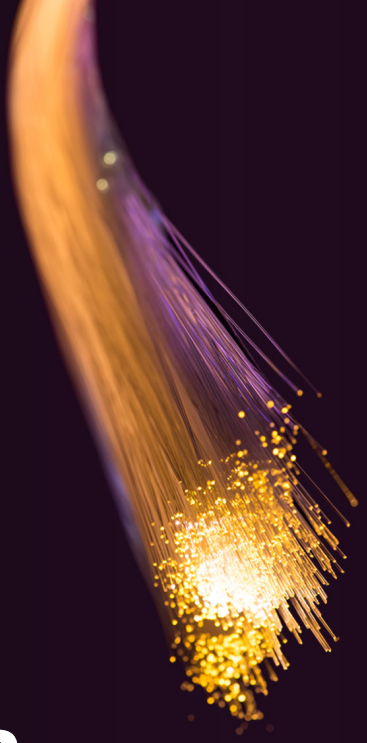


lights, data...

Action!

California-based SDL, Inc. created a series of innovations that allowed for efficient, accurate, and affordable improvements in high-capacity, fiber-optic communications.

Optical communication, which uses light to transmit information, has fundamentally changed the way we live our daily lives. Telephone, internet, and cable television signals all travel through optical fibers—threads of glass as thin as a strand of hair. Compared to electrical transmission with copper wires, fiber-optic communication experiences less loss of information over longer distances, has a higher data-carrying capacity, and sees virtually no crosstalk between cables.

Photo: asharkyu / shutterstock.com

For military applications, optical networks also have the benefits of greater security and lighter weight. Robust components can be made to withstand the harsh environment of the field, and free-space systems, which use lasers transmitting through air or in space, can provide warfighters a way to transmit data without the need for a hardline connection.

A major player in the development of optical communication systems was SDL, Inc. (originally Spectra Diode Laboratories), a San Jose, California-based laser company founded in 1983. In 1991, SDL developed one of the first commercially viable pump lasers for optical telecommunication systems. The pump laser is a key component in order to amplify the signal as it travels across longer distances of fiber without losing information or adding too much noise.

Although the initial publications describing the laser came out in 1991, the product continued to improve in stability and reliability for the next several years. From 1993 to 1997, SDL won a number of Phase I and II Small Business Innovation Research (SBIR) awards from DoD and other government agencies, including about 30 funded by the Defense Advanced Research Projects Agency (DARPA) and the Air Force. The proposals touched on everything from low-cost tunable lasers to new coupling schemes between lasers and optical fibers, including sending multiple signals simultaneously through a single fiber by WDM, or wavelength-division multiplexing.

"People outside of technology development often struggle to understand that much of what we do in research turns out to be banal or seemingly not of worth—but we still learn from doing it," said Jo Major, co-founder of InSite Partners, a venture investment firm, and former vice president of SDL, Inc. "The DoD SBIR programs led to us learning all kinds of things, which eventually contributed to a series of high-reliability products."

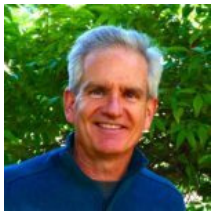
During the telecommunications boom, and in one of the largest high-tech deals in history, optical communications giant JDS Uniphase acquired SDL in 2000. In 2015, JDS Uniphase split into two companies: optical technology maker Lumentum (which still sells SDL's products) and network services consultancy Viavi.

The rapid rise of SDL's laser...demonstrates the vast and unexpected benefits that basic science and engineering research can have.

"Optical communication is the fabric of our life. A phone call didn't exist in its current form 20 years ago, and the quality of a call anywhere on Earth can be very good and effectively free," said Major, who joined SDL's R&D group in 1990. "How we speak to each other, how we get our entertainment, how we get our information—that's all fundamentally different now because of optical communication."

In the early 1990s, the semiconductor lasers that Major worked on hadn't yet found a niche in terms of commercial applications. Optical communication did exist, but the strength of the signal would fade as it propagated through the fiber. No good solution for maintaining the signal over long distances had yet been found.

Systems originally used optical-to-electrical-to-optical conversion, which meant overly complicated configurations of electronics and lasers. But then research groups began demonstrating that optical fibers doped with rare earth elements could be inserted between optical communication cables to boost the signal. The original signal and light



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from an excitation laser could be combined together in the doped fiber, causing its rare-earth element ions to be excited into a higher energy state. Those ions decay to a lower energy state, releasing photons and leading to amplification at the same wavelength as the original signal.

"The problem was that, at the time, the industry had no way of energizing this doped fiber," said Major. "Somehow we had to excite the rare earth dopant, get it into a higher state, such that the energy could transfer from the rare earth to the signal."

It turned out that the most common rare earth element for doped fibers, erbium, needed to be excited by a pump laser with wavelength of 980 nanometers—just the kind of semiconductor laser that Major happened to be working on. In the mid-1990s, commercial sales of semiconductor lasers to telecommunication companies took off, and the company was sold to JDS Uniphase shortly thereafter.

Major emphasized that the government-funded programs, including several SBIR contracts from DARPA and the Air Force, helped SDL elevate its initial product to a more sophisticated and clean form. Over the years, engineers improved the laser's stability, power output, and interface so that it was commercially ready for the telecommunications market. They tweaked seemingly small details that made a big difference: upgrading the machinery to grow the crystals, using better quality solder, high-precision optical coupling between laser and fiber, and more robust packaging. Today, a 980-nanometer semiconductor laser can produce 1,000 milliwatts of power in an optical fiber—more than 100 times Major's first model.

"The 980-nanometer laser was sort of my love and joy, and much of the government research programs that were not directly funding 980-nanometer laser development still really helped us, and the industry as a whole, clean up a lot of the details," he said.

In the end, the applications for SDL's semiconductor lasers went far beyond optical amplifiers. Laser beam welding, commonly used in the automotive industry, joins pieces of metal together with a laser beam as the heat source. In medicine, semiconductor lasers aid in hair or wrinkle removal, surgical cutting, photodynamic therapy for cancer, and dentistry. The military uses semiconductor lasers in their optical communication networks, wired and free-space, but also to remotely send power out in the field.

The rapid rise of SDL's laser—one that started out with no particular application or market—demonstrates the vast benefits that basic science and engineering research can have.

"Laser welding, optical telecommunications, lasers in medicine—those are all really big fields that exist now that didn't a quarter century ago, and part of what drove them forward is fundamental research with semiconductor lasers," said Major. "I think it's very beneficial for our country when our government funds basic science research."

Spectra Diode Laboratories, Inc. / SDL, Inc. (JDS Uniphase Corp.) • San Jose, CA (Milpitas, CA)
Modernization Priority: Networked Command, Control, and Communications (C3)
SBIR contract: DAAH01-96-C-R047 • Agency: DARPA • Topic: SB941-072, Very Low Loss Single Mode Fiber Coupling of Optoelectronic Devices
SBIR Contract: DAAH01-96-C-R254 • Agency: DARPA • Topic: SB942-102, Commercial Tunable Low Cost Laser for WDM
SBIR Contract: DAAH01-96-C-R083 • Agency: DARPA • Topic: ARPA93-058, Microbench for low cost single mode fiber coupling
SBIR Contract: F29601-96-C-0051 • Agency: Air Force • Topic: AF96-105, Low-Cost Robust Fiber Coupling for High Power Single-Mode Laser Diodes
SBIR Contract: DASG60-96-C-0140 • Agency: DARPA • Topic: DARPA93-002, Fiber Amplifiers for 1.3 um Optical Fiber Systems