

Lasers, Fiber Optics, and Endless Opportunities

Caltech's groundbreaking research has given rise to countless companies over the years. One remarkable success story is Ortel Corporation, which was founded in 1980 by Amnon Yariv, Martin and Eileen Summerfield Professor of Applied Physics and Electrical Engineering, and his group members Nadav Bar-Chaim and Israel Ury. The company was a pioneer in the development of semiconductor lasers for fiber-optic communication and was eventually acquired by Lucent Technologies. It subsequently spun off to become a division of Emcore Corporation and remains a prominent supplier of high-performance microwave optoelectronics components and fiber systems for the cable, wireless, and satellite communication industries.

ENGenious recently sat down with former Caltech postdoctoral scholar Nadav Bar-Chaim and two of his Ortel colleagues who are also Caltech alumni—Kam Lau (BS '78, MS '78, PhD '81, electrical engineering) and Henry (Hank) Blauvelt (PhD '83, applied physics)—to learn more about their training at Caltech and how it taught them to adapt to changes in technology and its applications.

ENGenious: What inspired you to become engineers?

Hank: I was always intrigued with trying to make things. Figuring out how to use technology to solve problems is challenging, interesting, and rewarding.

Nadav: I actually wanted to become a physicist. But when I went to do my PhD, the school of engineering was new and had sort of an unlimited budget.



Nadav Bar-Chaim

So, I got my degree in electrical engineering, but I was able to do everything I wanted to do—keeping one leg in physics and one leg in engineering.

Kam: I can trace my interest in engineering back to when I was a kid. My father didn't get past first grade in elementary school,

but he was extremely good with his hands. He used to buy model battleships for me that we glued together piece by piece, put in a motor and gears, and took to sail in a pond. That was a great inspiration for me, and I got interested in how to build things and how to improvise solutions when things don't work.

ENGenious: How did you come to join Professor Amnon Yariv's group at Caltech?

Kam: I actually came to Caltech fully intending to major in aeronautics. In high school, I had read a biography of Qian Xuesen, the father of Chinese rocketry and a Caltech alum, and I was inspired to follow in his footsteps. But I was coming from Hong Kong, and I soon learned how difficult it would be to get an aeronautics job in the U.S. as a foreign student. So I decided to do something more practical. And that's how I ended up in electrical engineering. Right away I was impressed by the off-the-scale caliber of the faculty. Early on, I connected with Professor John Pierce (BS '33, MS '34, PhD '36), a Caltech alum who had been an executive director at Bell Labs, famed for leading the first satellite transmission demonstration in the 1960s. He came back to teach at Caltech in the 1970s, and it was through him that I got a chance to do research at Bell Labs during the summers of my junior and senior years. It gave me a taste for research and hooked

me into the field of optical communication. Coming back to Caltech in the fall, I showed Amnon my work at Bell, and he was impressed enough to invite me to join his group to work for a PhD.

Hank: I was primarily attracted by the work they were doing on lasers. This research would be useful for fiber-optic communication, and it was a topic of particular interest to me. In addition, Amnon was able to put together a tremendous group of graduate students and postdocs, which made it a great environment to learn and develop your skills.

ENGenious: Tell us the story of Ortel.

Kam: Back in the 1970s, there were already a couple of companies building semiconductor lasers. To make them practical, we had to make them lase continuously at room temperature. So this was the main goal of our work in Amnon's group at that time. Nadav filled the important role of making the first continuously operating laser in our lab. Then Amnon asked me to look into how fast we could modulate it; that is, how to make a laser that could be modulated faster than anyone else could do it. At the time, the fastest speed anyone could modulate semiconductor lasers directly was stuck at about 1 to 2 gigahertz. Together with other visiting researchers from Amnon's group, we salvaged some World War II era microwave equipment from campus surplus and were eventually able to push the speed up to 3, 4 gigahertz. Around the time I graduated in 1981, Amnon and Nadav and another student in the group, Israel Ury, had the idea to start a company building and selling these lasers—and that was of course Ortel.

They asked me to join with the intention to differentiate the company as a supplier of high-speed lasers. Within a few years, we were able to push our lasers first to 8 gigahertz and then 10 gigahertz. No other company at the time came close.

Nadav: I believe the idea came up at a lunch. Amnon said we're making lasers as good if not better than anyone else, so we should commercialize them. At first, I thought he was joking. But I discussed it with my wife and figured, well, we have nothing to lose. If it works, great. If not, there are other opportunities. We'd try it for a couple of years and see. In those early days, each of us had our own territory. I was really into designing lasers and fabricating them. Israel was more of the packaging guy. Kam's area was testing, modeling, and designing high-speed lasers. And Hank joined later but eventually got involved in almost everything.

Hank: I joined in 1985. At that time, I was working on lasers with longer wavelengths—1.3 or 1.5 microns—which are outside the visible spectrum but work very well for transmitting signals through optical fibers. These signals can travel much longer distances than shorter wavelengths. I was still a graduate student when Ortel started. I was aware that starting a company was being explored, but I was not involved in the founding of Ortel.

ENGenious: Can you tell us a little more about the impact of Ortel's technology?

Hank: Ortel's main niche was making lasers that could reproduce signals with extremely high quality. The applications

we were working with involved complicated signals that correspond to what comes into your home through a cable TV network. There are lots of video channels and they all have modulation, so you have to reproduce that signal with the best accuracy possible. We had a very good



Kam Lau

reputation for making lasers that accomplished this goal, and the technology persisted even after Ortel was acquired by Lucent and no longer existed as an independent company.

Nadav: We were actually the first to show the cable companies that you can use semiconductor lasers to bring the signal to the home. It allows for much better quality, longer distance transmission, and more channels. About 60 percent of homes with cable TV get their signal via Ortel's technology. Interestingly, our main market before that had been defense. But in the late 1980s, when the Cold War ended, a lot of the defense work dried up. So we adapted and found a new opportunity in cable TV. Now of course the focus is on providing high-speed

internet rather than supplying TV channels, but Ortel's laser technology has remained crucial.

ENGenious: What are your favorite memories of your time with Amnon and the group?

Hank: My best memories from my time at Caltech are about the collaborative environment that existed in Amnon's group. There was a large group of graduate students and postdocs working to better understand the emerging field of semiconductor lasers, but for the most part we were working on independent projects. This resulted in a very high level of constructive interactions and discussions with minimal competition for credit for the results. I found it to be very favorable for learning.

Kam: I remember being extremely protective of my experimental setup. I used to plaster threatening signs all over my microwave measurement equipment: "DO NOT TOUCH!" "DO NOT MOVE!" "DO NOT LOOK!" "DO NOT THINK!" "DO NOT EVEN BREATHE!"

ENGenious: How is a Caltech education viewed in your industry?

Hank: Caltech is small, but in every area where it's heavily involved, its researchers are viewed as leaders. Especially people like Amnon who have such high standing in the scientific and engineering world. That affords Caltech students a lot of freedom. We would get these open-ended research projects where we could do almost anything we wanted. Being able to follow the science wherever it leads is a tremendous opportunity.

Nadav: Between the professors, students, and research fellows, you have a lot of good brainpower here. So the ability to translate ideas into reality is natural for Caltech trainees. At Ortel, our strength as a technology leader was based on our close connection to academic research. That's how we gained advantage over the competition—we were always a step ahead.

Kam: Training with the world-class faculty at Caltech really sets you apart. Amnon, for example, is extremely well known and well respected in the field of fiber optics and optoelectronics. When I was working in his lab, we constantly had recruiters from industry visiting our group. His students were hotly pursued as soon as—or even before—they graduated, and each of us got multiple job offers. This is a testament to how valuable a training in Amnon's group was regarded in industry, and still is today.

ENGenious: What advice do you have for current Caltech students?

Nadav: Keep an open mind in what you do. Don't get married to a specific idea—if it doesn't work out, just go around the corner and try something else. And be a team player. For practical work, it's much easier to accomplish things in teams.

Hank: Learn as much of the conventional wisdom and theory as possible, but realize it's always incomplete. Progress comes from finding what's wrong with or missing from the conventional wisdom. When things don't go as expected, those surprises often lead to whole new areas of study.



Henry (Hank) Blauvelt

Kam: As a student, it can be easy to focus just on coursework, exams, and your own narrow research topic. But you should take advantage of the world-class resources available to you through Caltech, the connections to industries, and faculty like Amnon. And take advantage of mission-oriented facilities like JPL, big optical telescopes like Palomar and Keck, and radio telescopes at Owens Valley. Those are major engineering undertakings that present tremendous real-life experience for EAS students. Especially JPL, since it is within daily commute distance of the campus. Don't be shy—knock on doors and ask for opportunities. ■ ■ ■

Nadav Bar-Chaim was vice president of Ortel Corporation. Kam Lau is Professor Emeritus in the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley and was a founding staff scientist and then the chief scientist at Ortel Corporation. Henry (Hank) Blauvelt is the Chief Technology Officer at Emcore.



The Caltech Y: Learn by Doing

For more than 100 years, the Caltech Y has engaged Caltech students in a wide variety of programs and services that create opportunities for adventure, leadership, and service. The activities and events offered are student-driven, and remarkable programs have emerged over the years. One shining example is the Rise Program, a low-cost after-school tutoring program in math and science in which Caltech undergraduate and graduate students tutor public-school students between grades 8 and 12. Another is the Student Activism Speaker Series (SASS), the student-run lecture series. And, last but not least, the Y is still the place to go to rent camping equipment!

ENGenious interviewed the Caltech Y team that includes executive director Athena Castro, staff members

Greg Fletcher, Liz Jackman, and Agnes Tong, and board chair Peter Hung (BS '08, PhD '16). Working out of the Tyson House on Wilson Avenue (the Y moved there in 2011), the team helps facilitate programs centered on the five pillars of leadership, service, adventure, civic engagement, and perspective—and, along with Caltech students and many friends (some of them four-legged), continues to provide profound experiences for Caltech and its surrounding community.

Top row: Camila Fernandez, Maria Johnson Kriechbaum, Liz Jackman, Greg Fletcher, Miranda Maxwell; bottom row: Marta Lopez Viseras, Athena Castro, JJ the dog, and Agnes Tong at the Tyson House

ENGenious: What is the role of the Caltech Y?

Athena: The Y's mission complements Caltech's mission—we help to create citizen scientists. Part of what we do is present current issues to students and challenge them to become involved. By inviting speakers to campus