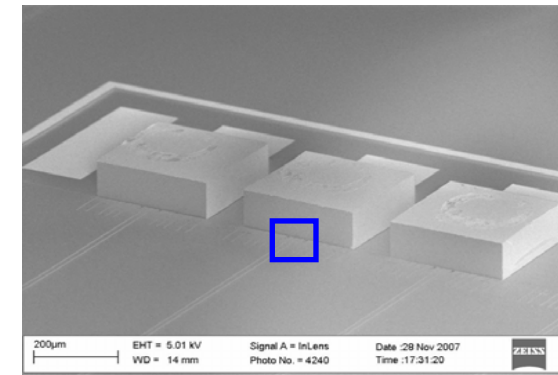


AR = anti reflection  
BOX = buried oxide

## Laser integration results

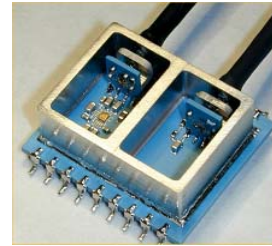
- Alignment accuracy:  
 $\pm 100$  nm vertical,  $\pm 1 \dots 2$   $\mu\text{m}$  horizontal,  $0 \dots 5$   $\mu\text{m}$  gap
- High mechanical bond strength confirmed  
 by temperature cycling  $-55 \dots +130^\circ\text{C}$   
 (and by polishing)
- No junction resistance
- Coupling loss 2.7 dB  
 (2.1 dB mode coupling, 0.6 dB reflections)

Laser Number	Alignment Accuracy ( $\mu\text{m}$ )	
	Horizontal	Gap
1	0.1	3.1
2	1.9	1.8
3	0.2	3.1
4	0.6	4.1
	$0.7 \pm 0.8$	$3.1 \pm 0.9$



# Industrialization

Optical instruments  
Special sensors  
Consumer solutions



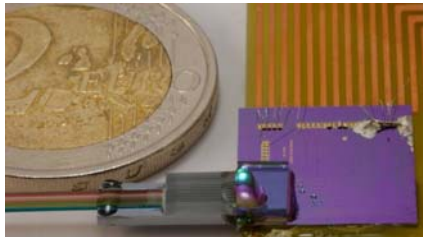
## Industrialization

- Technology transfer
- Product support & revisions



## Proof-of-technology demonstrator

- Processing & integration & fabrication
- Verification of technologies



## Proof-of-concept demonstrator

- Components or modules in lab or field tests

## Proof-of-principle demonstrator

- Laboratory setup on optical table
- Modeling and simulations

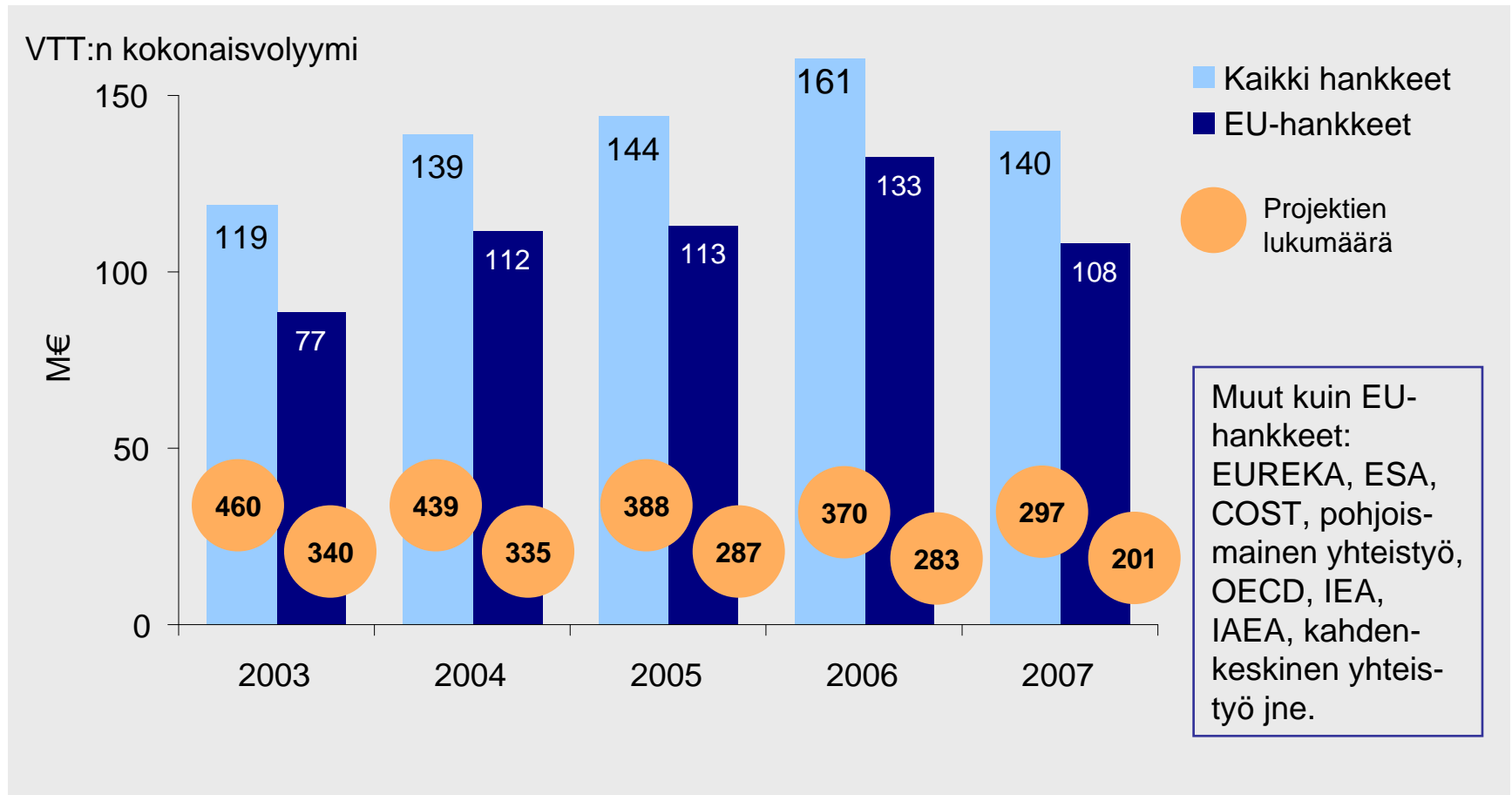
The background features a dark blue color with a pattern of light blue, semi-transparent geometric shapes, including cubes and rectangular prisms, and small arrows pointing in various directions, creating a sense of movement and technology.

## VTT as a research partner for SMEs in international projects



Business from technology

## VTT:n osallistuminen kansainvälisiin julkisiin tutkimushankkeisiin



VTT:n EU-tulot ~33M€ vuodessa

## Mikä on SME-projekti?

- SME\*-projektissa eurooppalaiset pk-yritykset\*\* kehittävät EU:n rahoituksella uusia palveluita tai tuotteita yhdessä tutkimuslaitosten kanssa. Projektin aikana voidaan myös kehittää toimivat markkinointikanavat ja asiakaskontaktit.
- Yritykset kehittävät kansainvälisiä liiketoimintaketjuja, joissa hyödynnetään osapuolten erilaisia osaamisalueita.
- Hyvä keino suomalaiselle pk-yritykselle kansainvälistyä, uusiutua ja kehittää liiketoimintaansa.

\* SME: Small and Medium sized Enterprise

\*\*Pk-yritys: alle 250 työntekijää, liikevaihto max. 50 miljoonaa euroa ja taseen loppusumma max. 43 miljoonaa euroa.

# PK-yritys

### SME-projektikonsortio:

- Yrityksiä vähintään kolmesta eri EU-maasta tai EU:n liitännäismaasta, (tyypillisesti 5 ... 10)
- Projektin kesto on n. 1 ... 2 vuotta
- Budjetti n. 0,5 ... 1,5 milj. €
- EU:n tuki kattaa n. 75 % tutkimuslaitosten yrityksille tekemästä kehitystyöstä





# VTT creates business from technology

