

#### THE VIRTUES OF PHOTONS FOR THE CONNECTED SOCIETY

Ludovic Poupinet – Head of the Optics and Photonics Division

leti ceatech

#### **HUGE INNOVATION POTENTIAL OF PHOTONICS**



# Europe's age of light!

Leverage the unbroken innovation potential of Photonics

#### Photonics – a key digital technology for global mega markets and challenges

Live longer, feel better - Photonics in life sciences and healthcare Feed the world - Photonics for safe, nutritious and affordable food Keep our traffic flowing - Photonics for autonomous & connected mobility Zero emission, less waste - Photonics for C sustainability and a clean environment Empowering Industry 4.0 - Photonics in manufacturing and production A new quality of urban life - Photonics for smart homes and liveable cities Building our digital society - Photonics for a secure and resilient IT infrastructure Linking big ideas - Photonics as a driver of the digital knowledge society

See also Photonics 21 Vision Paper : « Europe's Age of Light! How photonics will power growth and innovation »

https://www.photonics21.org/downl oad/ppp-services/photonicsdownloads/Photonics21-Vision-Paper-Final.pdf

# HOW TO DELIVER THE FULL POTENTIAL OF PHOTONICS ?

- Most of the targeted applications of photonics are in relation with connected society.
- Most of the photonic components include an optical circuit, a driving or readout CMOS, a companion chip for data analysis or preparation and an optical system
- Miniaturization, integration and embedded intelligence are mandatory to reduce cost, size and improve functionalities and performances
- We believe that four major technological trends will support the evolution of photonics throughout the 21st century



#### FOUR MAJOR TECHNOLOGICAL TRENDS TO ENHANCE THE PHOTONICS TOOLBOX



leti <sup>Ceatech</sup>

#### **TOOLBOX TREND 1 : PHOTONICS MOVES TO CMOS-TYPE FAB AND DESIGN**



leti

#### **TOOLBOX TREND 2: DENSER INTERCONNECTION WITH ELECTRONICS**





#### **TOOLBOX TREND 3: LENS AND FILTERS INTEGRATION OR SUPPRESSION**





#### **TOOLBOX TREND 4: PROCESSING IN PHOTONICS**



- Aberration compensation
- Edge extraction

STVD991

Noise correction





#### **EXPECTED MAJOR IMPACTS IN THE COMING 5 YEARS**



#### **IMPACT ON COM. AND COMPUTING : LIGHT IN SILICON**

#### • III-V laser integration on Silicon

- ✓ III-V patterning in CMOS fab
- ✓ CMOS compatible contacts on III-V
- ✓ Process compatible with existing Si photonics III-V die bonding → on going Upscale from 8" to 12" → on going

#### • Ge based laser integration on Silicon

- $\checkmark$  Sn doping toolbox
- ✓ Strained Ge toolbox
- ✓ Optically pumped laser at 180 K
  Electrically pumped laser → on going
  Ambient temperature lasing → on going







#### IMPACT ON COM. AND COMPUTING: TOWARDS MORE COMPLEX CIRCUITS (1/2)





#### IMPACT ON COM. AND COMPUTING : TOWARDS MORE COMPLEX CIRCUITS (2/2)



#### Improved computing

- Potential constant latency vs communication distance
- Horizontal network in datacenter
- Optically interconnected neural network



leti

#### IMPACT ON SENSING: THE SMALLEST MID INFRARED CHEMICAL SENSOR





#### **Industry** Process control, fuel quality

#### Defense

Hazardous gas & chemical agents detection

# Q

**Healthcare** Breath analysis, hospital air control

#### **Environment** Air quality, gas emission monitoring



#### **IMPACT ON SENSING: INTELLIGENT PHOTONIC COMPONENTS**



Image sensor pixels include 3 memories for depth mapping with modulated illuminating light





Pixels adapt their samplig rate depending on changes in the scene. Address Event Representation

PROPHESEE METAVISION FOR MACHINES



Communication and high quality lighting with modulated LED light. Possible use of LED matrices for automotive, smart city and home.



#### **IMPACT ON DISPLAY : NEW GENERATION OF DISPLAYS**

#### • GaN light emission on Silicon

- ✓ Nanowire based technology on Si
- $\checkmark$  Better integration with electronics
- ✓ 30M€ series-C funding in 2018

High brightness displays  $\rightarrow$  on going



- High resolution GaN microdisplays
  - ✓ WVGA resolution (873x500 pixels, 10µ pitch) prototype microdisplay

AR/VR devices, Head-Up Display and compact projectors  $\rightarrow$  on going





#### EXPECTED IMPACT ON EMERGING APPLICATIONS AND DEVICES

### Smartphone, tablets

- 3D imaging
- Face recognition
- Gesture recognition
- 3D displays
- Haptic interface



#### **Vision for transport**

- 3D mapping
- Visible image sensors
- Low cost infrared imaging
- Compact lidar
- Sensor fusion
- A priori informations



#### TAKEAWAYS

- The impact of photonics on the connected society requires componants and systems with small size, low cost, low power consumption and advanced functions
- A new « toolbox » is under development allowing a tight and seamless integration of photonics, electronics and processing
- Large size markets will probably drive those developments and take benefits of all the advantages of this toolbox
- Impact will certainly be huge in all the applications from sensing to computing, communication and displays
- Conventional photonics will most likely be disrupted except in niche areas

# Thank you for your attention



Leti, technology research institute Commissariat à l'énergie atomique et aux énergies alternatives Minatec Campus | 17 rue des Martyrs | 38054 Grenoble Cedex | France www.leti-cea.com

