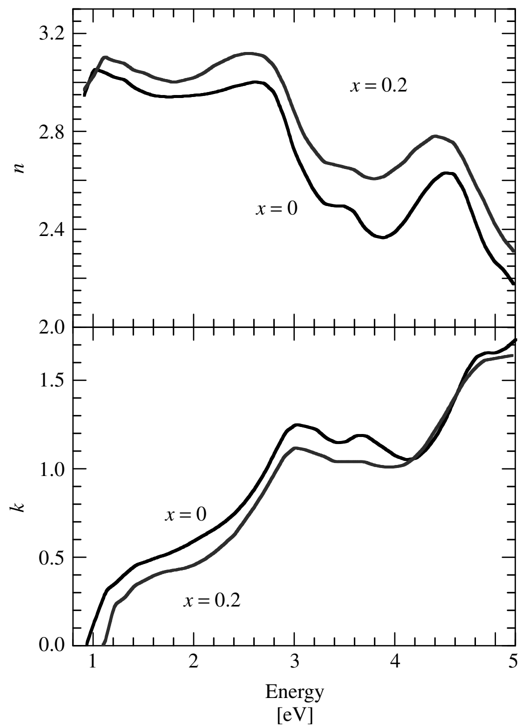

Figure 13.6 Complex refractive index for $CuInSe_2$ and $CuIn_{1-x}Ga_xSe_2$ with $x = 0.2$ (After Alonso M *et al.*, *Appl. Phys. A* **74**, 659–664 (2002) [43])

There is a large spread in mobility values reported for $CuInSe_2$. The highest values of hole mobilities have been obtained for epitaxial films, where 200 cm^2/Vs has been measured for $Cu(InGa)Se_2$ with about $10^{17}/cm^3$ in hole concentration [37]. Single crystals have yielded values in the range of 15 to 150 cm^2/Vs. Electron mobilities determined from single crystals range from 90 to 900 cm^2/Vs [46]. Conductivity and Hall effect measurements of thin-film samples are made cross-grain, but for device operation through-the-grain values are more relevant, since individual grains may extend from the back contact to the interface of the junction. The sheet conductivities of polycrystalline *p*-type films correspond to mobility values of 5 to 50 cm^2/Vs, but it is quite possible that they are limited by transport across grain boundaries.

A large number of intrinsic defects are possible in the chalcopyrite structure. Accordingly, a number of electronic transitions have been observed by methods such as photoluminescence, photoconductivity, photovoltage, optical absorption, and electrical measurements (see, for example, Reference [31]). However, it is difficult to assign transitions to specific defects on an experimental basis. Instead, theoretical calculations of the transition energies and formation energies provide a basis for identification of the different intrinsic defects that are active in $Cu(InGa)Se_2$. Calculations of intrinsic defects in $CuInSe_2$ and comparison with experimental data can be found in the comprehensive paper by Zhang *et al*. [47]. A summary of their results is schematically shown in Figure 13.7. The defects that are considered most important in device-quality material are presented in Table 13.2.