New Semiconductor Materials

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While Si and Ge have become detection standards for energy dispersive spectroscopy at X-ray wavelengths in the laboratory, their use for an increasing range of applications is becoming marginalized by one or more of their physical limitations; namely the need for ancillary cooling systems or bulky cryogenics, their modest stopping powers, radiation intolerance and relatively slow response times. Compound semiconductors encompass such a wide range of physical properties that it is technically feasible to engineer a material to any application. Wide band-gap compounds offer the ability to operate in a wide range of thermal and radiation environments, whilst still maintaining sub-keV spectral resolution at hard X-ray wavelengths. Narrow band-gap materials, on the other hand, offer the potential of exceeding the spectral resolution of both Si and Ge, by as much as a factor of 3. Assuming that the total system noise can be reduced to a level commensurate with Fano noise, spectroscopic detectors could work in the XUV, effectively bridging the gap between the UV and soft X-ray wavebands. Thus, in principal, compound semiconductor detectors can provide continuous spectroscopic coverage from the far infra-red through to gamma-ray wavelengths. However, while they are routinely used at infra-red and optical wavelengths, in other bands, their development has been plagued by material and fabrication problems. This is particularly true at hard X- and gamma-ray wavelengths, where only a few compounds (*e.g.*, GaAs, CdZnTe and HgI_2) have evolved sufficiently to produce working detection systems.

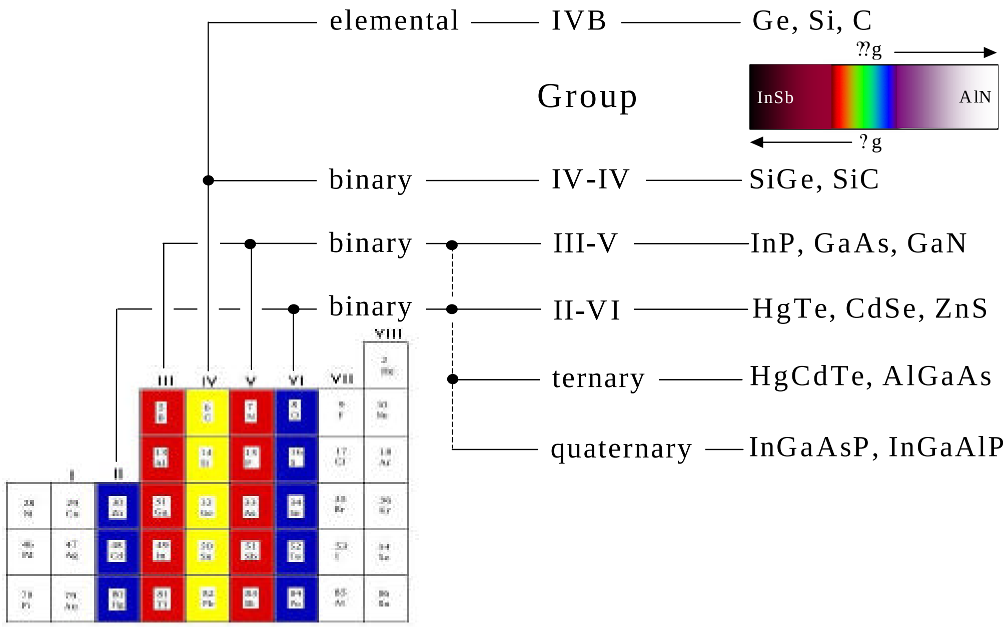

Figure 1: Diagram illustrating the relationship of the elemental and compound semi-conductors. Examples of each compound type are given, listed by increasing bandgap energy, $?_g$, or alternately, decreasing wavelength, from the infrared to the ultraviolet.

We examine the current status of research in compound semiconductors and by a careful examination of material properties and future requirements, recommend a number of compounds for further development.