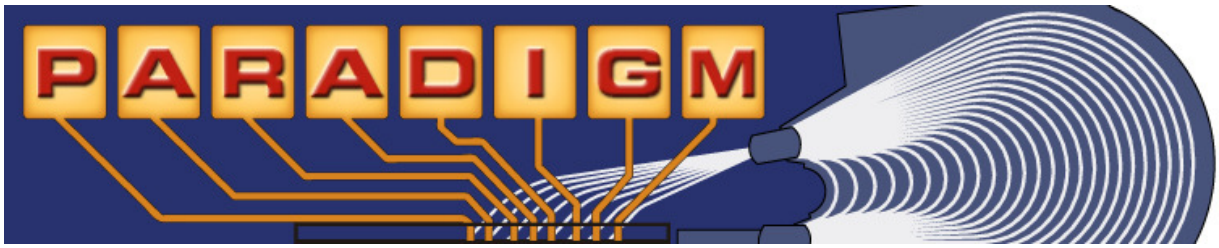


PARADIGM: Photonic Advanced Research And Development for Integrated Generic Manufacturing

***The PARADIGM project* aims to establish, and facilitate access to, cost-effective Photonic Integrated Circuit (PIC) manufacture in Europe**

Background: PARADIGM is an *integrating project* focusing on platform technology. It aims to create a paradigm shift in the development and manufacturing of photonics. It will develop an open-access industrial generic foundry production capability for integrated components based on Indium Phosphide (InP). The project has brought together a strong cross-European consortium of experts, consisting of a mix of SMEs, industry and academic partners in the fields of component manufacturing, PIC design and applications, photonic CAD, and packaging. It has a total budget of in excess of 13M€, with €8.75 million funding from the European Community's Seventh Framework Programme to effect a fundamental change in the way applications based on InP-based photonic integrated circuits are designed and manufactured in Europe.

Objectives: PARADIGM will create the foundations for a powerful, cost effective and versatile foundry platform in Europe. This will lead to a dramatic reduction of fabrication, packaging and testing costs as well as the development time of Application Specific Photonic ICs (ASPICs) and thereby pave the way for the breakthrough of the large-scale application of photonics in our daily lives. The project will integrate the various elements of the required foundry processes at different locations, create design rules, libraries, building blocks, packaging, test and validation mechanisms and promote the adoption of the developed standards. PARADIGM targets the following objectives:

- **Technology convergence and roadmapping:** Two highly capable, stable and convergent technology platforms will be created, covering the major part of today's and future application areas. Platforms I and II will address a wide range of applications operating in the 1.3-1.65µm wavelength range, including fibre optic sensors, medical applications and signal processing as well as telecommunications and data communications systems. A platform-level extension to longer wavelengths (Platform III) focuses on sensing and medical applications requiring longer wavelengths (out to 2.3µm).
- **Create methods and tools:** New working methods and tools will be developed to decouple the design work from the fabrication technology and to bring the design of photonic integrated components to a higher (circuit) level of abstraction.
- **Set up generic packaging and test:** A generic packaging approach will be created by standardizing the positions of optical and electrical ports, which allows packaging of a variety of different chips in a single standardized package,. Standardized in-line test methods to control the quality of the fabrication platforms and off-line test methods to characterize and prove the performance of the products that will be developed.

- **Platform exploitation:** The project will provide access to the created generic platforms for the project's Applications Group by offering several multi project fabrication runs. Interaction with external users of the technology will help to bring PARADIGM into the public domain, expanding awareness of the potential of ASPICs and enlarging the potential application areas of photonics.

PARADIGM Extension programme

An extension programme won under ICT call 7 has allowed the introduction of Warsaw University of Technology, Poland, as an additional partner with effect of 1st September 2011; strengthening the consortium and broadening its impact in Eastern Europe countries. The main objective of the new partner is to extend the outreach of the PARADIGM project to Eastern Europe by establishing a Design Hub, that will offer state-of-the-art expertise in design, development and characterization of ASPICs to large companies, SMEs and research institutes from the Eastern part of Europe. It will also provide a centre for the dissemination of the knowledge of the potential of ASPICs among the Eastern Europe members (Poland, Lithuania, Ukraine, Slovakia, Czech Republic, etc.).

Expected Results

PARADIGM is working towards, development, characterization and validation of generic platform capability embracing:

- 40GHz TxRx platform with extended functionality (polarization handling, modular gain blocks, SSC-array for I/O).
- Extension of platform capability to new wavelength ranges (possibly out to 2.3µm)
- Use of a high isolation processes (e.g. SI substrates and ion implantation processes) for low parasitics and high integration levels.
- Extension to selective area growth (SAG) techniques for multi-wavelength circuits, and investigation of mixed BH and surface ridge technology.

This will involve the development of supporting technology in many areas

- Development of a full photonic circuit simulator including layout tools.
- Development of a design library at the component level, as well as the full range of building blocks provided by the new extended platforms
- Attention to RF-design aspects
- Attention to cross-talk issues
- Design rule checking
- Development of a generic packaging approach and prototype generic package(s) for a) low (optical) port count, b) close packed array I/O.
- Development of Generic Test algorithms and experimental setups for rapid testing and wafer validation. Standardised I/O and test layout (see generic testing)

More generally, PARADIGM plans to fully involve the university sector in spinning out design expertise, and the move to create local design centres e.g. in the new EU member states is one example. This will involve setting up photonic IC design and technology courses and educating users about application opportunities. The brokering organization (JePPIX[1]) also needs to be expanded for facilitating user access, for example by setting up an organization with national contact points, for informing and supporting users and organizing training.

[1] *Joint European Platform for InP-based Photonic Integrated Components and Circuits*

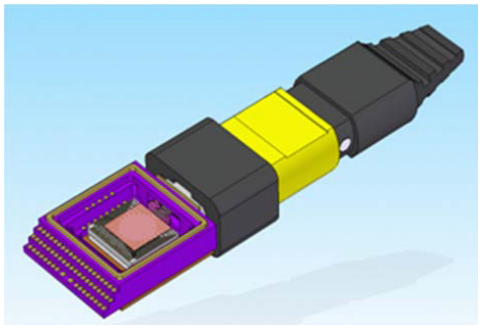
Achievements so far

The first phase of the programme has progress on two distinct fronts. The first has been to set up the project infrastructure needed to utilise platform technology. An applications group has been set up, which through suitable NDA arrangements, has allowed the consortium to collaborate with external users and designers, leading to the first trials of the generic process line using new photonic integrated circuit designs with real applications from users external to the project. An important concept for cost reduction is that of multi-project wafers, shared between several designers. In the end 18 designs in total were completed, with 11 of these from groups external to the programme. Many of these designs are state of-the-art on InP in terms of their complexity.

The first PARADIGM Multi-project wafer run has completed its design cycle and is about to commence in the wafer fab of Oclaro. The designs have used a platform design environment which in PARADIGM's first year has been extended to include more simulation information for both frequency and time-domain modelling, new building blocks from the chip foundries have been introduced into the design environment and additional packaging templates for use by designers. In addition a broad set of design rules from the documentation are now implemented in the mask layout part of the design environment (as automatic design rule checking routines) and where appropriate also in the simulation / design layers of the design environment.

The RF performance is one of the focus points of PARADIGM and within the design environment a start has been made with the design and simulation of RF building blocks for both chip platforms, to support designers in the later MPW's with well defined building blocks for RF also.

The second front concerns the initiation of new technology tasks which, during later periods of the project, will lead to the introduction of superior technology throughout many aspects of the process chain. Generic packaging concepts are a very important aspect of this and some of the PARADIGM ideas are outlined below.



PICOSA package with PIC and optical connector (optical sub assembly)

A new generic package has been designed based on current standards and with the potential for IEC adoption. This new PICOSA (PIC Optical Sub Assembly), measuring just 15.5 x 18 x 5mm, with an internal active device cavity ~9.5mm square will support up to 10 x 10Gb/s RF lines along with at least 36 DC connections and a high current TEC connection. The package has been designed in conjunction with one of the largest manufacturers of this style of package to ensure the highest performance, best price and manufacturability. All of these factors should help minimise cycle times for new products with the best cost.

Potential Impact of PARADIGM

- **Reinforce European leadership and industrial competitiveness:** As a result of the pioneering work within the ePIXnet[2] NoE Europe has a lead in the elaboration of the new generic platform paradigm for InP Photonics.
- **Provide opportunity for new applications and new products:** By reducing the production costs by more than an order of magnitude, PICs will get a competitive advantage over hybrid or micro-optic solutions, or solutions based on discrete components. Superior cost-effectiveness will create a business case for a wide range of products where the production costs are presently too high to address a sufficiently large market.
- **Establish an integrated production path from design to volume manufacturing:** The key to a generic process is the availability of design tools for circuit design and layout which are fully integrated with mask layout tools and fab processing technology. By adding a generic packaging capability (with compatibility ensured by standardised design rules) integrated with the chip process, PARADIGM will for the first time put together a truly integrated end-to end process methodology for ASPIC production
- **Provide cost-effective access:** Users will be able to develop circuits in a "frozen" technology release, and those willing to make the shift will experience the new freedom that it brings; designing complex circuits with sophisticated design tools and a powerful component library in a high performance technology. These developments will make it possible for the first time to provide cost-effective access for fabless companies and through the mechanism of shared MPW runs, costs per user can be driven even lower.

General facts and figures

The website address for the project is http://PARADIGM.jeppix.eu Partners in the PARADIGM consortium are:

Technical University of Eindhoven (Co-ordinator), Willow Photonics Ltd, UK, CIP Technologies, UK, Oclaro Technology, ltd., UK, Fraunhofer Institute for Telecommunications,Heinrich Hertz Institute, Germany, Fraunhofer Institute for Telecommunications,IZM, Germany, Chalmers Tekniska Hoegskola AB, Sweden, Filarete, Italy, PhoeniX Software, Netherlands, Gooch and Housego (Torquay) Ltd UK, Photon Design Ltd, UK, Alcatel-Thales III-V Lab, France, University of Cambridge, UK, Linkra srl, (Italy), Politecnico di Milano, Italy, Politechnika Warszawska, Poland, Bright Photonics, Netherlands.

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[2] The "*European Network of Excellence on Photonic Integrated Components and Circuits*" is a European FP6 research project.