Single photon detector wins UC San Diego engineering research competition

February 27 2007

With a flash of light, photons simultaneously fly toward the face of a person waiting to be identified for security purposes. The packets of light bounce off the face and land on a specially engineered photon sensor that clocks when each photon arrived and uses the information to reconstruct a three dimensional image of the face almost instantaneously.

This is just one potential application of a new single-photon detector created by Hod Finkelstein, an electrical and computer engineering Ph.D. candidate at the UCSD Jacobs School of Engineering. For this work, Finkelstein won top prize – the Rudee Outstanding Poster Award – at the UCSD Jacobs School of Engineering Research Expo on Thursday 22, February 2007. More than 250 Jacobs School graduate students presented posters at the event, which was put on by the Jacobs School Corporate Affiliates Program.

The potential applications for Finkelstein's single photon detector extend well beyond face recognition and other biometric applications.

"Biological imaging is where I think this technology is going to make the biggest impact," said Finkelstein, who put cancer detection at the top of the list of 4D bio-imaging applications. The fourth dimension is time.

Finkelstein works in the OptoElectronic Computing Group led by Sadik Esener, a professor of electrical and computer engineering at UCSD's Jacobs School. Utilizing novel nanotechnology approaches for cancer imaging and therapeutics is one of the focus areas in the Esener lab.

“Let’s say you want to have a device you swallow that picks out minute fluorescent signals from beacons that have been attached to cancer cells. You want to detect only the signals from the cancer cells. Healthy tissues may also fluoresce, but the way the light decays is different, so if you measure the time behavior of the fluorescent light, you will be able to only detect the cancer cells,” said Finkelstein.

Due to technical and space constraints, there are no such imaging techniques yet. Existing time-domain bio-imagers only make use of single-pixel photon detectors. “My dream is to have an array of pixels that can image with high spatial resolution and give you the time of arrival of photons at each pixel. Imagine both a camera and a processor on a single chip. That’s where my project is headed, that’s the vision: to integrate many detectors and all the processing power on a single chip,” explained Finkelstein.

In his poster presentation, Finkelstein demonstrated how he shrunk the size of individual photon-sensing pixels, and increased both the precision with which you know the time the photon arrived at a pixel, and the percentage of each pixel’s surface that can detect photons.

These improvements are all tied to Finkelstein’s main technical innovation within photon-detecting devices: better separation between the energetic flow of electrons that each sensed photon triggers and the surrounding areas, which are comprised of other pixels as well as the circuitry that senses and times photon arrival.

“I used a guard-ring that better isolates the sensitive circuitry from the avalanche of electrons that occurs when a photon is detected,” said Finkelstein, who has filed for various patents related to this advance.

"This is the first time that a single photon detector has been manufactured using off-the-shelf, mature manufacturing technology," said Finkelstein. The mature manufacturing technologies that produce huge, dense microprocessors can do the same for large, megapixel single-photon imagers, Finkelstein explained. "This work opens new possibilities for signal processing, analog circuits, and new architectures and devices. Now that we have the detector, it's time to understand how to process all this information. The processor is not built yet, but it can fit on the same chip."

Source: University of California - San Diego