Quantum-well infrared photodetectors (QWIPs), a technology first developed for the Star Wars missile-defense program, is now finding applications in medicine. At the Dana-Farber Cancer Institute (Boston, MA), surgeons are using a digital infrared camera system fitted with a 256×256 gallium arsenide/aluminum gallium arsenide (GaAs/AlGaAs) QWIP to map the photon flux produced in a tumor immediately following chemotherapy. With a thermal resolution of better than 0.009°C, the BioScanIR (OmniCorder Technologies; Stony Brook, NY) is helping doctors determine the effectiveness of new forms of cancer drugs and therapies.

Normal blood vessels generate predictable patterns of heat transfer, while tumor blood vessels react in a very confused way, says Mark Fauci, president of OmniCorder. Computer algorithms in the system analyze changes in the photon flux to produce maps depicting these patterns of blood perfusion in tissues, which helps doctors monitor tissue physiology, before (top) and after (bottom) treatment.
activity in response to therapies.

Currently, researchers do not have an adequate technique for imaging lesions, nor do they have good surrogate markers, notes George Demetri, medical director of the Center for Sarcoma and Bone Oncology at Dana-Farber. It is difficult to determine what is happening in the treatment of cancer patients, especially when physicians use recently developed drugs. "The newer cancer drugs are smarter and more gentle," he says, "but they are also occasionally more subtle in terms of their activities. It’s not so obvious to determine when the drugs are actually working."

The detection mechanism of the QWIP involves photoexcitation of the electrons between the ground and first excited states of a single- or a multi-quantum-well structure. When the photo-excited carriers escape from the well, they are collected as photocurrent. The responsivity spectrums of QWIPS are much more narrow and sharp than those of intrinsic infrared detectors, due to the resonance intersubband absorption of QWIPs. Currently, there is a great interest in the GaAs/AlGaAs–based QWIPs because techniques like molecular beam epitaxy (MBE) allow the precisely controlled growth of highly uniform and pure layers of materials on large substrates. The detector in the Omnicorder system is sensitive from 8 to 10 μm, a region at which the skin possesses maximum emissivity and minimal reflectivity, to reduce environmental artifacts.

Unlike conventional thermal imagers, the additional sensitivity of the QWIP system allows researchers to observe heat generated by a tumor over a period of time and helps them obtain a pattern recognition from the computer. "It is so much more complicated than typical thermal imaging," says Demetri. "We hope it will give us more subtle information. Our challenge is interpreting the wealth of information provided by the images."

As to the BioScanIR’s effectiveness, the jury is still out. "We have to recognize that any time you introduce new technology, there is a learning curve with it," says Demetri. "We are very excited by this new technology, but as a researcher, I am notoriously cautious about the interpretation of the information. We are still trying to interpret CT-scan data, and that technology has been around for 25 years." –Laurie Ann Toupin

wavelengths interchange with photonic crystals

Wavelength conversion in wavelength-division-multiplexed (WDM) systems is currently implemented using slow and expensive electronic-based switching elements. Ideally, signal manipulation should be performed in the optical domain. Now researchers at the University of Wisconsin–Madison (Madison, WI) have demonstrated optical wavelength conversion using a nonlinear photonic crystal (NLPC) fabricated in LiNbO3 to interchange the wavelengths 1535 nm and 1555 nm.

Using lithographic techniques, the group fabricated a lattice consisting of 4.4-μm-diameter cylinders on a 7.6×10.1-μm grid with a 47.1° interior angle. By applying lithium chloride (LiCl) electrodes on both sides of the wafer, the group poled the material using a 22-kV/mm voltage to form the 2-D-NLPC. In the demonstration, they illuminated the 0.5-mm-thick, 11-mm×6-mm sample crystal with collinear beams from three sources: a 325-mW, 772.5-nm titanium-doped sapphire (Ti:sapphire) pump laser and two 500-mW distributed feedback diode lasers, all with their polarization oriented along the z-axis of the LiNbO3. With other approaches, it has been difficult to isolate the converted signals from the remaining unconverted data streams due to their collinearity. In the UW system, the interchanged data of 1535 nm and 1555 nm exited on opposite sides of the crystal at +5° and -7° respectively, with an output power of about 70 μW each (see figure).

"The low conversion efficiency is due to the fact that the NLPC contained only 20% of the periodic pattern" explains Leon McCaughan of the research group. Future work will aim at improving the fabrication method to produce a nearly perfect 2-D lattice as well as exploring new applications. – Phillip Espinasse