Profile

CONNIE CHANG-HASNAIN

Communication at the speed of light

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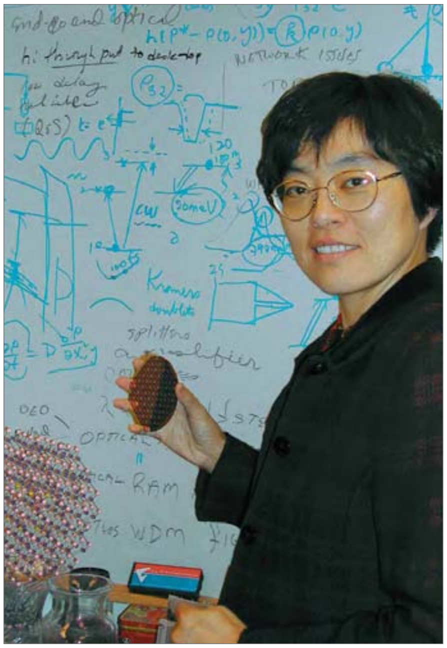
Dr. Connie Chang-Hasnain, a UC Berkeley Electrical Engineering professor and founder of the laser manufacturer BANDWIDTH9, Inc., has long worked to advance the optical networking industry. The head of the Optoelectronics Research Group in Cory Hall, Chang-Hasnain investigates the applications of semiconductor lasers to high-speed communication. In all likelihood, her micromechanical tunable lasers will someday change the way we ping, email, ftp, and chat.

Chang-Hasnain focuses on streamlining the optical transmission of information. When you sit down at a computer with Internet access, you rarely think about how the information travels or what impediments may lie in its way. For transmission across the globe, data is typically broken up into small units called packets. These packets travel along a tortuous path, starting down optical fibers as light, passing through intermediate routing points, and ending along electrical wires as they reach their destination. With present technology, this journey is often slow and inefficient. The Optoelectronics Research Group is working to make the process 1,000 times faster by eliminating the various roadblocks that a digital signal faces.

Chang-Hasnain began her optical network research on tunable Vertical Cavity Surface Emitting Lasers (VCSELs). These lasers are etched onto a chip of semiconducting material, like that used in computer microprocessors. A VCSEL looks like a sandwich, with a resonant cavity formed between the chip's mirrored surface and a small, cantilevered reflective disk. The cavity emits small bursts of monochromatic light, with the length of the cavity determining the light's wavelength. Precisely controlling wavelength is important in data transmission since it allows engineers to multiplex several different signals down a single fiber, without any overlap. However, current laser technology is still limited because a separate laser is required for each different wavelength of transmission or channel. "It's like needing 200 sizes of clothes," explains Chang-Hasnain. "You need a huge amount of inventory."

Chang-Hasnain's career in optoelectronic networking started while earning a BS in Electrical Engineering at UC Davis. Sometime during her third year there, she "fell in love with electromagnetism." From E&M, it was a natural progression to the fast-growing field of lasers. She specialized in low-power semiconductor diode lasers (like those used in CD players), earning a PhD from UC Berkeley in 1987 and working at Bell Communication Research (now known as Telcordia) from 1987 to 1992. She then joined the faculty at Stanford University, returning to Cal in 1996.



Professor Connie Chang-Hasnain's tunable VCSELs may someday change the way we use the Internet. (Photo courtesy of Karen Levy.)

Taking the existing technology to the next level, Chang-Hasnain experimented with tuning VCSELs on the fly, using microelectrical mechanical systems (MEMS) to raise or lower the laser's hovering disk, thus changing the length of the resonating cavity. [*For a related article on MEMS research at Cal, see "Micro Machines" in the* BSR *Volume 2, number 2.*] As the cavity length alters slightly, the wavelength of emitted light also changes. By making small changes in the voltage applied to electrodes in a MEMS device, a single laser becomes capable of operating at 50, 100, or 1,000 different wavelengths. Equally impressive is that the MEMS device can initiate this mechanical change within a few microseconds. Chang-Hasnain points out that this creates "a laser where one size fits all: you tune, you dial, and you lock on to [the wavelength]."

Tunable lasers give packets of data more flexibility, since many different data channels can fit into the same optical fiber, all controlled by the same laser. Even better, if you need a new channel, you just tune your laser to a new frequency. Before this tunable laser development, packets could be slowed down by heavy traffic on the few existing channels. Says Chang-Hasnain, imagine "getting stuck behind a huge truck driving at 25 mph all the way to LA. Now we have 100 lanes, which is fantastic."

In 1997, Chang-Hasnain founded BANDWITH9 to manufacture and market these tunable lasers. Some researchers who have engineered breakthrough devices and started their own companies become lost forever to academia. However, returning to Berkeley in 2000 seemed a natural choice for Chang-Hasnain. "Research is what excites me—research and teaching," she explains. Chang-Hasnain credits contact with students here at Cal as being integral to developing new twists and turns on old technology. "A teaching environment is the best place for you to do research. We're surrounded by extremely intelligent students who are always excited to learn new things. These two years have been really, really exciting."

Today, Chang-Hasnain is cofounding a new Berkeley-based research center, which will focus on creating a new class of optoelectronic materials based on nanotechnology. Over the last few years, she has been collaborating with her students to develop fully optical switching. Currently, when packets of data reach a junction the light signal is converted into electrical pulses, routed to its proper destination, and finally converted back to light to be sent further down the line. This conversion process is slow and has a negative impact on data integrity. The Optoelectronics Research Group is trying to develop new semiconductor optical switching devices to replace these electrical switches, so that packets remain in optical form through their entire journey. Chang-Hasnain explains that with existing electronic switching, packets wait around like passengers at Grand Central Station before transferring to a new channel. However, "optical switching would mean that each passenger would switch by themselves. It cuts out the need for a Grand Central."

With semiconductor processing capacity doubling every 18 months and the potential for seamless optical switching just around the corner, it appears that computer users everywhere will soon be networking even faster. Eventually, only the speed of light will limit the speed of information transmission. So remember: for more information—better, faster, and on demand—stay tuned. ■

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