Furthermore, the insulating layer 108 is formed on the second semiconductor layer 104 and the insulating layer 103. Note that the insulating layer 108 need not always be formed, and an air layer may be used instead. However, by forming the insulating layer 108, the second semiconductor layer 104 can be protected from the surrounding environment.

[0027] According to the first embodiment, since the second semiconductor layer 104 is formed by a compound semiconductor made of three or more materials, it is possible to improve the modulation efficiency of the optical modulator, as will be described below.

[0028] The effective mass and refractive index of a ternary or quaternary compound semiconductor can be controlled by controlling a composition. It is possible to improve light confinement and a carrier-induced refractive index change.

[0029] For example, the relationship between a composition y and a band gap energy Eg of $In_{1-x}Ga_xAs_yP_{1-y}$ is given by:

$$Eg = 1.344 - 0.738y + 0.138y^2$$

[0030] As is well known, a refractive index change induced by current injection in a semiconductor has the carrier plasma effect, band filling effect, and band gap reduction effect. In consideration of these effects, when an electron concentration is changed by 2×10^{18} cm^{-3}, the refractive index of InP changes by 0.0094.

Conversely, when the electron concentration is changed by 2×10^{18} cm^{-3}, the refractive index of $In_{1-x}Ga_xAs_yP_{1-y}$ with Eg = 0.95 eV changes by 0.013, the refractive index of $In_{1-x}Ga_xAs_yP_{1-y}$ with Eg = 0.92 eV changes by 0.0145, and the refractive index of $In_{1-x}Ga_xAs_yP_{1-y}$ with Eg = 0.89 eV changes by 0.016.

[0031] Note that $In_{1-x}Ga_xAs_yP_{1-y}$ with Eg = 0.95 eV has a band gap wavelength λ of 1.3 μm, $In_{1-x}Ga_xAs_yP_{1-y}$ with Eg = 0.92 eV has a band gap wavelength λ of 1.35 μm, and $In_{1-x}Ga_xAs_yP_{1-y}$ with Eg = 0.89 eV has a band gap wavelength λ of 1.4 μm.

[0032] As for $In_{1-x}Ga_xAs_yP_{1-y}$, as the band gap energy decreases by changing the composition ratio, a carrier-induced refractive index change increases to be greater than that of InP of a binary material.

[0033] In general, as for $In_{1-x}Ga_xAs_yP_{1-y}$, as the band gap energy decreases, the refractive index increases. The light confinement effect in the optical waveguide portion 121 increases by using a material with a high refractive index for the second semiconductor layer 104 forming the optical waveguide portion 121, thereby making it possible to strengthen the light intensity (distribution) in the optical waveguide portion 121. As a result, majority carriers generated at the interface of the second semiconductor layer 104 with the insulating layer 103 in the optical waveguide portion 121 can be made to more strongly work on light that is