

CYNOSURE, INC.

Harnessing Cheap Diode Lasers to Power a Low-Cost Surgical Laser

Surgery is performed tens of millions of times a year in the United States, and it is usually a painful, risky procedure for the patient. It is also risky for the surgeon in terms of malpractice liability. Patients, surgeons, and health insurance companies are constantly looking for new, less invasive procedures to replace conventional surgery. Laser surgery is a prime candidate. One problem that limits this approach, however, is the price of equipment. A typical 100-watt surgical laser costs about \$700 to \$1,000 per watt of laser output, or about \$70,000 to \$100,000.

COMPOSITE PERFORMANCE SCORE

(Based on a four star rating.)



A Laser for Lower Cost, Less Invasive Surgery

This ATP project with Cynosure, founded in 1991, was designed to develop a smaller, less expensive laser source for surgery and other applications. The idea behind the Cynosure laser system — which was expected to sell for about \$150 to \$200 per watt of laser light delivered at the end of a surgical optical fiber — is based on harnessing the light from an array of 200 semiconductor, or diode, lasers. The problem with this approach in the past has been the difficulty of exactly aligning all 200 beams before they go into the diffractive optics transformer that collimates them into one tight, powerful beam. Minor inaccuracies in the alignment of the individual lasers can greatly degrade the performance of the system.

Cynosure's innovation was to develop an automated system to custom-mill arrays of 200 corrective lenses to match arrays of 200 diode lasers. In such a system, diagnostic equipment measures the alignment error of each laser beam and feeds the results to a computer, which drives a powerful laser that mills the lens array in less than 10 minutes. The result is a customized lenslet array that corrects the beams before they enter the transformer.

Barriers to Commercialization

Cynosure successfully designed and built a customized lenslet array to correct the beams from an array of 200 diode lasers. The researchers, however, failed to build a system that could generate the target power level — 20 watts of laser light from a medical optical fiber — because the company was unable to secure an adequate, low-cost supply of



Photomicrograph of an array of multilevel diffractive lenses, fabricated with a 193 nanometer excimer laser.

a low-tech component: a collimating array. The intended supplier, which was the sole source of the collimating array, stopped making the device and sold its production division. The new owner also chose not to produce the array.

To make use of some of the technology developed in the ATP project, Cynosure is collaborating with the Lincoln Laboratory at Massachusetts Institute of Technology and using about \$100,000 from the Small Business Technology Transfer Program to develop a low-cost diode-laser system for treatment of arrhythmia for the National Heart, Lung, and Blood Institute. The com-

PROJECT HIGHLIGHTS

PROJECT:

To design an optical system for collecting, aligning, and combining beams from an array of semiconductor lasers into one powerful beam, an achievement that will lead to the development of smaller, cheaper lasers for surgery and other applications.

Duration: 5/1/1993 — 4/30/1995

ATP Number: 92-01-0136

FUNDING (in thousands):

ATP	\$1,965	49%
Company	<u>2,067</u>	51%
Total	\$4,032	

ACCOMPLISHMENTS:

Cynosure designed and built a fault-tolerant optical system for a diode-laser array but was unable during the project to obtain a laser beam with the targeted 20 watts of output from a medical optical fiber. Later, the company achieved this goal with an alternative approach built, in part, on the knowledge developed during the ATP project. The company:

- received one patent for technology related to the ATP project: "Fault-Tolerant Optical System Using Diode Laser Array" (No. 5,369,659; filed 12/7/1993, granted 11/29/1994);
- published a paper on its research findings;
- was ranked number 112 in the 1996 *Inc.* magazine list of the 500 fastest-growing private companies in America;
- increased its sales from \$626,000 in 1991 to more than \$23 million in 1997; and
- is collaborating with Lincoln Laboratory and using funds from the

Small Business Technology Transfer Program to develop a low-cost diode-laser system for treatment of arrhythmia, based on the ATP technology, for the National Heart, Lung, and Blood Institute.

CITATIONS BY OTHERS OF PROJECT'S PATENTS: See Figure 4.5.

COMMERCIALIZATION STATUS:

Commercialization was stymied by Cynosure's inability to secure the supply of a critical part at an affordable price. Since the ATP project ended, the company has taken a different, less-sophisticated approach to building a commercializable medical laser, using its own funds. That device has achieved the 20-watt ATP goal, and the company is scaling it to achieve 200 watts output. Commercial lasers are scheduled for market introduction in the near future.

OUTLOOK:

The benefits originally expected from commercialization of the ATP-funded technology should be realized via commercialization of the alternative technology that built on the technical knowledge developed in the ATP project.

Composite Performance Score: ★ ★ ★

COMPANY:

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Number of Employees: 30 at project start, 120 at the end of 1997

Informal collaborator: Massachusetts Institute of Technology, Lincoln Laboratory

The researchers, however, failed to build a system that could generate the target power level . . .

pany is proposing to extend the scope of the project to include other conditions, besides arrhythmia, that can be treated with minimally invasive surgery. This new project is based in part on the demonstration that the ATP-funded technology, as modified by the company, is capable of delivering 10 watts of power into a 100-micron fiber-optic tube.

Alternative Approach

After the ATP project, Cynosure investigated alternative techniques, based on commercially available components, to channel the many beams from diode-laser arrays into a surgical optical fiber. The company found this can be done by grinding a hyperbolic lens onto the end of a small optical fiber, fitting one such fiber to each diode and stacking

the fiber-coupled diodes into a two-dimensional array, as the ATP proposal had suggested. The fibers take the place of the diffractive optics in the proposed ATP laser system, with the tiny lenses directing the output from the diode array into a single fiber.

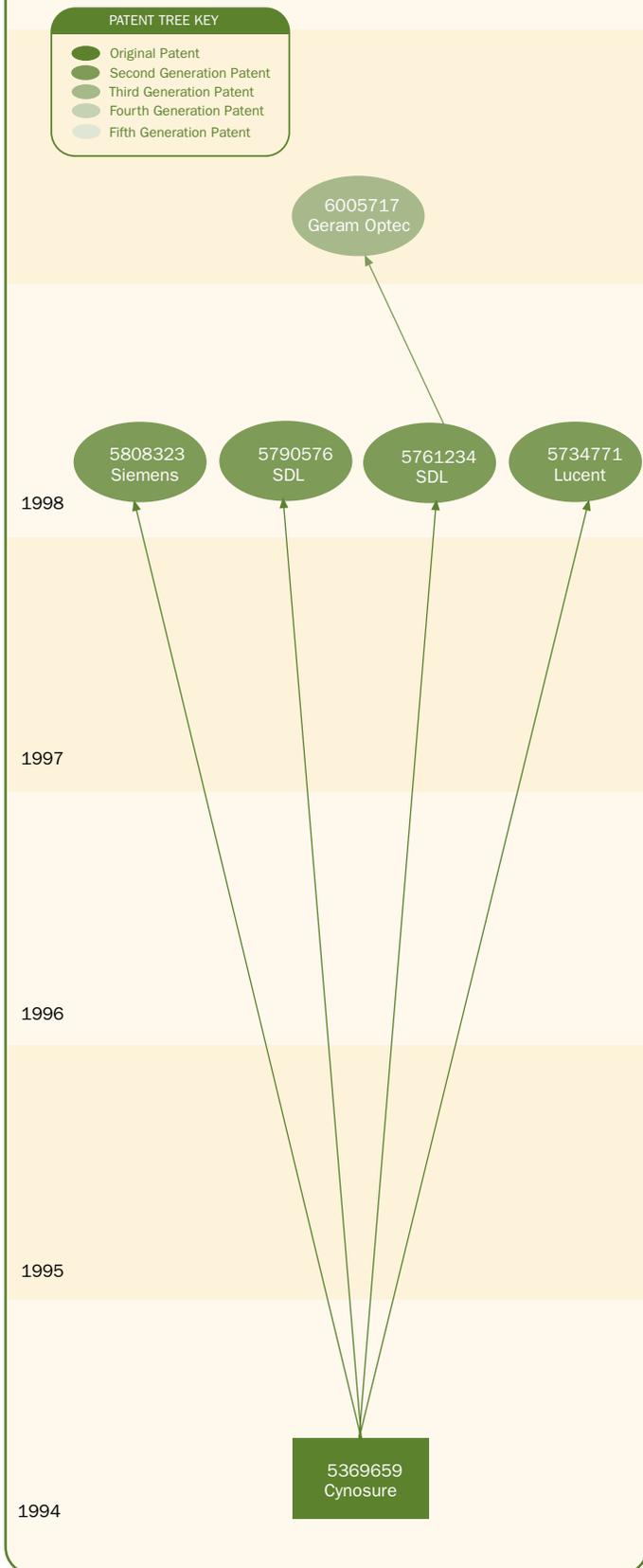
The company's switch to a different technological approach using readily available parts to concentrate the laser beams allowed commercialization to resume. Commercial lasers are now scheduled to be available in the near future.

Mission Accomplished

Lower-cost, higher-power medical diode lasers are a necessity for minimally invasive surgery, and it is said that necessity is the mother of invention. Cynosure invented the approach using fiber-coupled lasers, which are manufactured using standard optical fabrication methods and readily available components. The company expects this approach will not only reduce the cost of medical lasers but will also cost less than the diffractive optics-combiner approach envisioned by the ATP project.

By significantly reducing the cost of surgical lasers,

Figure 4.5 Patent Tree for Project Led by Cynosure, Inc.: Citations by Others of Cynosure, Inc. Patents



the Cynosure technology would enable wider use of minimally invasive surgery, reducing hospitalization times and lowering health-care costs. For example, gall bladder removal by conventional surgery requires a four-to-six-inch incision that results in four to seven days of hospitalization and a month of recovery time. When the removal is done by laser via a fiberoptic scope inserted through a small

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incision (a procedure already in widespread use), the patient is hospitalized for only two or three days and recovers much faster. Less costly medical lasers would likely increase gall bladder removal by laser.

Funding from the ATP allowed Cynosure to perform research and development work it would otherwise have been unable to do. The award enabled it to hire highly qualified optical physicists to conduct the research on diffractive optics, and to develop the technical capability needed for future manufacture of diffractive optics devices. Cynosure is currently considering licensing this technology to a company whose core business is diffractive optics. In addition, the availability of highly sophisticated optical diagnostic equipment allowed Cynosure to better understand and test the fiber-coupled equipment it is developing for the commercial sector.

