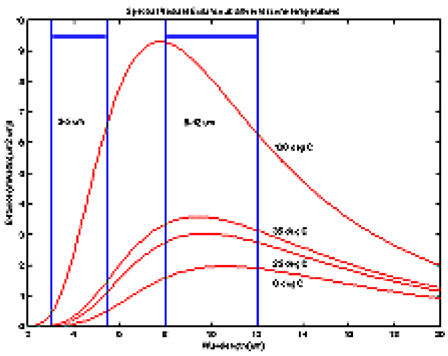
Infrared Detector Arrays for Thermal Imaging Tutorial "Infrared Detectors"

General

Infrared detectors and detector arrays are used in many fields of applications today, both civilian and defence oriented. Many of these are based on *passive detection* of thermally emitted electromagnetic radiation as described by the wellknown Planck's law. In this way it is possible to image objects in darkness, or carry out contactless temperature measurement. *Active systems*, on the other hand, are basedon illumination of the object by an infrared source, such as a thermal emitter or an infrared laser. Laser radar is anexample.

Planck's radiation law: $$R_{BB\lambda}\,d\lambda = \frac{2\pi c\,h\,\nu\,d\lambda}{\lambda^4\left[\exp\left(\frac{h\nu}{kT}\right)-1\right]}$$



***R**$_{BBl}$* = Spectral Radiant Exitance (emitted power (in a half sphere) per unit area and unit wavelength)

c = vacuum speed of light
h = Planck constant
u = frequency
l = wavelength
k = Boltzmann constant
T = absolute temperature

Planck's radiation law states that every object at a temperature above absolute zero emits electromagnetic radiation, and the higher the temperature the higher is the emitted intensity. In addition, the wavelength of maximum intensity decreases when the the temperature increases (Wien's displacement law). Planck's law isstrictlyvalid only for ideal *blackbodies* which by definition have 100 % absorption and maximum emittingintensity(i. e. exitance). Real objects can be handled by introducing *emissivity*, a factor less than unity, equal to the ratio of the emitting intensity of the object and that of a corresponding blackbody having the same temperature as the object. In the general case the emissivity is wavelength dependent. Objects with a less than unity and almost constant emissivity are named *grey-bodies*.

Usually infrared imaging is performed in either of two different atmospheric transmission windows: the 3-5 um range *MWIR - Medium Wavelength Infrared*, or the 8-12 um range *LWIR - Long Wavelength Infrared*. In these windows atmospheric transmission is maximum or equivalently the absorption minimum. However, some applications such as gas analysis is performed at wavelengths where the absorption is maximum, i. e. 4.2um for carbon dioxide and around 6 um forwater vapour.

It is notable, that in a global perspective, for many years all the major breakthroughs in infrared technology, and the major purchases of infrared equipment, have been funded by a military sponsor. Consequently, the technology has been developed with the military user in mind, and the emphasis been onhigh performance IR systems, predominantly cooled photon detectors. However, a main future trend will most certainly be to reexamine one of the strengths of infrared technology i. e. its suitability to applications outside the military sector, and meet the needs of the civil customer. The civil sector can accept a lower performance, but the price per unit must be kept low, and the equipment user friendly.

The medium performance, uncooled thermal detector technology is certainly suitable for this. To reach the goals of a civil product can be at least equally technologically challenging as for R&D on high performance detector systems. A potentially important civilian market for uncooled infrared detector arrays is the car industry (driver's aids) and surveillance systems for inspection purposes (e. g. radio stations, fire control, frontier control). Other areas are medical diagnostics and robotic manufacturing. When a higher performance is needed, the QWIP technology is suitable. In spite of the fact that it is a cooled detector technology, detector arrays can be fabricated at a comparatively low cost.