Global Trends in Optical Manufacturing

Jeff Ferry

After the telecom bubble burst in 2002, many North American optical companies outsourced production to Asia on a grand scale. A decade later, the global industry is rebalancing itself in interesting ways.

It was around a decade ago that the majority of the production of optical components in North America was largely moved to Asia. Recently, however, some optical companies have begun planning to bring some portion of that manufacturing back to the United States. This should be encouraging news for the U.S. industry and U.S. jobs. However, for many executives, the growth of the industry that began in Asia more than 10 years ago is leading to another significant shift, with the presence of a large manufacturing base in Asia attracting other functions, including research and development (R&D) at both locally and internationally owned companies. If that trend accelerates, it would undoubtedly be good for the Asian industry, but perhaps not for the United States. One interesting change is that China seems to be losing some of its appeal as the world's low-cost center for optical manufacturing.

Few industries have undergone as turbulent a recent history as optical communications. The first Internet bubble—which took place roughly between 1998 and early 2000—led to a massive industry boom, with hundreds of companies entering the industry and revenue and employment skyrocketing as companies struggled to meet demand. The growth was fueled by what turned out to be an illusory boom in worldwide telecommunications networks.

After peaking at $10 billion (USD) in annual revenue in 2000, the total optical components industry revenue fell a staggering 80 percent, to $2.1 billion in 2003, according to data from Ovum. As the industry shrunk and lost money on a grand scale, it struggled to adapt to the new world. One of the major initiatives was to cut costs by moving production to Asia. According to estimates, approximately 66 percent of optical component production took place in North America in the year 2000, with 24 percent occurring in Europe, and only 10 percent in Asia.

By 2010, the situation had completely changed. That year, an estimated 80 percent of optical component production took place in Asia, while Europe accounted for 13 percent. North America comprised just 7 percent of the market. "We moved to the low cost regions out of necessity," recalls Yves Lemaitre, who was then at Avanex and is today the chief commercial officer at Oclaro. "The large established companies were losing far too much money on fixed costs, and the smaller players were bleeding cash and no longer getting access to venture capital money," he said. "They had to conserve cash to spend it on innovation instead of manufacturing infrastructure."

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It is difficult to gather comprehensive data on worldwide or U.S. employment within the industry. Data from the U.S. Bureau of Labor Statistics provide an indication of the decline of the U.S. industry. Total employment in two major segments of the communications industry has fallen some 30 to 50 percent since 1990 (and much more since the peak of the bubble). However, this probably understates the impact on the optical components industry in the United States, which suffered more than the general communications industry.

We can get some sense of the decline of the North American industry by looking at SEC filings by JDS Uniphase, which was, until recently, the industry leader. At its peak, in March 2001, JDSU employed 28,677 people, the majority of them in North America. Over the course of the next two years, JDSU implemented a "global realignment program," which cut its staff numbers by 19,347. Along with other attrition, that resulted in a much-reduced staff count in June 2003 of 5,489—a decline of 81 percent.

JDSU closed a total of 29 sites, including facilities in eight U.S. states, two Canadian provinces and three European countries. At the same time, it moved labor-intensive, high-volume production to a centralized in-house manufacturing facility in Shenzhen, China, in order to reduce costs, slim down the product catalog and achieve profitability. It sold at least six facilities to Fabrinet, a contract manufacturer, which then shifted most of the production to its facilities in Thailand.

By 2011, JDSU had bolted on a large test-and-measurement business and saw its total revenue rise 32 percent, to $1.8 billion. It had achieved profitability, with a net income of $72 million. But the employee number had actually shrunk slightly, to 5,000. JDSU did not reveal employee breakdown by country in its 2011 10-K report. However, Finisar, which recently surpassed JDSU to become number one in the components business (with 2011 revenue of $949 million compared to JDSU's components segment revenue of $771 million), did publish a regional employee breakdown: It disclosed that, of its 8,065 full-time employees in 2011, 712, or 8.8 percent, were located in the United States. The other 91 percent were at production facilities in Malaysia and Shanghai, China.

So, by 2011, the optical components industry was still dominated by companies headquartered in the United States—yet some 90 percent of their employees were located in Asia.

What's next?

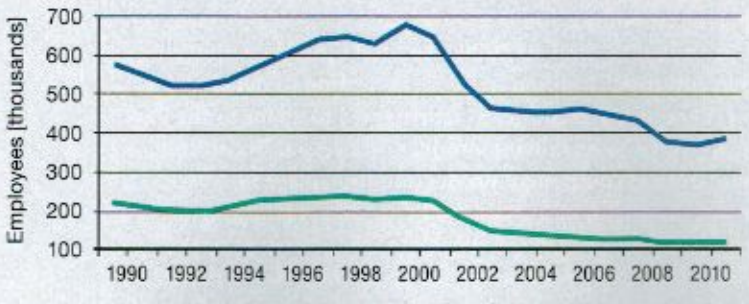
The last couple of years have seen a gradual resurgence of optical components manufacturing in the United States, due to several factors. The first is that strong revenue growth since 2003 (specifically a seven-year compound annual growth rate of 15 percent from 2003 to 2010) has led to the growth of new entrants in the market. New players typically rely on innovative, differentiated products with high levels of intellectual property (IP), and that strengthens the relative competitive advantages of the United States as a manufacturing center.

Companies that have invested in U.S. manufacturing recently include Coadna, Cyoptics, NeoPhontonics (via its Santur acquisition) and Optoplex. Cyoptics' manufacturing is unusual in that it is divided between Pennsylvania and Mexico, with very little presence in Asia. At press time, the company had filed to go public. Citing tight U.S. Securities and Exchange Commission rules on public comments, company representatives were unwilling to discuss its strategy. Its S-1 filing showed that it had $108 million in revenue in 2010, derived primarily from the sale of modules and products, including indium phosphide (InP) and silica-on-silicon photonics lightwave circuits. It has its own fab in Pennsylvania, and its 550 employees are split nearly evenly between the United States and Mexico.

Based in San Jose, Calif., NeoPhotonics has assembled a string of acquisitions with innovative technology. Now it boasts an annual revenue run rate of around $250 million. Like Cyoptics, it is focused on photonic integrated circuit products, both hybrid and monolithic, in InP and silicon, and including modules and subsystems—which it sells to many tier 1 equipment vendors. NeoPhotonics has a fab in San Jose, and it does some small volume manufacturing there. Its large-scale assembly and test, and the vast majority of its 3,112 employees, are located in China. It is expanding its operations in both centers.

"IP matters," says NeoPhotonics CEO Tim Jenks. "Where the IP content is high or the labor content is low, U.S. manufacturing is more competitive." Jenks adds that China has recently become a less competitive manufacturing center due to strong wage inflation there. He cites alternatives, including Singapore, Vietnam and the Philippines. "Six to eight years ago, China was

[U.S. employment: Two proxies for optics industry]



U.S. employment (thousands of employees)

Industry sector	1990	2011	% change
Semiconductors & electronic components	574.0	385.1	-32%
Communications equipment	223.0	117.2	-48%

Source: U.S. Bureau of Labor Statistics

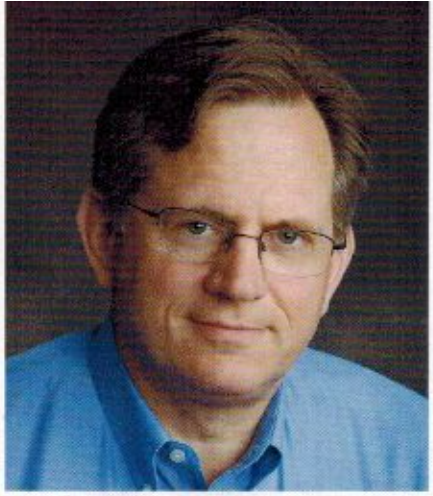
the only choice. Today it's one among many." As a manufacturing center, the United States has two main advantages: its good protection for IP and the strategic and logistical advantages associated with siting product design and manufacturing at the same location.

II-VI Inc. of Saxonburg, Pa., is a vertically integrated producer of laser optic materials and optoelectronic components for industrial, medical, military, security and aerospace applications. A series of acquisitions in the last two years, including Photop, Aegis and MLA, have taken it deeper into the semiconductor and infrared laser business. Its current revenue run rate is some $500 million a year. About 16 percent of its 7,000-strong workforce is located in the United States. Mark West, general manager of II-VI's infrared segment accounting for about 40 percent of the company's revenue, is planning to expand production in 2012/2013 and add jobs in Saxonburg as well as in California, Mississippi and Texas.

While the company has operations in China, its executives have had second thoughts about them due to high inflation, high employee turnover and labor disputes. "I think more high-end optics will remain in the United States," says West. "For lower volume, more complex, more proprietary manufacturing processes, the United States is an excellent place to manufacture, and I believe we'll see some of what went to Asia in recent years come back here."

Oclaro's Lemaitre agrees that China is becoming a less competitive place to manufacture. While Oclaro has, until recently, been shifting more manufacturing into China, Lemaitre foresees many in the industry rebalancing their manufacturing over the next few years into east Asia, and expanding their U.S. operations for products with lower labor content. In addition to wage inflation in China, high staff turnover, stricter labor laws, and the high cost of training offset China's advantages.

After the crisis- and cash-driven move to Asia in the 2002-2006 years, companies are only now beginning to move towards their "ideal" manufacturing



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—Tim Jenks, NeoPhotonics CEO

model, says Lemaitre. "It's actually pretty attractive to manufacture in the United States," he says. "It's efficient because you save on travel, and there is a fantastic skilled labor pool that you can draw on. We will see a rebalancing and we will see some very targeted manufacturing lines coming to the United States."

Interest in U.S. manufacturing received an unexpected boost in 2011 from two natural disasters. First came the tsunami and earthquake in Japan, which did not hit components. It did, however, affect the optical fiber industry, causing delays in the buildout of some U.S. broadband stimulus networks due to the near-impossibility of finding long-haul single-mode optical fiber in the United States in the summer months of 2011. Then came the floods in Thailand, which affected virtually the entire optical food chain.

Since 2002, Fabrinet had done an excellent job of persuading components and systems companies to outsource and concentrate manufacturing at its Thailand facilities. When the floods hit in October 2011, Fabrinet production came to a standstill, affecting many optical companies. JDSU forecasted revenue loss of $25 to $35 million in its fiscal second quarter—representing more than 15 percent of its quarterly revenue—due to lost production in Thailand.

Oclaro forecast a revenue impact of $25 to $30 million for its December quarter—representing more than 25 percent of the quarterly revenue—due to the Thai floods. The disaster in Thailand also limited shipments and revenue at some systems companies. Fabrinet declined to be interviewed for this article, but a notice on its website at press time commented: "The water has been pumped out of our Chokchai facilities …The water levels outside the walls surrounding our Chokchai campus continue to recede but still remain at approximately 30 inches." Early in 2012, dislocation continued as Fabrinet tried to move Chokchai production to its other facilities.

"After Japan and Thailand, people want to 'de-risk'," says Lemaitre. "We will balance more between North America, Europe, and various parts of Asia. You could see as much as 20 percent of capacity move back to the United States as part of the 'de-risking' process."

Progress in Asia

At the same time that U.S.-based component companies are thinking about diversifying their manufacturing centers, Asian component companies and Asian governments are focused on deepening their own technology base. Several component company executives said that Asian companies, especially those in China and Singapore, are already trying to broaden their skill sets to generate more value at home. This will supplement their manufacturing capabilities with capacities in new product introduction (NPI) and R&D.

The ultimate goal is to develop an entirely self-sufficient optical industry. NPI refers to the process of customizing products to suit individual customer needs. It is an important part of the business—and one that is a stepping stone towards fundamental product design. One longtime veteran of AT&T/Lucent who preferred not to be named commented that NPI is the current target of Chinese-based manufacturers. "NPI is the goal of the next generation of contract manufacturers who want to help with

design in any way they can. This development will only help weaken the U.S. innovation engine, since NPI and manufacturing are two (out of three) crucial steps of the ecosystem," he said.

Another executive at a large components company commented that the government of Singapore is highly focused on developing optical R&D capabilities inside Singapore, which already has a significant optical R&D base, although typically not at the leading edge of design and capability. "Singapore officials come to me and say: If you increase the technology level of the R&D you are doing, we'll give you 50 percent of your cost and pay for tools and equipment." According to this executive, initiatives like this in Singapore, and other Asian countries such as China, raise questions about the future role of the U.S. industry.

"If R&D moves [out of the United States], then industry leadership moves, and the United States could lose a huge competitive advantage—not immediately but over the years to come," he says. In his view, this is a political decision by the Singapore government. "Singapore doesn't need to do this; they don't have very high unemployment," he says. "They are doing this because they believe high technology is important to their future." He questions whether the U.S. government places the same value on technology.

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—Yves Lemaitre, Oclaro Chief Commercial Officer

"In China, we've seen strong government actions over the past 10 years to support the growth of the industry at the systems and the component level," comments NeoPhotonics' Jenks. "And we have to acknowledge that it has been quite successful. By going to Asia a decade ago, the U.S. industry has sown the seeds of innovation there."

Alan Willner of the University of Southern California, one of the foremost academics in U.S. optics, has also been impressed by China's focus on optics. After several visits to China in recent years, he observes that Chinese universities are focusing on building their optical capabilities by luring outstanding researchers from the United States—with offers of very good salaries, labs with up to $1 million worth of equipment, and shared laboratory facilities to create productive cooperation.

"China is focused on becoming a powerhouse," he says. "They are strongly encouraging people to publish in the most prestigious journals." Willner serves as editor-in-chief of *Optics Letters*, which has four topical editors in China. "I see many top papers coming from there today," he says. "Given the progress of optics programs around the world, we could perhaps reach a tipping point in the future when the best Chinese students will want to attend only the most top-ranked graduate programs in U.S. universities."

Willner points out that China is not the only country whose government deems optics a strategic industry. Australia, Canada, Germany and Korea

[2010 world patent leaders]

Rank	Applicant's name	Country	Patent filings
1	Panasonic Corp.	Japan	2,154
2	ZTE Co	China	1,863
3	Qualcomm Inc.	U.S.	1,677
4	Huawei Technologies Co. Ltd.	China	1,528
5	Koninklijke Philips Electronics	Netherlands	1,435
6	Robert Bosch GMBH	Germany	1,301
7	LG Electronics Inc.	Korea	1,298
8	Sharp Kabushiki Kaisha	Japan	1,285
9	Telefonaktiebolaget LM Ericsson	Sweden	1,149
10	NEC Corp.	Japan	1,106
11	Toyota Jidosha Kabushiki Kaisha	Japan	1,095
12	Siemens Aktiengesellschaft	Germany	833
13	BASF SE	Germany	818
14	Mitsubishi Electric Corp.	Japan	726
15	Nokia Corp.	Finland	632
16	Innovative Properties Co.	U.S.	586
17	Samsung Electronics Co., Ltd.	Korea	578
18	Hewlett-Packard Development Co.	U.S.	564
19	Fujitsu Ltd.	Japan	476
20	Microsoft Corp.	U.S.	469

Source: World Intellectual Property Organization

[2010 optical communications patent leaders]

Rank	Country	Patents
1	United States	327
2	Japan	198
3	Germany	31
4	Canada	29
5	South Korea	28
6	United Kingdom	21
7	France	14
8	China, People's Republic of	13
9	Italy	10
10	Israel	10
11	Taiwan	10
12	Netherlands	4
13	Sweden	3
14	Australia	3
15	Singapore	2
16	Finland	1
17	China, Hong Kong S.A.R.	1
18	Switzerland	1
19	Denmark	0
20	Russian Federation	0

Source: U.S. Patent and Trademark Office

—among others—have also prioritized the industry. However, the United States—the place where the laser was invented and first demonstrated—has so far taken a different approach. "With exceptions, the U.S. government tends not to provide long-term, large funding commitments in specific strategic areas," he says. "However, optics in the U.S. could benefit mightily from such a strategy."

He adds: "Although we like to boast that we are still the capital of innovation, the United States keeps losing manufacturing jobs to overseas countries. I wonder: Will we still be a worldwide hub of innovation in the long-term future?"

Patent data already bears out some of Willner's concerns. The World Intellectual Property Organization is a Geneva-based organization that registers international patents. In its rankings for 2010 for patents across all industries, two telecom equipment companies ranked in the top five—ZTE and Huawei. International telecom companies, such as LG, Ericsson and NEC, scored in the top 20. Alcatel-Lucent, the current owner of Bell Labs, came in at number 49.

One would expect U.S.-based companies to score better in U.S. government patent tables—and they do. The U.S. data enables us to analyze patents by the lead author's country of origin. In the category of optical communications, the United States is still the leader by far, with 327 patents in 2010. But China has risen strongly from zero patents in 2006 to the eighth-ranked country, with 13 patents in 2010.

Culture and politics

One executive says there is a cultural issue standing in the way of a larger resurgence of optical manufacturing in the United States. "We have plenty of people in California with great dexterity and a great work ethic who want to work," he says. "What we need is strong management with less self-imposed limitations." He claims that management teams are too worried about legal issues. "With the right management attitude, you would have more highly

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profitable manufacturing operations in the United States today."

A key aspect of this culture is the recognition that manufacturing is a critical part of the technology industry. "It's an iterative loop," he explains. "You can have the brightest R&D engineer, and he will not design the optimal product without a manufacturing team telling him what's manufacturable. When you move manufacturing offshore, you break that loop."

"Today there is living proof of a few small- and medium-sized optical companies doing a much better manufacturing job in Silicon Valley than their counterparts who took their manufacturing to China many years ago," he continues. "European companies have recently got smarter and begun to look to Africa for low-cost labor and much better control over their IP while keeping the innovation loop intact, thanks to the close proximity, often with no time zone difference."

Some executives in the components industry see the industry's future as a political question. Yves Lemaitre points out that the one area of production that has not moved to China is laser chips. China and other Asian technology leaders are well aware of the strategic nature of semiconductor laser fabrication and are targeting that capability. "The laser is a crown jewel of Western technology, and we have to think long and hard before we let it go to Asia," comments Lemaitre. "I hope this is something that people in the White House are thinking about."

Another component executive is concerned with the employment implications if the United States were to lose a major part of its R&D capability and industry leadership. "Everybody can't earn a living building apps for Facebook or Google," he says. "Those Internet companies need a hardware infrastructure to run on." According to him, companies are telling the networking industry they need a faster, better network to drive their data centers. "We have a huge opportunity to be a true leader in network hardware—but the U.S. government needs to wake up to the challenge."

Mark West is optimistic. He sees huge opportunities for optics in communications, medical and defense applications. He says that U.S. companies are benefiting from excellent young engineers coming out of universities like Rochester, Arizona and Florida.

"This will be an issue in the 2012 election," he predicts. "The United States is starting to recognize this problem, and with high unemployment, there will be incentives and a recognition that, with some tax help, you can level the playing field and the United States can be very competitive." Despite the challenges, says West, "I feel good about the future."

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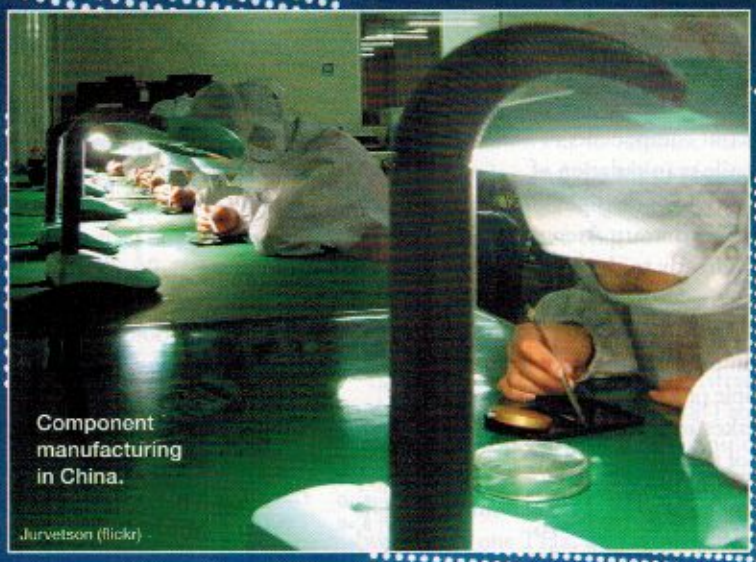
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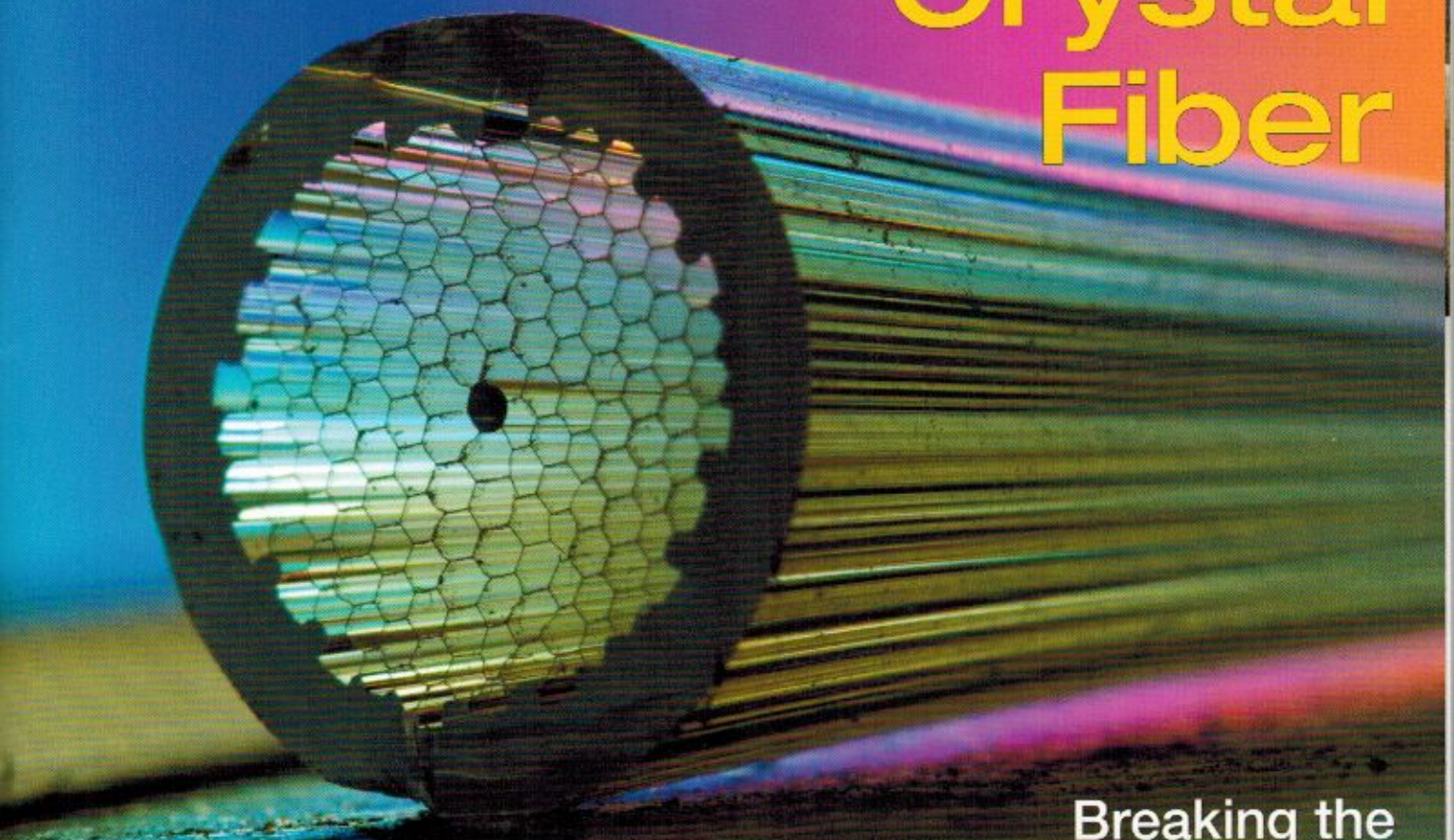

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