Contribution ID: **32**

Type: **Talk**

High Performance Infrared Imaging Sensors, Basic Principles to the State-of-the-Art

Monday 4 September 2017 17:00 (30 minutes)

The universe is an amazingly huge place. While humankind has directly explored Earth's sister planets with space probes, we don't have the means to venture beyond the solar system, and so almost all information about the universe comes from sensing light that happens our way. Astronomy is constantly striving to find better ways to sense the feeble amount of energy from distant stars and galaxies. This quest has led to a new generation of very large telescopes (10-m diameter) on the ground and the deployment of the 2.4-meter Hubble telescope in space. Ground-based astronomy has commenced construction of an ambitious generation of 30-meter class Extremely Large Telescopes, and the James Webb Space Telescope's 6.5-meter mirror will launch in 2018.

Possibly more important than the development of bigger telescopes is the rapid advancement in solid state detector technology. The detector revolution was led by silicon CCDs starting in the 1970's for sensing visible light, but the materials that were developed during the past three decades for sensing infrared light have made the most significant difference in astronomy. Long before the CCD, astronomers could detect visible light with the human eye and photographic plates, but until recently, infrared astronomy was not possible.

This paper presents the basic principles of high performance infrared imaging sensors, including the physics of detector materials, the electronic readout circuitry, and the packaging that is required to keep the detector flat and not self-destruct during cooling to the cryogenic temperature of operation.

In addition to presenting astronomical detectors which are optimized for low light level long exposures, this paper will cover the design of sensors used for Earth Science and laboratory instrumentation, for which the light levels and frame rates are much higher than needed for astronomy.

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Session Classification: Sensor development