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Complex refractive index

Abstract:
Characterizes the propagation of a light wave in a medium in which there is a loss of energy, that is, the electromagnetic wave experiences attenuation, due to various loss mechanisms such as the generation of phonons (lattice waves), photogeneration, free carrier absorption, scattering, etc.

Keywords: Refractive index , Laser Sensor.

Detailled explanation:

If N is the complex refractive index, then N = *n* − *jK*, where the real part *n,* the refractive index, represents the effect of the medium on the phase velocity, and the imaginary part, K, called the extinction coefficient, represent the attenuation suffered by the wave as it travels along a well-defined propagation direction.
N can be defined in terms of the *complex relative permittivity* $\varepsilon_r = \varepsilon_{r'} - j\varepsilon_{r''}$ by $N = n - jk = \sqrt{\varepsilon_r} = \sqrt{\varepsilon_r' - j\varepsilon_r''}$
By squaring both sides we can relate *n* and *K* directly to ε*r*′ and ε*r*″.
The final result is $n^2 + k^2 = \varepsilon_r'$ and 2*nK* = ε*r*″ Optical properties of materials are typically reported either by showing the frequency dependences of *n* and *K* or ε*r*′ and ε*r*″. The complex relative permittivity and the complex refractive index of crystalline silicon in terms of the photon energy hω (or frequency) are shown below. For photon energies below the bandgap energy, both ε*r*″ and *K* are negligible and *n* is close to about 3.7. Both ε*r*″ and *K* increase and change strongly as the photon energy becomes greater than 3 eV; far beyond the bandgap energy (1.1 eV). Notice that both ε*r*′ and *n* peak around hω ≈ 3.5 eV.
The optical properties *n* and *K* can be determined by measuring the reflectance from the surface of a material as a function of polarization and the angle of incidence (based on Fresnel's equations). The reflection and transmission coefficients that are normally given by Fresnel's equations are based in using a real refractive index, that is, neglecting losses. We can still use the Fresnel reflection and transmission coefficients if we simply use the complex refractive index N instead of *n*. For example, consider a light wave traveling in free space incident on a material at normal incidence (θ*i* = 90°).

The reflection coefficient is now $r = \frac{N-1}{N+1} = \frac{n-jK-1}{n-jK+1}$

The reflectance is then $r = \left|\frac{n-jK-1}{n-jK+1}\right|^2 = \frac{(n-1)^2+K^2}{(n+1)^2+K^2}$

which reduce to the usual forms when the extinction coefficient *K* = 0.

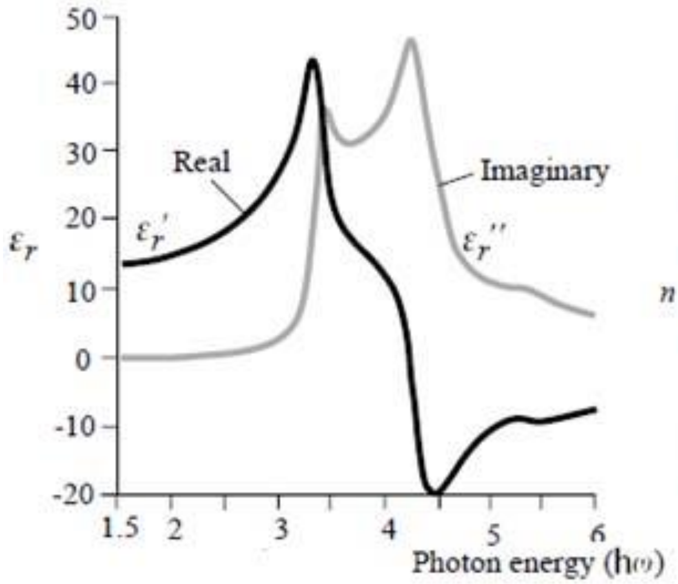

Figure.1

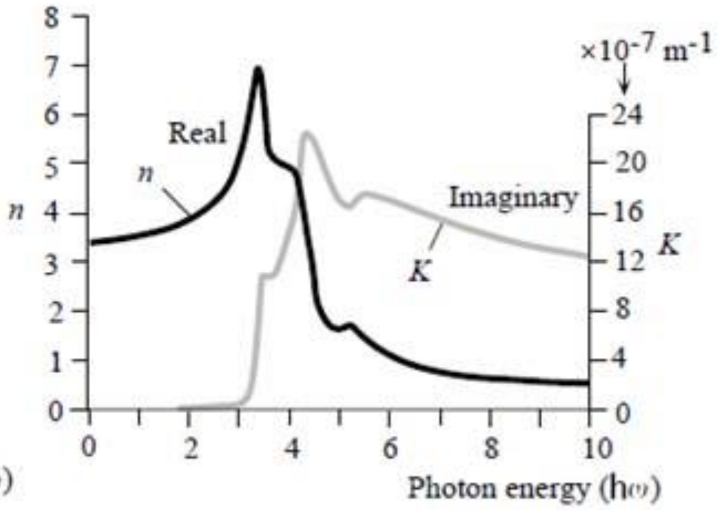

Figure.2

Figure.1: Complex relative permittivity of a silicon crystal as a function of photonenergy plotted in terms of real (ε_r') and imaginary(ε_r'') parts.

Figure.2 : Optical properties of a silicon crystal vs. photon energy in terms of real (*n*) and imaginary (*K*) parts of the complex refractive index.

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