Digital Optics Corporation

IMOS Technology Improves Scalability and Lowers Cost

Founded in 1991, Digital Optics Corporation began as a micro-optics developer and is now a leading supplier of diffractive and micro-optical components. In the late 1990s, Digital Optics recognized that the labor-intensive integration and packaging of its components in the optoelectronic industry was driving customer costs higher and was leading manufacturers to seek inexpensive, overseas labor to produce these components. In 1998, Digital Optics identified an innovative technology that had the potential to change the telecommunications, data storage, and scanner industries in many of the ways that the integrated circuit has changed computer electronics since 1959. The technology, called integrated micro-optical systems (IMOS), uses many of the same processes of reflective manufacturing to make miniature optoelectronic systems.

Potential benefits from Digital Optics's IMOS technology were threefold: it would decrease costs, reduce component size and reduce the need for offshore labor production of the components. Digital Optics would develop an infrastructure that could easily transition to the prototyping and pilot production of IMOS; but first, the company would need sufficient resources from an investor that would assume the high risk factor. To complete the early infrastructure development of IMOS, in 1998 Digital Optics applied for and was awarded cost-shared funding from the Advanced Technology Program's (ATP) Focused Program for Photonics Manufacturing. After completion of the project in late 2000, Digital Optics successfully brought to market the IMOS technology, branded as the Photonic Chip™, and is now experiencing commercial growth despite a slowing economy and inventory gluts in the telecommunications and data communications industries. The IMOS project broke through industry barriers of size, reliability, and high-volume replication in the optical component market to open new markets of competition and development. Spillovers from these new markets will affect manufacturers and consumers alike in many of the ways that the integrated circuit has affected the microelectronics industry.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* * *

Research and data for Status Report 98-02-0034 were collected during October - December 2001.

Digital Optics Identifies Need to Integrate Micro-optic Components

As the optoelectronic industry flourished during the technological boom of the late 1990s, the need to more efficiently integrate and package optical components increased. Originally operating as a micro-optics firm, Digital Optics identified the future potential of subassemblies and integrated optical components. The company refocused its research and development (R&D) activities to move ahead of the competition in the evolving optoelectronic marketplace.

Historically, discrete components were purchased and integrated into assemblies through labor-intensive processes, which were typically outsourced to developing countries where labor costs were lower than in the United States. To address this market-driven need to decrease both production cost and component size, and to curb the exportation of production, Digital Optics sought to develop the key processes and infrastructure necessary to use wafer-scale integration of these components in integrated micro-optical systems (IMOS).

IMOS Technology Lowers Fabrication Costs

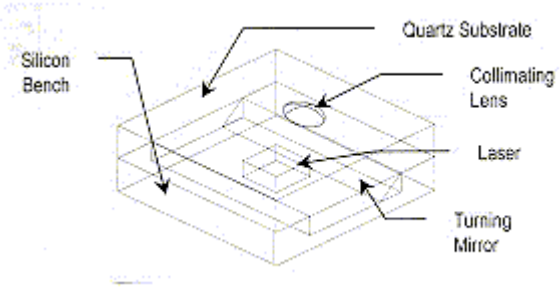
IMOS modules are compact (typically a few millimeters on a side), integrated optoelectronic systems comprising micro-optics, lasers, detectors, and interfacing electronics. IMOS technology does not consist of a single type of component. Rather, it is a new, functional paradigm in which the fabrication, integration, and packaging of micro-optics and electronics are all considered from the very beginning of the design process. Furthermore, IMOS fabrication makes use of wafer-like manufacturing techniques similar to those used in the microelectronics industry for producing integrated circuits. With IMOS, components are aligned and assembled at the wafer level, allowing the production of complex, three-dimensional optical systems on a chip. This integrated approach allows the inexpensive fabrication of miniaturized, high-performance optoelectronic modules and subsystems.

Benefits of IMOS Devices

IMOS takes many elements (e.g., micro-optics, lasers, detectors, and interfacing electronics) and creates an optical system that is a single, discrete unit. These low-cost devices have broad applications, including incorporation into bar code scanners, telecommunications equipment, miniature sensors for the environment, medical sensors, and precision encoders. The IMOS technology has the potential to enter and dominate markets such as compact disk/digital versatile disc (CD/DVD) systems, magneto-optical disk drives, and optical tracking for floppy disks.

Strong Parallels Exist Between IMOS and Integrated Circuits

There are many parallels between the introduction of the integrated circuit in 1959 and the IMOS technology that Digital Optics sought to develop. Whereas integrated circuit technology made it possible to "shrink" large systems of transistors into much smaller elements, the IMOS process "shrinks" an expensive, macroscopic optical system into an inexpensive, compact optical system. Before the invention of the integrated circuit, the production of computers and other electronic systems involved slow hand-assembly



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of discrete components and resulted in low yields. In the optoelectronic industry, laborious assembly of individual components with high failure rates has been the norm. The development of semiconductor manufacturing techniques allowed for the efficient production of high-quality integrated circuits; some of these same manufacturing techniques can be used to manufacture less expensive, high-quality integrated micro-optical systems. Automated design, layout, and production tools for integrated circuits are now commonplace (Digital Optics proposed to develop analogous design, layout, and production tools for photonics).

Digital Optics Identifies High-Risk Optical Integration Opportunity

The marketplace and the investors considered Digital Optics' IMOS technology too risky and cutting edge to support a significant investment. Therefore, the company turned to ATP's Focused Program for Photonics Manufacturing for R&D support for this innovative technology. The ATP funding would serve as a catalyst for U.S. industrial investment into IMOS technology by overcoming the basic technological hurdles and by accelerating the development of a sufficient prototyping and manufacturing foundation from which future applied projects would be viable. Macroeconomic benefits could then be realized from products based on the technology, to include a decrease in labor outsourcing and the potential to revolutionize the optical industry with smaller, faster, and less expensive components.

Development Objectives Defined for IMOS

The ATP-funded project for IMOS development simulated and designed IMOS devices using integrated software modules for optical, mechanical, thermal, and electromagnetic analysis.

The IMOS technology has the potential to enter and dominate markets such as CD/DVD systems, magneto-optical disk drives, and optical tracking for floppy disks.

The development objectives for the IMOS devices were fabrication at the wafer level and then integration and testing. The project focused primarily on infrastructure development while maintaining alignment with photonics industry requirements.

Digital Optics and Its Partners Solve Technological Barriers

At the project's outset, Digital Optics identified several technological barriers to achieving the project's goals. The primary barriers were a lack of systems-level design and fabrication engineering capability; incompatibility across multiple vendors; low yields for both fabrication and assembly processes; and lack of testing mechanisms, particularly at the wafer level, for both components and finished modules.

Digital Optics has identified the $20 billion data storage industry as a potential early adopter of the IMOS technology.

To meet the challenges of these technical barriers, Digital Optics developed integrated design tools, used lithographic techniques to manufacture high-precision diffractive and refractive micro-optics at the wafer level, and integrated and tested optics and optoelectronic components at the wafer level. The final barrier of component testing was solved with the help of two strategic partners (Agilent Technologies, Inc. and MicroE Corporation).

Partners Help Expand Project Scope

Agilent, a market leader in communications and life science innovation, had worked previously with Digital Optics on other research initiatives. Following the ATP award, the scope of the project expanded to include the development of a demonstrator module by Agilent for use in transmitter/receiver communications applications in support of the infrastructure development of IMOS technology. The Digital Optics-Agilent partnership continued after the end of the project and still is a mutually beneficial relationship.

Digital Optics formed a second partnership with a previous customer, MicroE. Similar to the Agilent work, MicroE created a technology demonstrator during the ATP project. Although no product development directly resulted from the partnership with MicroE, the knowledge spillover positively benefited both companies, and their relationship continued beyond the project's completion.

Digital Optics Meets Project Objectives

As a result of the ATP-funded IMOS project, Digital Optics can now quickly produce miniaturized components with higher performance and lower cost than conventional optoelectronic approaches. As an ISO 9001-certified manufacturer, Digital Optics maintains the highest level of quality to meet the market demands of the photonics industry. The modular, wafer-level nature of IMOS manufacturing enables reductions in manufacturing risk, delivery time, and cost through the use of common, modular components.

Photonic Chip™ Completed as a Result of ATP Funding

In early 2001, after the project's completion in October 2000, Digital Optics officially launched the IMOS technology under the brand name Photonic Chip™. The optical subassembly (OSA) of a Photonic Chip™ is based on wafer-fabricated micro-optics. Passive optical functions, such as collimation, focusing, splitting, and reflection, are fabricated with photolithographic techniques. Standard die-bonding equipment then attaches active components such as lasers and detectors. A key benefit of the Photonic Chip™ OSA

integration platform is the ability to accomplish at the wafer level as many of the critical alignment steps and assembly steps as possible. This, in turn, enables high-volume capacity, tight alignment tolerance, and lower cost OSAs.

The Photonic Chip™ developed for the project platform simplifies and enhances optical integration within fiber-optic transmission systems. Potential applications include integrated OSAs for dense wavelength division multiplexing, coarse wavelength division multiplexing, terabit routers, all-optical switches, optical interconnects, and many other telecommunications and data communications applications.

Future of Photonic Chips and Integrated Optical Components

Digital Optics has secured the intellectual property rights to the technologies supporting the Photonic Chip™ technology and brand to ensure a return on its investment. Since the ATP project, Digital Optics has applied for 42 U.S. patents either directly or through licensing agreements with research universities. Before the ATP funding, Digital Optics held or controlled 28 patents. Digital Optics has identified the $20 billion data storage industry as a potential early adopter of the IMOS technology.

The data storage industry is affected by optics in three ways. First, CDs and DVDs are becoming more prevalent as a form of business data storage and commercial entertainment. Second, magneto-optical disk drives have the potential to replace conventional magnetic hard drives. Third, optically tracked floppy disk drives have the potential to replace conventional floppy drives. IMOS can become a key technology in expanding storage density, volumes, and retrieval times in these three large markets. In addition, Digital Optics has targeted the telecommunications and data communications markets, which would profit from the improved scalability and miniaturization aspects of IMOS, as well as the elimination of the excessive manual labor required to produce conventional optoelectronic subassemblies.

Conclusion

The technological boom of the late 1990s generated inflated demands on industries such as optoelectronics. During this time of accelerated growth, Digital Optics, with the support of ATP funding, successfully developed new IMOS technology, which led to its launch of the patented Photonic Chip™. When the telecommunications market contracted in early 2001 and developed a surplus of optical components, the demand for the Digital Optics' Photonic Chip™ decreased. Despite the negative market conditions, Digital Optics continued to grow and outpace its competitors through its new R&D initiatives and aggressive promotion of its products. The potential remains positive for the Photonic Chip™, as well as the IMOS technology that supports it and the infrastructure developed as a result of the ATP funding. Once the markets recover and inventories diminish, IMOS technology will be positioned to serve new customers and lead the next paradigm in optical integration.

PROJECT HIGHLIGHTS
Digital Optics Corporation

Project Title: IMOS Technology Improves Scalability and Lowers Cost (IMOS Infrastructure for Photonics Manufacturing)

Project: To develop an integrated optical infrastructure that can easily be transitioned to prototyping and pilot production of low- and mid-volume optoelectronic devices and can serve as the foundation for efficient production in higher volumes in later years.

Duration: 11/1/1998-10/31/2000
ATP Number: 98-02-0034

Funding (in thousands):

ATP Final Cost	$ 1,700	59%
Participant Final Cost	1,200	41%
Total	$ 2,900	

Accomplishments: This project accomplished the intended goal of developing an infrastructure for the IMOS technology. Additionally, Digital Optics has successfully commercialized the Photonic Chip™. The ATP funding gave Digital Optics the ability to anticipate market trends and to become the leader in integrated optical modules. Digital Optics has applied for 42 patents since the ATP project.

Commercialization Status: Digital Optics has fully commercialized the IMOS technology under the brand name Photonic Chip™. The company continues to refine, redesign, and customize the Photonic Chip™ to meet the needs of various customers, as well as pursuing potential future markets, such as the huge data storage industry and the telecommunications and data communications markets.

Outlook: Digital Optics has weathered the recent contraction in the telecommunications and data communications markets and is well-positioned to ramp-up operations when the market returns to positive growth. Digital Optics's technology is highly regarded in the marketplace and is poised to become the primary production method for integrated OSAs.

Composite Performance Score: * * *

Number of Employees: 35 employees at project start, 130 as of December 2001

Focused Program: Photonics Manufacturing, 1998

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Subcontractors:
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MicroE Corporation

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