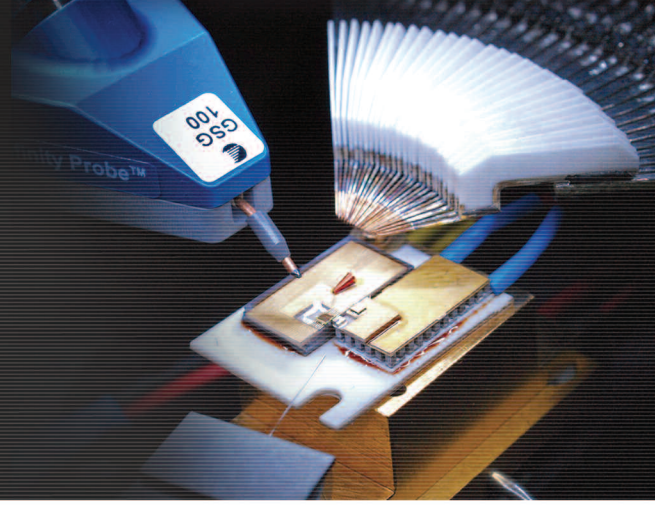

Photonic Integrated Circuits Accessible to Everyone

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Welcome to the third newsletter of the EU H2020 PICs4All project. Photonic integrated circuits (PICs) open up whole new opportunities to create novel products and improve already existing electronic and photonic devices.

A mature generic InP PIC technology, which is now offered commercially by European foundries, enables and accelerates many market sectors with a 9.3 billion market forecast for potential PIC enabled products for 2021. The ecosystem is now looking to expand from communications (3/4 of the actual PIC market) to sensors and completely new markets. The fabless model and existing open access platforms allow universities, research centers, SMEs and big companies to do PIC design, manufacturing, testing and packaging at a low cost.

The PICs4All consortium partners form a network of experts in the field of photonics, ready to help and support you free of charge, from the very first idea of a photonic integrated circuit through design, fabrication and packaging, to final testing of your chip. We also advise how your products and applications can gain from the added value of PICs. Our application support centers (ASCs) are distributed around Europe and offer support and expertise on various markets, like high-speed data communication, sensing, biomedical, automotive, where photonic integrated devices can be applied.

In this issue we introduce our support center located at Aarhus University and present a PIC application note on data center switching. In the events section we present a brief on the 8th European Photonic Integration Forum at ECOC 2017 and PICs4All workshops on photonic integration organized during Photonic Integration Week 2017 and Nanotexnology 2017.

Aura Higuera Rodriguez (TU/e)

How to contact us:
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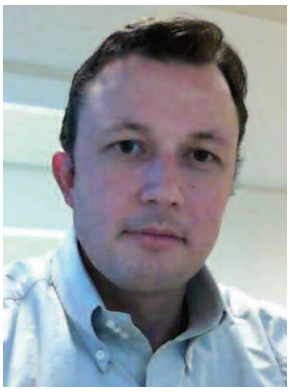
Application Support Center @ Aarhus University – Photonic Integration in Denmark

The Department of Engineering at Aarhus University is young and dynamic, having been established in 2011 only. It is built on the combination of a strong tradition in natural sciences and applied engineering, through a merger of the Aarhus School of Engineering into Aarhus University. An ambitious 5-year growth and recruitment plan, combined with a strongly growing student population, will bring it to a full-strength research-based academic engineering education in 2023.



Associate Professor Martijn Heck, leader of the Photonic Integrated Circuit group at Aarhus University, Department of Engineering

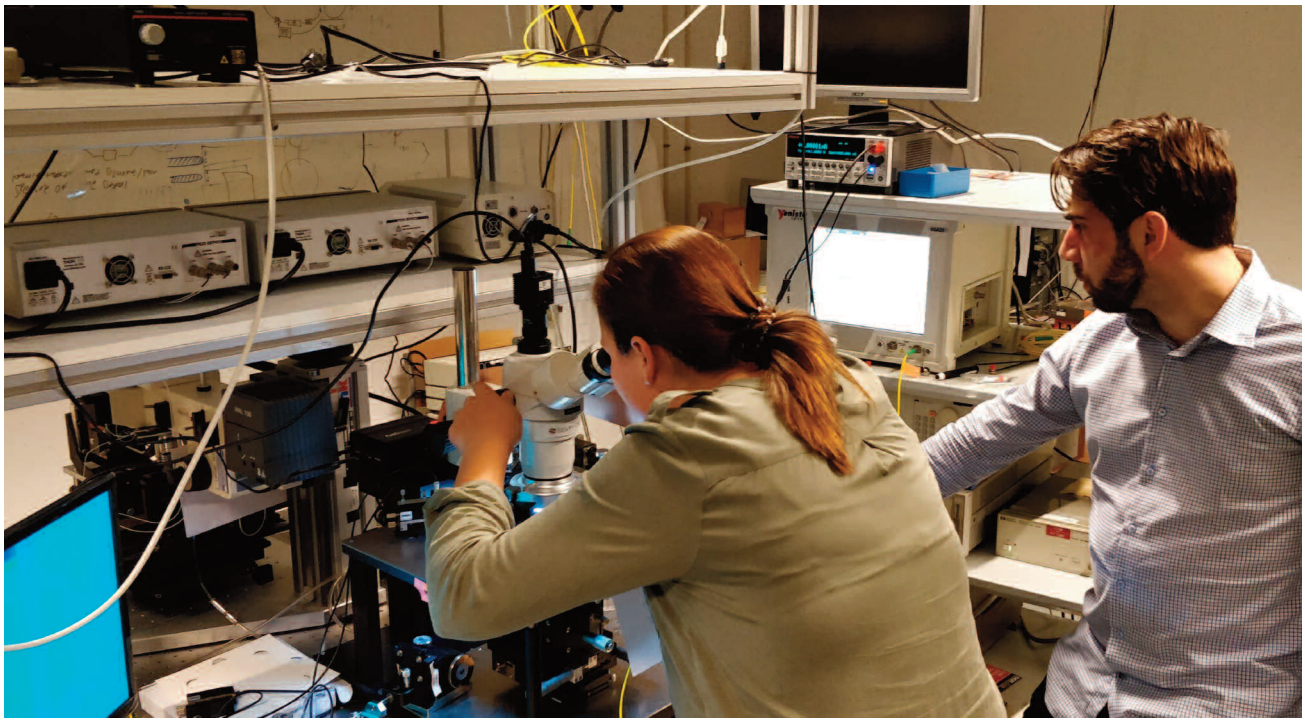
The **Photonic Integrated Circuits group** was established end of 2013, with the appointment of **Associate Professor Martijn Heck**. He brought his extensive experience in indium phosphide, silicon nitride and silicon photonics with him, obtained through PhD and postdoc stays at the Technical University Eindhoven and the University of California Santa Barbara. The group has since grown to five PhD students and two postdocs, all funded by competitively obtained grants.

The research in the group is exclusively based around a fabless approach, meaning that PIC fabrication is done at foundry partners, like SMART Photonics, Heinrich Hertz Institute, LioniX, and imec. The group has been building up design and experimental characterization experience over the last few years and now has a fully equipped "Fotonik" laboratory, dedicated to PIC characterization, with strong emphasis on ultrafast photonic and microwave-frequency measurements, apart from all the basic characterization equipment.

Aarhus University main campus in the heart of the city

The PIC technology is used in the current focus areas of microwave and terahertz photonics, **gas sensors**, and energy-efficient interconnects. The group collaborates extensively with Danish and European industry, such as Synopsys, MyDefence Communication and SEGES. Furthermore, Aarhus University's focus on PICs is very complementary and synergetic with other strong Danish academic activities in the field of high-bandwidth optical communications, specialty fibers, and nanophotonics and plasmonics, for example, at the Danish Technical University.

As the PICs4All Application Support Center in Denmark, Aarhus University is proactively reaching out to Danish and wider Scandinavian industry and academia, to connect them to the European ecosystem for PIC technology. It offers expertise in feasibility studies and design support. Interested parties are encouraged to contact Martijn Heck (**mheck@eng.au.dk**).



Some of the group members at work on a probe station, which allows for 360-deg access to the PIC with multiple DC, RF and fiber-optic probes, and viewing the PIC both through a camera, coupled to a screen, and through a microscope

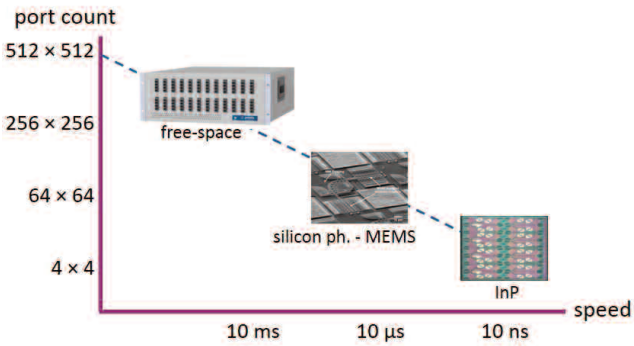
How to contact us:

http://eng.au.dk/om-ingenioervidenskab/organisation/elektro-og-computerteknologi/photonic-integrated-circuits/
https://www.linkedin.com/in/martijnheck/
https://www.linkedin.com/pulse/photonic-integrated-circuits-gas-sensing-martijn-heck/

Photonic Integrated Circuits for Datacenter Switching

Optical switches find application in numerous diverse fields, including digital communications, fiber optic sensing, optical metrology, LIDAR systems, atom interferometers, laser interferometry, opto-pyro-electronics and system redundancy when reliability is critical (e.g. satellite payloads). Each application field comes with different requirements and entails its own challenges. This application note focuses on the application of optical switches in digital communications, more specifically in optical datacenter networks (DCNs), which represent a promising field for their large-scale deployment.

Optical switching is gaining traction as a path for gracefully scaling datacenter networks, due to its inherently broad bandwidth, energy efficiency and transparency to bitrate and protocol[1]. A multitude of switching schemes have been proposed leveraging the most prominent optical switching technologies, such as space-switching (e.g. using micro-electro-mechanical systems – MEMS or semiconductor optical amplifiers – SOAs), wavelength-switching (through combination of tunable lasers with arrayed-waveguide-grating routers – AWGRs), or combination thereof (e.g. using wavelength-selective switches – WSSs). Currently there is no standardization or regulatory framework for optical DCNs since commercial use of the technology is still in its infancy, focusing mostly on pre-commercial demonstrators and pilot deployments of early products[2]. As a result, the network designer is free to innovate and develop a DCN architecture tailored to the needs of the particular system, using the switching approach of choice.

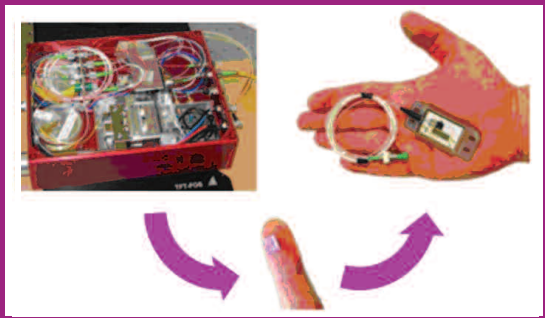


Schematic overview of speed vs. port count for typical optical switch technologies.

Photonic Integrated Circuits (PICs)

Also known as optical chips, PICs can contain tens to hundreds of optical components. While electronic ICs consist of transistors, capacitors and resistors, a PIC consists of, for example, lasers, modulators, photodetectors and filters, all integrated on a single substrate. These PICs are nowadays extensively used commercially, mainly in datacom and telecom.

PIC technology has now become accessible to users without a cleanroom, through so-called multi-project wafer runs and open foundries. Indium phosphide based technology is commercially available through SMART Photonics and Heinrich Hertz Institute. Access is coordinated by the JePPIX platform: http://www.jeppix.eu/.



[1] ITRS 2.0, 2015

[2] http://www.polatis.com/series-7000-384x384-port-software-controlled-optical-circuit-switch-sdn-enabled.asp

One of the key challenges in optical DCNs is the combination of scalability with fast reconfigurability. At the optical switch device layer, this translates to a need for high port-count switches with fast reconfiguration time. This is arguably the main limitation of current technologies, which exhibit a tradeoff of speed vs. size: High port-count optical switches, like MEMS, typically offer millisecond reconfiguration times, whereas nanosecond-speed optical switches like PLZT (lead zirconate titanate) strive to exceed the dimensions of an 8×8 matrix, thus inhibiting network scalability. Innovative network design can partially mitigate these handicaps (e.g. by means of hybrid networks); however to make optical switching in DCNs mainstream, network designers are urgently seeking a technology for low-cost, fast and scalable optical switches.

The opportunity for photonic integration

At the device level, optical switches used in DCNs rely mainly on the following architectures:

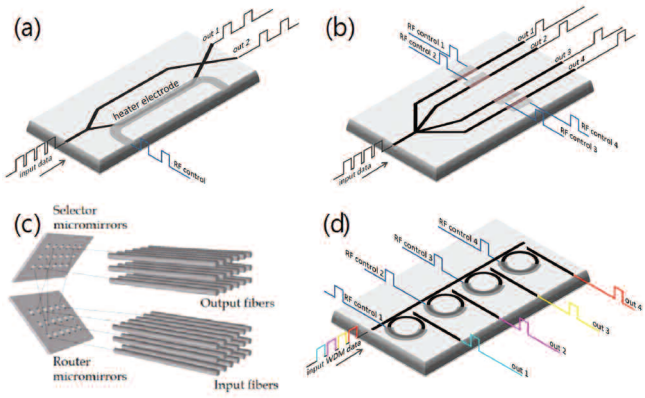
(i) interferometric switches, usually in 1×2 or 2×2 configurations. Scaling of their dimensions can be achieved by cascading several stages of switches, e.g. in a Clos network topology;

(ii) on/off switches configured in broadcast-and-select topologies;

(iii) free-space optical switches.

These device architectures can be used in conjunction with wavelength-selective components like AWGs, gratings or prisms to yield wavelength-selective switch (WSS) devices. Another scheme frequently used in optical DCNs is wavelength switching, combining fast tunable lasers with AWGs – in essence, the ensemble of tunable lasers and AWGs forms a distributed switch. Finally, resonant devices like ring resonators can be used as very energy-efficient switches, which can potentially fit in certain DCN architectures.

Photonic integration (see inset) can be used to implement all the above types of optical switch devices, with the exception of free-space switches – although photonic integration can still benefit from technologies typically used in free-space switches (e.g. combination of silicon photonics with MEMS). With mature laser diode technology, tunable lasers capable of changing their wavelength within a few nanoseconds can be fabricated. Combination of tunable lasers with on-off switches can be achieved on the InP fabrication platform, enabling tight integration of the transceivers with the switch. Silicon photonics offer a low-cost technology for large scale interferometric, on/off or resonant switches. Very precise, compact and low-loss optical filters can be implemented in various platforms like silicon nitride or glass. These PICs are typically packaged and fiber-coupled for environmental stability and ease of operation.



Optical switch device architectures: (a) interferometric switch; (b) on/off switches in a broadcast-and-select topology; (c) free-space switch; (d) resonant, ring-resonator switch

Packaging of the PIC with electronics and with fiber coupling, at low cost and large volume, though, is still a challenge. In this framework, commercial solutions, e.g., as offered by Technobis IPPS and Linkra/Cordon, have recently become available.

Discuss your application with us

If you are interested to know more about the use of PIC technology for optical datacenter networks, please contact Hercules Avramopoulos, coordinator of the PICs4All Application Support Center (ASC) at the National Technical University of Athens, Greece. We are currently leading collaborative projects for datacenter networks, (NEPHELE, 3PEAT), funded by the European Commission, with a focus on technology development, prototype fabrication and integration with the DCN architecture. We are set up to help you do a feasibility study for the use of PICs for datacenter network applications.
The PICs4All consortium[3] is funded under the Horizon 2020 framework and brings together expertise to support end-users, like academia, research institutes and industry, with PIC technology. The ASCs can help you connect to the eco-system of designers, foundries, packaging and test services.

[3] http://pics4all.jeppix.eu/

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Events

Nanosciences and Nanotechnologies (N&N)

NN Conference is a world-class international event in Nanosciences and Nanotechnologies (N&N) that focuses on the latest advances on N&N and promotes profound scientific discussions between scientists, researchers from different disciplines and market leaders. Front-line experts from multidisciplinary research and application areas join this conference every year to discuss the benefits of N&N in their R&D efforts, to advance the networking and collaborating between different academia, research and industry players in the field and to stimulate the exchange of educational concepts (http://www.nanotexnology.com/).

Memory photo of organizers and invited speakers of the PICs4All workshop on Photonic ICs and applications in the framework

Within the framework of the 14th NN Conference that took place in 4–7 July 2017 in Thessaloniki Greece, PICsAll organized a 3-session workshop with the aim to highlight opportunities offered by photonic integration in diverse industrial applications and to explain

the path for incorporating photonic integration into commercial products, outlining the available tools and ecosystems. In more detail, the first session focused on the role of photonic integration in next generation optical interconnects with invited talks from Richard Pitwon (Seagate), David de Felipe Mesquida (Fraunhofer Heinrich Hertz Institute) and Ivan Nikitskiy (The Institute of Photonic Sciences – ICFO). The second session focused on the general progress on the possibilities and the availability of photonic integration technology with invited talks from Katarzyna Lawniczuk (Technical University of Eindhoven), Charles Caër (IBM), and Periklis Petropoulos (University of Southampton). Finally the third session discussed the role of photonic integration in emerging technologies and applications including biosensing applications with invited talks from Christos Kouloumentas (National Technical University of Athens), Jochen Kraft (AMS), George Dabos (Aristotle University of Thessaloniki), and Ruben Alemany (University of Valencia).

The workshop was organized by the PICs4All consortium members **Paraskevas Bakopoulos** and **Dimitrios Kalavrouziotis** (National Technical University of Athens).

ECOC 2017

On the 18th of September 2017 during ECOC conference in Gothenburg JePPIX together with ePIXfab organized the 8th EPIF forum, where successfully a brief on open access technology platforms was presented to the new incomers of photonics integrated technology. Around 35 people attended, the forum resumed all the available open access platforms (InP. SiN and SiPh) giving a general overview of the integrated photonics market growth, processing technologies, MPW runs and the ongoing development on open access packaging.

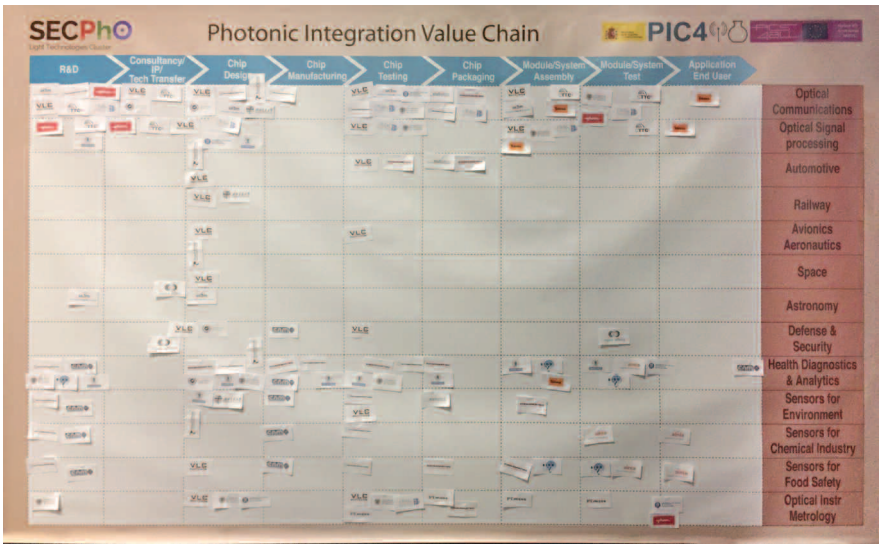
The Photonic Integration Week

The first edition of the Photonic Integration Week, **PIW2017**, organized by the **Universitat Politècnica de València** took place last **January from 16th to 20th**. The event combined industrial presentations, business to business meetings, scientific and technical speakers and training activities.
The event started with two Workshops under the framework of the project **H2020 PICs4All** (**Photonic Integration Circuits Accessible to Everyone**) and the Spanish Network of Excellence **PIC4TB** (**Photonic Integration Circuits for Telecommunications and Bio Sciences**).

Industrial keynote speakers provided the **commercial perspective of use** of photonic integration technologies at different positions of the supply chain, from component manufacturers and system integrators to end users of these technologies. **Scientific invited speakers** presented their **latest achievements** and prospects of use of the technology in research and development. Once the industry speakers presented their work, the members of the PIC4TB network imparted **4 master lessons on practical design considerations for the development of Photonic Integrated Circuits for Bio and Telecom applications**.

The Workshop was followed by a **2.5 days training on the Design of Photonic Integrated Circuits (PICs)** given by the design company **VLC Photonics**.

The Southern European Cluster in Photonics and Optics (**SECPhO**) organized business to business meetings facilitating the cooperation between companies and researchers. **SECPhO** also organized an activity where attendees located their logo in a map of coordinates pointing their activity on the value chain on several application fields. As a result of the **PIW2017**, **SECPhO** wrote an interesting report on the **Photonic Integration Value Chain in Spain**.



Picture at the end of the activity organized by SECPhO showing the Photonic Integration value chain in Spain

The first edition of the PIW had 77 attendees and most of the **invited speakers participating** in the event belong to the **industry sector (53%)**, followed by the academy **(37%)** and **clusters (10%)**.

Second edition, PIW 2018

The **Universitat Politècnica de València** continues contributing to the development of the Photonic Integration value chain in Spain through a **2nd edition of the Photonic Integration Week. From 15th to 20th January, 2018**, the **PIW2018** will provide a scenario where industry and academy meet, share, learn and collaborate scientific and technically. It will combine industrial presentations, business to business meetings, scientific and technical speakers and training activities.

The **PIW2018's** edition will consist on **2 days of workshop** under the framework of the project H2020 **PICs4All (Photonic Integration Circuits Accessible to Everyone)** and the Spanish Network of Excellence **PIC4TB (Photonic Integration Circuits for Telecommunications and Bio Sciences). Industrial keynote speakers** will provide the commercial perspective of use of photonic integration technologies and **Scientific invited speakers** will present their latest achievements in research and development. After the workshops there will be **a 3 days training on the Design of Photonic Integrated Circuits (PICs)** given by the design company **VLC Photonics**.
The **PIW2018** will take place in the beautiful Mediterranean City of **Valencia** which is equivalent to sunshine, Mediterranean cuisine, beaches, lifestyle, festivals and traditions, green spaces, 2000 years of history, cutting-edge architecture… Do you want to join us?

For more information, visit the event website at http://piw.blogs.upv.es/

GENERIC INTEGRATION TECHNOLOGIES FOR PHOTONICS

IMiO

JUNE 2018

WARSAW UNIVERSITY OF TECHNOLOGY
FACULTY OF ELECTRONICS AND INFORMATION TECHNOLOGY

About PICs4All

PICs4All (Photonic Integrated Circuits Accessible to Everyone) is a Coordination and Support Action from the EU H2020 ICT-27-2015 programme. The prime objective of PICs4All is to increase the impact of photonics and enable an access to the advanced photonic integrated circuit (PIC) technologies for academia, research institutes, SMEs and larger companies. This will be achieved by establishing a European network of Application Support Centres (ASCs) in the field of PIC technology. The main task of the ASCs is to lower the barrier to researchers and SMEs for applying advanced PICs, and thus to increase the awareness of the existence of the worldwide unique facility provided by JePPIX (InP and TriPleX PIC design, manufacturing, testing and packaging).

The main PICs4All objectives:

- scouting, acquiring and supporting new PIC users;
- promoting the use of the European photonic integration platforms;
- strengthening Europe's industrial lead in the business of integrated photonics;
- bringing together academia to explore photonics and promote its critical importance.

The PICs4All consortium:

- actively explores the market, searching for new application fields for ASPICs;
- offers guided access to Multi-Project Wafer runs for ASPIC fabrication;
- provides support in ASPIC design and prototype testing;
- connects users to professional design houses and packaging vendors;
- organizes ASPIC design courses and workshops.

PICs4All ASCs will actively support users in taking full advantage of the PIC-technology and its deployment in existing and new applications. For this reason, it combines two targets of an EC supported CSA, i.e. enabling the access to advanced design, fabrication and characterisation facilities, and stimulating the innovation potential of users, esp. SMEs, by supplying hands-on support in developing their business cases. All this is achieved by connecting existing PIC-development infrastructure throughout Europe and by lowering the risk at the investment stage in PIC development by enabling access to low-cost prototyping.

Fact and Figures:

Project reference:	EU H2020-ICT-27-2015 CSA no 687777
Project acronym:	PICs4All (Photonic Integrated Circuits Accessible to Everyone)
Timeline:	1 January 2016–31 December 2018
Budget:	1 051 895,- EUR
Website:	http://pics4all.jeppix.eu
E-mail:	pics4all@jeppix.eu
Coordinator:	Aura Higuera Rodriguez (TU/e) ahiguera@tue.nl

Partners:

The PICs4All consortium consists of nine academic research institutes with a good regional balance throughout Europe, enabling Application Support Centres in Germany, United Kingdom, France, Denmark, Spain, Poland, Italy, Greece, the Netherlands. It also includes the EPIC association located in France and Berenschot in the Netherlands.

Members of the consortium:

Eindhoven University of Technology
University of Cambridge
Universitat Politècnica de València
Politecnico di Milano
Warsaw University of Technology
Technische Universität Berlin
Aarhus University
Telecom ParisTech
National Technical University of Athens
European Photonics Industry Consortium
Berenschot