Fluorescence Microscope Lands Presidents' Scholarship for Teen

Harikrishna (Hari) Rallapalli, a 16-year-old from Pleasanton, Calif

By JOHN R. PLATT 8 July 2008

Harikrishna (Hari) Rallapalli, a 16-year-old from Pleasanton, Calif., is the 10th recipient of the IEEE Presidents' Scholarship.

Rallapalli, who just completed his sophomore year at Amador Valley High School, received the US $10 000 scholarship for his project, "Low-Cost Total Internal Reflection Fluorescence Microscopy." The scholarship was presented in May at the 59th Annual Intel International Science and Engineering Fair, in Atlanta.

Administered by IEEE Educational Activities and awarded by the IEEE Foundation, the scholarship is given annually to a high school student who creates a project that demonstrates an understanding of electrical and electronics engineering, computer science, or other IEEE area of interest. The award is payable over four years of undergraduate study and includes complimentary IEEE student and student society memberships during the four years of college. The winning student also receives a framed certificate and an engraved plaque.

In addition to the scholarship, Rallapalli's project earned him the third-place award in the Intel fair's physics and astronomy category.

Rallapalli found that competing in the fair was "an incredible experience. Every time I step into an environment filled with brilliance, I step back and try to take everything I can out of what I see and hear," he says. "Seeing so many people with amazing minds and a passion for what they do has taught me that I really love science."

A MICROSCOPIC LOOK The idea for Rallapalli's microscope had its genesis in his freshman physics class. Learning about Brownian motion, the random movement of particles suspended in a liquid or gas, was one thing, but seeing it was another. Rallapalli wanted to observe Brownian motion of just a few particles but learned that his school could not afford the US $300 000 total internal reflection fluorescence (TIRF) microscope needed to do the job. At first he built a relatively inexpensive low-power microscope, with which he was able to see and record Brownian motion of thousands of particles. But zeroing in on one or a handful of particles required TIRF microscopy. This made him determined to build a low-cost TIRF microscope for classrooms like his, both for demonstrations and student-level research.

To accomplish this, he turned to TIRF technology first proposed in the early 1980s by Daniel Axelrod. He and his group at the University of Michigan developed TIRF microscopes to observe fluorescent elements in biological specimens, usually less than 200 nanometers thick, by using short pulses of light to illuminate and excite molecules in a narrow region of the spectrum. Conventional fluorescence microscopes excite too many molecules in the entire specimen, overwhelming the image of the surface particles.

"Dr. Axelrod proposed many different TIRF microscopy methods," Rallapalli says. Current commercial microscopes use Axelrod's "through the objective" approach with through-the-lens illumination, in which light from a laser travels through the lens system of the microscope, is totally reflected on the surface of the subject, and then travels back out through the lens, where it must be focused on the viewing device. This method involves many expensive optical elements and requires users

to make calculations and calibrations, Rallapalli says, which makes the microscopes too expensive and intricate for high schools or undergraduate institutions.

Instead, Rallapalli resurrected another method proposed by Axelrod. He found that sending the laser light through an external prism instead of through the lens system still illuminates the sample while producing comparable results with an easier-to-use interface for students.

UNDER $1,000 In Rallapalli's method, a prism is placed on top of the specimen, while the lens system is placed on the other side. As light is reflected internally in the prism, the evanescent wave front of the excited sample travels down through the objective on the opposite side and is captured by an extremely sensitive charge-coupled-device camera. The resulting digital image can be viewed on a TV or computer screen and then recorded and analyzed.

Rallapalli says he put together a microscope with components costing only $825. However, he has not finished his microscope, nor will it ever be completed, he says.

"I want to keep refining it to both reduce costs and add more functions. There are almost no limits to what this technology can do, just by adding or removing components," Rallapalli says. "For example, a physicist may need to classify a certain material, so he or she would add on a spectrometer."

Rallapalli is enrolled in an undergraduate summer program for high school students at Stanford University. "I will be taking a course in research methods in biology with undergraduate students and with real professors, which I hope will provide me with a taste of a college workload," he says.