Optical Determination of Carrier Concentration in Degenerately Doped InAs Thin Films in Radiation Generating Devices in the THz Region

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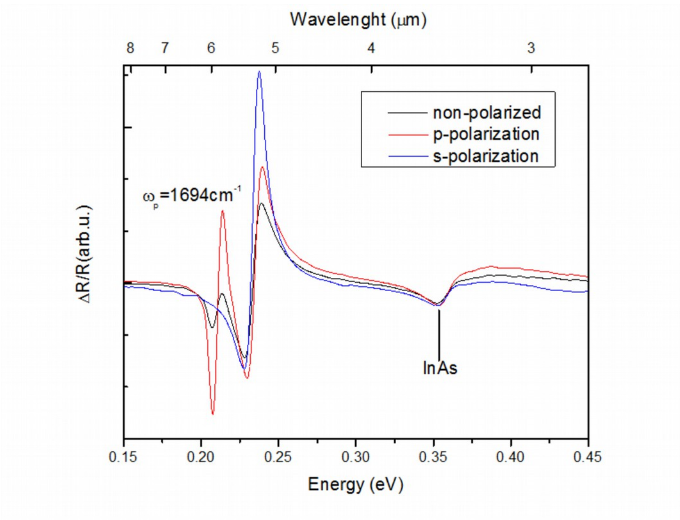
The need for improvement of commonly available terahertz (THz) sources has led to advances in semiconductor surface based generation methods. One approach is to incorporate a heavily doped reflection layer into the sample structure [1]. In these InAs based systems it is critical to use a proper dopant density in order to achieve high enough reflectivity to further increase the emission intensity. However, the latter depends on the plasma frequency characteristic for the given free carrier concentration. According to the Drude-model, at a carrier concentration level of $1\cdot 10^{19}\,cm^{-3}$, which is often used in the structures of terahertz emitters, the resulting plasma frequency is on the order of $31\ THz$ - far above our samples emitted center frequency. Radiation of frequencies below the plasma frequency is very well reflected, because the electrons in the metal-like material screen the electric field of the electromagnetic wave.

By using spectroscopic techniques we may gain additional insight into the efficacy of employed doping methods. At the origin of the used approach lies the phenomenon of absorption of longitudinal optical modes in the *p*-polarized component of radiation (fig. below) as described by Berreman [2] and later named after him. By utilizing this effect to reflectance measurements [3] we have been able to extract information about carrier concentrations.



We also considered the shift of the fundamental energy gap transition in InAs, due to the Burrstein-Moss effect and band gap renormalization, to obtain further confirmation of our experimental findings. We argue that this fast and non-destructive technique could became the go-to method for the determination of doping densities in thin semiconductor films.

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[2] D.W. Berreman, Phys. Rev. **130,** 2193-2198 (1966)

[3] M. Motyka, J. Misiewicz, Appl. Phys. Express **3** 112401 (2010)