Imagine a detector that combines near 100% quantum efficiency, speed independent sub-electron readout noise and negligible dark current with virtually unlimited dynamic range; a non-aging sensor technology that provides the ability to take true quantitative measurements, while giving the ultimate in detection capabilities. Imagine no longer; it’s a reality!

The Technology
PI/Acton have been working on a new technology, known as hybrid sensor technology which combines the benefits of both CCDs and CMOS detectors to give a dedicated spectroscopy detector that has unparalleled sensitivity and speed. As is well known, in a conventional CCD, photons of light are converted to electrons and stored in pixels, in a 2D array. The charge in each pixel is shifted vertically in a controlled manner through vertical shift registers, into a horizontal shift register. In spectroscopy applications, the array is essentially divided into columns and all the charge in each column is shifted simultaneously (binned) into the horizontal shift register. The charge from each pixel is then shifted horizontally to an output amplifier, where the charge signal is converted to a voltage signal.

CMOS imagers capture photons in the same manner as CCDs, however their architecture differs significantly in terms of the readout process. CMOS devices have circuitry at each pixel which makes back-side illumination impractical. The presence of this circuitry also reduces the fill factor of these devices and limits the overall sensitivity. On the other hand, having electronic circuits at each pixel provides some benefits, such as random access, non-destructive readout etc. CMOS also has the advantage that both analog and digital electronics can be incorporated on the same chip as the detector. CMOS devices can be designed to operate very fast as the readout and processing electronics can be duplicated many times with each circuit connected to a sub-region of the sensor and all these sub-regions with their associated electronic circuits can be operated in parallel to attain very high frame rates.

**Figure 1:** Illustration of bump bonding technique used to bond CMOS processors to CCD sensor.
Hybrid Sensor Technology (HST) combines the quantum efficiency benefits of CCD devices with the analog and digital signal processing capabilities of CMOS devices. The CCD is used to collect and convert photons into electrons in potential wells, in the same manner as conventional CCDs. The CCD can be either front or back-illuminated, giving the benefit of much higher sensitivities than traditional CMOS devices. The charge from each pixel is transferred through vertical and then horizontal shift registers, as with a conventional CCD. However, this is where the similarities with traditional CCDs end. Patented technology, replaces the need for the CCD to have an on-chip amplifier, instead the charge is transferred through a unique “bump-bonding” technique from the CCD silicon to a CMOS silicon chip, as illustrated in figure 1. Once transferred, the charge is amplified by a very low noise charge amplifier. The CMOS amplifier is operated at KHz speeds to attain the very low noise performance, however, because the CCD can be divided into many sub-regions, each with its own output connected to a separate CMOS amplifier circuit, and all these outputs can be operated in parallel, the net effect provides an extremely high net charge throughput rate, as illustrated in figure 2.

Figure 2: A schematic representation of a spectroscopy HIT device.

The Benefits
• Virtually unlimited dynamic range
• Sub-electron read-noise independent of speed
• High QE
• Quantitative
• Unsurpassed spectral rates-1000’s of spectra per second
• 100% fill factor
• Non aging sensor technology