LIGHTWAVE

Berlin works towards broadband access for everyone

by Wolf von Reden, Bernd Weidner, and Bernd Ludwig

The optical networking industry is flourishing in Berlin and the surrounding federal state of Brandenburg, where some 270 companies provide 8,400 jobs and have in total an annual turnover of about &euro2 billion. The area's scientific and research facilities involved in fibre optics employ another 3,500 people.

Many of the area's optical networking enterprises are experiencing annual growth of about 10%, which is expected to continue through at least 2010.

Berlin is the home to one of the world's leading institutions in the field of optical data communication, the Heinrich Hertz-Institute (HHI)-part of the renowned Fraunhofer Gesellschaft-as well as global players such as Siemens, OSRAM, and ADC Krone that are also involved in the data communication business. There are also many medium and small-sized companies including Rhode & Schwarz and ADVA Optical Networking. And while Infineon closed its Berlin branch at the end of 2005, a part of its technical know-how has remained with former employees who founded their own start-up companies.

Some of these emerging companies chose to be in the creative environment of the Berlin Adlershof Science and Technology Park (STP). These companies are part of a cluster of more than 400 technology-oriented businesses and 18 scientific institutes, like those of the Humboldt University.

Approximately 100 companies within Berlin Adlershof are active in the field of photonics/optical technologies/microsystems-some 15 of them in optical data communication. The STP features the 17,000-m² Centre for Photonics and Optical Technologies, which was finished in 1998, supported by EU money. WISTA-Management GmbH, the development company of the STP, has helped double the number of companies within the last 10 years by attracting technology-oriented companies with new technology centres and incubators for start-ups.

Meeting bandwidth demand

Although optical communications technology is already used in a host of applications, the industry is still at the beginning of a revolution that will see optical communication become omnipresent. In the next few years, broadband networking of home and office by optical communications will be needed to support

data rates between 100 Mbit/s and 10 Gbit/s. Inter-machine and intra-machine communications will need data rates in the terabit range.

Consequently, Berlin is on the way to delivering open access to these rates by introducing low-cost technology. The research, development, and mass production of this technology will be situated in the region, so the creation of the value chain will stay in Berlin. A cluster project, *Berlin Access*, was initiated by six medium-sized enterprises (AVM Computersysteme, Berliner Glas, FOC, VPIsystems, MergeOptics, and Elbau GmbH) and the HHI. The idea was to develop low-cost broadband, fibre-to-the-home (FTTH) access that would be affordable for anyone. The project included a basic concept and the development of technologies and prototypes of passive and active optical components for an optical network. Above all, a network provider should test the components for their technical and economic aspects.

In 2005, the German capitol set up a master plan supporting optical technologies with the following main targets for the region:

- Public funding of lighthouse projects of national and international importance that may bring economic effects for the region. Projects have included “Terabitoptics” and Berlin Access. The goal was to build the complete value-creation chain-from basic research to mass production of the individual components-in Berlin and Brandenburg.
- Cofinancing of spin-offs and start-ups in related fields at existing centres of excellence, such as Berlin Adlershof.

This master plan was coordinated by Optec-Berlin-Brandenburg (OpTecBB), a regional cluster of competencies. As a registered nonprofit association, OpTecBB, headquartered in Berlin Adlershof like many of its members, is part of the nationwide strategy to develop optical technologies so that research and industry can contribute internationally to important areas of optics and photonics.

OpTecBB was founded in 2000 by 14 companies and scientific institutes. Its members search for common ways to develop and use optical technologies and network the potential of optical technologies, support the technology and knowledge transfer in the Berlin-Brandenburg region, and make lasting contributions towards strengthening the innovation potential of the regional economy. OpTecBB now has more than 90 members, including large companies such as OSRAM GmbH, Siemens AG, and ADC Krone, as well as high-performance small and medium enterprises like Berliner Glas GmbH, the biggest part of the German nationwide network OptecNet Deutschland. Company-driven to a large extent, OpTecBB has become a platform for regional cooperation, international contacts, and joint marketing activities, especially in optical communications.

New technologies for FTTH

The efforts of the STP and OpTecBB have already begun to bear fruit. One example is the work to develop a polymer-waveguide-based optical transceiver as a core component in the Berlin Access project.[1]

Integration and miniaturisation offer a path to low-cost, highly reliable, and modularised products. However, optical integration has not progressed as fast as electronic integration. One of the main reasons is that for integrated optics it is hard to use only one material system to fabricate cost-effective devices that offer both a wide range of functions and optimised performance for each building block.

Currently, optical splitters, arrayed-waveguide gratings, and optical switches are the predominant applications of silica-based integrated optical technology. On the other hand, polymer waveguide devices are attractive because they offer the potential of fairly simple and low-cost fabrication involving low-temperature processes and low-cost packaging based on passive alignment.[1-3]

Polymer waveguide devices can be integrated with other functional devices such as switches, detectors, laser diodes, etc. Using hybrid integration, one can choose discrete elements that are made of a suitable material system by a suitable fabrication technique. Therefore, the hybrid integration enables full functionality and high yield, and offers the benefits of high performance, compactness, and cost reduction by reduced packaging expenditures.

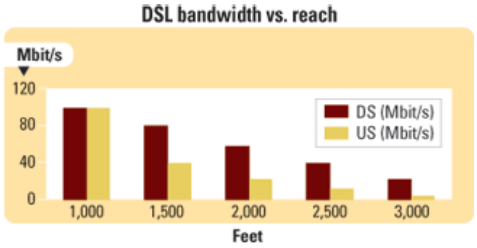
As an example, an optical transceiver for FTTH integrating polymer waveguides with laser diodes and photodiodes has been designed. For improving the coupling between laser diode and waveguide, as well as reducing the chip size, a refractive index contrast of $\Delta n = 0.020$ was chosen. Polymer waveguide transmission loss is <0.5 dB/cm at 1,550-nm wavelength.

Unlike current products, the optical subassembly (OSA) of the FTTH transceiver is an integrated optical circuit based on a polymer planar lightwave circuit (PLC), as depicted in the figure.

The polymer waveguide directional coupler is used as a demultiplexer for separating the downstream and upstream channel at 1,490 nm and 1,310 nm, respectively. The coupler is very compact; the length of the central coupling region is only about 1.4 mm. The coupler provides more than 25 dB isolation.

For the sake of low manufacturing costs, the optical fibre carrying the down- and upstream signals is butt-joint coupled to the polymer-based transceiver. Passive alignment and fixture is provided by self-aligned U-grooves of 3-mm length together with a lid glued on top. The passive alignment of fibre-chip coupling is regarded as a requirement for low-cost packaging.

To facilitate light coupling to and from the laser diodes and photodiodes, respectively, optoelectronic chips with surface emission/reception are considered a favourable choice.



Click here to enlarge image

Through the use of polymer technology and hybrid integration, the FTTH transceiver provides good performance in a small package. It has been designed for automated manufacturing.

The assembly of the active diodes is a critical issue in hybrid optoelectronic ICs designed for low-cost mass products. In most of the current modules these diodes have to be assembled in canned versions. The PLC-based hybrid OSA version is geared towards manufacturing with a high degree of automation using bare chips. While optimum yield management is an inherent advantage of hybrid integration, the mounting and alignment steps are often time and labour consuming. Today the industry offers equipment with image recording and analysis, which permits automatic actively controlled placement of optoelectronic chips on the PLC motherboard with a precision of around 1 µm and turnaround times of only a few minutes per OSA. This assembly technology has matured to a level where it is, in many cases, superior to flip-chip assembly employing mechanical studs.

Polymer waveguide devices can be hybrid integrated with active devices to form different optical modules. As examples, a polymer-based spectrometer and an optical transceiver have been described. The concept of these devices is an optical polymer PLC motherboard relying on a surface-mount technology and automatically placed and aligned optoelectronic chips, and a simplified passive fibre-PLC coupling

scheme. This concept provides a solution for added functionalities like access link monitoring (OTDR, for example) and advanced FTTH approaches like CWDM or colourless ONU.

Wolf von Reden is responsible for public services at the Heinrich Hertz-Institute (www.hhi.fraunhofer.de), FHG Berlin. **Bernd Weidner** is chief executive officer of OpTecBB e.V. (www.optecbb.de). **Bernd Ludwig** heads the Centre for Photonics and Optical Technologies at the Berlin Adlershof (www.adlershof.de). He also works with WISTA-Management GmbH (www.wista.de).

References

1. N. Keil, et al., “Polymer as Integration Platform for Low-cost Devices in Future Optical Networks”, Proc. NOC 2006.

2. S. Lehmacher, A. Neyer, “Integration of Polymer Optical Waveguides into Printed Circuit Boards”, Electron. Lett., Vol. 36, pp. 1052-1057, 2005.

3. A. Rogner, H. Pannhoff, “Mass Fabrication of Passive Polymer Multimode and Single-mode Waveguide Devices”, OFC 1994, Paper FB1, pp. 279-280.

4. J.T. Kim, C.-G. Choi, “Simultaneous Optical and Electrical Interconnection of Polymer PLC Device by Using a Hot Embossing Process”, ECOC 2004, Paper Th1.4.2, pp. 806-807.

Lightwave Europe September, 2007
Author(s) : Wolf von Reden Bernd Weidner Bernd Ludwig