1. Publishable summary

EURO-FOS: Pan-European Photonics Task Force: Integrating Europe's Expertise on Photonic Subsystems

www.euro-fos.eu
www.eurofoslab.eu

Project Objectives

Towards a coherent European research scene on photonics: EURO-FOS has been creating a powerful Pan-European network on photonic subsystems by clustering European academic systems groups with proven track record in the design, development and evaluation of photonic subsystems applicable to high-capacity broadband optical networks. EURO-FOS has aimed to bridge the gap between research on device-level physics and new architectures from the network-level. EURO-FOS has shared the necessary mechanism for enabling shared access to expensive infrastructure creating synergy and economies of scale in the development and testing of photonics. Moreover, EURO-FOS has strengthened European research by creating a mechanism for partners to access devices developed in complementary European projects on photonic components. EURO-FOS has also focused on complementing European Commission efforts for turning scientific know-how developed in universities into exploitable technology. This has been pursued through the creation of an academic pan-European laboratory with strong industrial links.

Work performed and results achieved until now

A platform stimulating collaboration between researchers: An efficient mechanism was established during the project for facilitating information exchange within the network members and promoting collaborations and joint research on topics of common scientific interest. The project has been organized in four Centres of Excellence (CEs), each one representing a broad research field and comprising specific research topics (RTs) that are being dynamically modified during the course of the project according to the evolution of the research activities and the emerging trends in the area of photonics technology. Members of the network have been brought together exploring each group's research interests and activities and developing consensus on opportunities for collaborations and joint experimental endeavors. EURO-FOS is based on the realization of joint research through the organization of joint experimental activities (JEAs). Each JEA represents a series of small- or large-scale experiments, requiring different expertise, components and testbeds, and being performed at different university labs with the participation of at least two consortium members and possibly of external academic or industrial partners. Within this framework, a number of researchers have participated in mobility actions promoting the integration of expertise and the creation of a cluster of active European researchers in the field of photonics technology. Within Year 4, the structure of the research activities has been as shown in the figure below. Activities have been supported by the implementation of 14 JEAs resulting in highly interdisciplinary and complex research efforts and having an impressive scientific outcome of 270 paper publications/submissions including 20 invited papers and 2 vision papers, release of 56 application notes on specific techniques and procedures, filing of 3 patents and organization of 21 mobility actions involving a large number young researchers that spent a cumulative time approximately 40 weeks at hosting laboratories all over Europe.

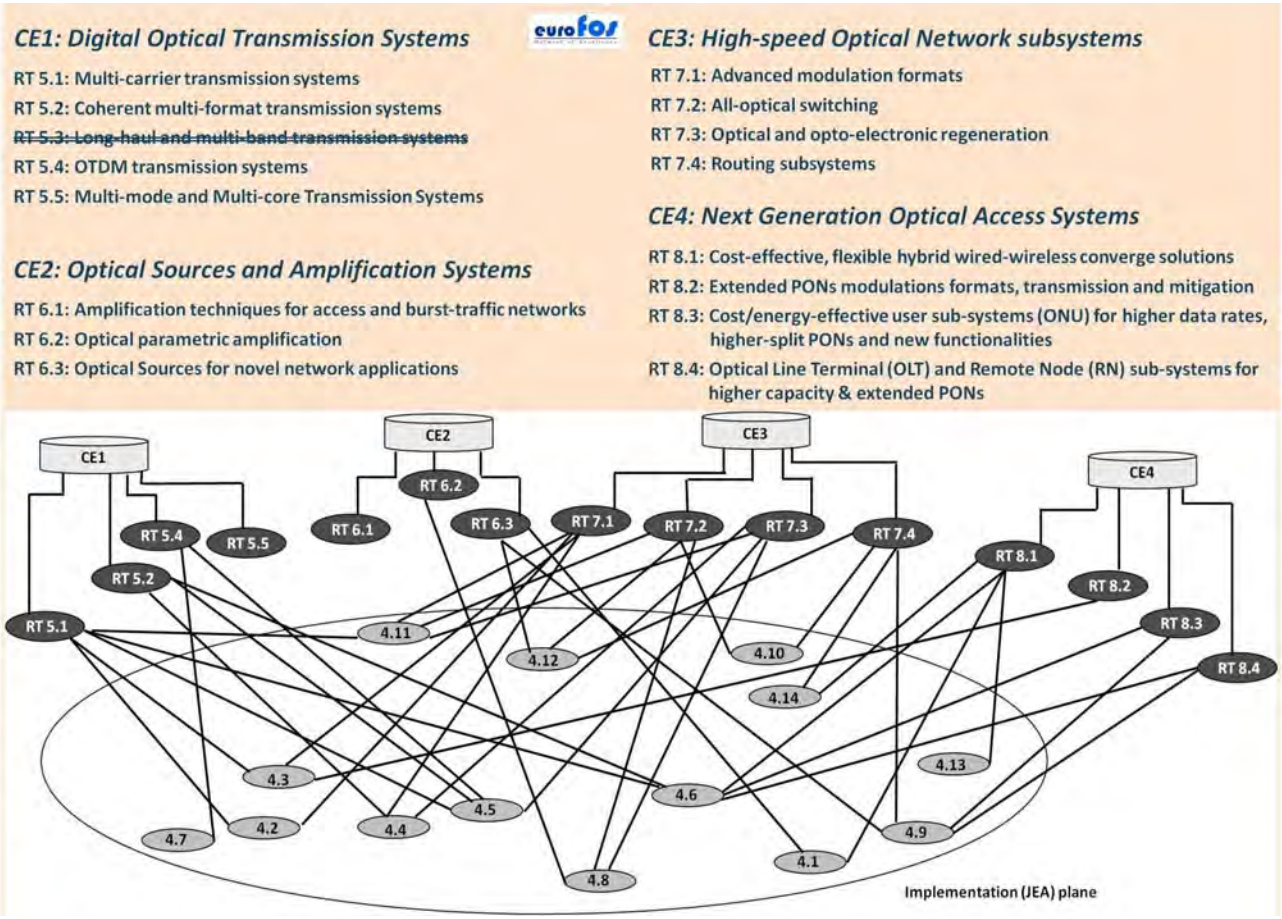

Figure 1: Research structure and implementation of research through JEAs in Year 4 of EURO-FOS.

Towards a coherent European research scene for photonics in communications: Acting as an umbrella, EURO-FOS continued within Year 4 establishing collaboration with EU-funded projects extending the scientific objectives and the experimental exploitation of devices and concepts developed under smaller-scale projects, and identifying common issues faced, new potential research lines and solutions. Examples include the technology projects POLYSYS, GALACTICO, ALPHA, CHRON, ACCORDANCE, PHODIR, DAPHNE and MARISE. Furthermore, EURO-FOS has been in close collaboration with the STRONGEST and GEANT projects that investigate next generation optical transport technologies providing test and measurement facilities for validating these technologies.

Dissemination to the scientific community and the European citizens: Within Year 4, the network has targeted dissemination of the project activities and results through numerous scientific publications, organization and planning of 2 workshops and a booth at ECOC 2011 exhibition. In parallel, efforts have been devoted to disseminating photonic technology to the academic community and the general public through the organization of the second winter school with more than 1000 attendees, the organization of the second "Best Phd student research award", the preparation of articles in technical magazines like the IEEE Photonics Society news magazine, as well as a long series of smaller-scale, "Open Days"-type dissemination events. Raising public awareness on photonics is necessary today more than ever, due to the rapid developments of optical access networks and the deployment of new FTTx solutions.

The Pan-European Laboratory: The Pan-European Laboratory (www.eurofoslab.eu) aims at pooling all resources available in academia throughout Europe, for creating economies of scale and synergy in available photonic components, system testbeds, transmission laboratories, access to deployed fiber and advanced test & measurement equipment. During the fourth year of network operation, the web-based tools of the laboratory (equipment inventory, JEA planner and scheduler) have been continuously updated and optimized enabling the functional role of eurofoslab in the planning, scheduling and reporting on the

joint experimental activities of the project participants. The total number of registered resources is 839 at the end of the project including test & measurement equipment, photonic, electronic and optoelectronic components, subsystems, complete systems and testbeds, deployed fiber links and software platforms.

Collaborating with Industry: EURO-FOS network has the support of 29 industrial partners that are affiliated to the project and closely monitor and collaborate with the network members. The industrial advisory board (IAB) consisting of 6 representatives from the industrial affiliates has been in Year 4 the point of reference for interaction between the consortium and the European industry and has enabled the acquisition of feedback on the research lines of EURO-FOS and the roadmap of eurofoslab for sustaining the basic of its structure after the end of the project life-time. Furthermore, collaboration between project partners and industrial affiliates resulted in 67 joint publications.

Stimulating joint research outside EURO-FOS: EURO-FOS project is an open platform in the sense that joint activities are not restricted within the consortium. External academic or industrial research groups collaborate with EURO-FOS members and perform joint experimental activities exploiting the management mechanisms developed within the project. Collaboration with European, US, Chinese, and Japanese groups were reported during the fourth year, too. As part of this interaction with non-European consortia and the efforts for bringing together researchers from these consortia to share their views, resulted in the participation of a EURO-FOS delegation in a joint EU/Japan workshop in Tokyo in January 2012.

CE1 Digital Optical Transmission Systems: In Year 4 highlights of the activities within CE1 include advancements of the state-of-the-art by HHI in the field of 4D modulation formats, large scale experiments using OFDM and Nyquist WDM superchannels by DTU, POLITO and AIT, theorectical analysis, numerical studies and experimental validation of models for the the mitigation of nonlinear transmission impairments in coherent transmission systems by ACREO, POLITO, IT, Chalmers, TNI and HHI, the generation, transmission and coherent detection of 640 Gbaud RZ-16-QAM, polarization-multiplexed OTDM signals by HHI and DTU and the introduction and experimental validation of an all-optical concept for TDM-to-DWDM and DWDM-to-OTDM conversion by DTU.

CE2: Optical Sources and Amplification Systems: Similarly, in Year 4 highlights of the activities within CE2 include the collaboration of a large number of partners on investigations of optimum configurations for the parametric amplifiers including signal/pump placement, minimization of noise transfer between pump, signal and idler, and optimization of amplifier parameters for simultaneous maximum gain and extinction ratio (by Chalmers, DTU, TNI and HHI), the development of high-quality mode-locked lasers as multi-wavelength comb sources in integrated WDM-PON and millimeter-wave radio architectures (by UPVLC, SSSUP and DTU), and the study and development of low-chrip, multi-wavelength sources based on electro-optic modulation with excellent perspectives for use in WDM-PONs (by Inst. TELECOM in collaboration with Orange Lab).

CE3: High-Speed Optical Network Subsystems: Partners participating in CE3 achieved in Year 4 to demonstrate state-of-the-art, real-time Nyquist transmitters for short and long-reach transmission systems (by KIT, POLITO), to demonstrate diverse methods employing micro-rings resonators in schemes for modulation format generation and manipulation (by DTU), to develop a novel D clocked type flip-flop (by IT and ICCS/NTUA), to investigate the use of carbon-based nanomaterials for switching applications (by UPVLC and SSSUP). Moreover, they achieved to prepare a comprehensive set of publications describing best approached to optical parametric amplification (DTU, Chalmers, TNI and HHI), to demonstrate an OCDMA-based packet forwarding/switching optical node (by Institut TELECOM, ICCS/NTUA), and finally to set-up a large-scale experimental activity that demonstrated part of the operation of an all-optical router combining devices/concepts that had been developed within CE3 over the first 3 years of the network.

CE4: Next Generation Optical Access Subsystems: Highlights of CE4 activities within Year 4 include the demonstration by UPVLC, DTU and SSSUP of a novel concept for high-capacity wireless links based on multi-band OFDM employing optical comb generation, the investigations by UPVLC, UEssex and IT on the transmission of multi-standard OFDM-based signals in coexistence with legacy baseband data signals in PONs, the set up of a digital Nyquist transmitter for access networks by POLITO, the development of a simple intradyne PSK system for udWDM-PON systems by UPC, Inst. TELECOM, IT, IMEC, KIT and AIT, the

realization by IMEC and the testing by IMEC, UPC, ICCS/NTUA and TNI of a 10 Gb/s burst-mode receiver (BM-Rx) with record characteristics in terms of sensitivity and settling time and the demonstration of novel schemes of combined remote pumping from OLT and ONUs by UPC, IMEC and Orange.

Expected results and impact

Photonics has revolutionized the world of communications the past decades. Since the invention of the laser, photonic technology and optical fiber communications enabled the development of ultra-high capacity broadband networks and ultimately shaped the Internet as it is today. Optical fiber cables made the interconnection of countries, cities and more recently individual homes a reality. Lightweight and smaller than a human hair, optical fibers were and will remain the ultimate enabling technology for delivering exciting new applications of voice, video and data.

Reinforcing research on photonics: Research on photonics in telecommunications is more active than ever with researchers now focusing on the development of new, faster, greener and cheaper photonic components and systems for the design and deployment of next generation Terabit capacity core and Gigabit-speed access networks. EURO-FOS has already had and is expected to further have in the longer-term a high impact on Europe's research through integration of people and clustering of research groups under the guidance of European industry. The creation of a unified and coherent European network of researchers with excellence in this field ensures that Europe will continue to excel in this crucial part of the photonic systems development chain.

Stimulating innovation with industry: The pan-European research lab created within EURO-FOS has diverse R&D capabilities, highly-skilled scientific personnel and state-of-the-art testing facilities. It has been a significant factor for enabling the network members to perform complex and forward-looking experiments. The structure of the pan-European research lab will be sustained and is expected to assist Europe's industry in performing innovative research and evaluate their technology in an environment with advanced equipment and using accurate testing methods defined by researchers of the project.

EURO-FOS has been a Network of 17 European academic research groups that are active in the design and development of new photonic systems that find application in telecommunication networks.
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