Characterization of Terahertz Emission from High Resistivity Fe-doped Bulk $Ga_{0.69}In_{0.31}As$ Based Photoconducting Antennas Excited at 800 nm

by

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ABSTRACT

In this dissertation we investigate pulsed terahertz (THz) emission characteristics of semi-large aperture photoconducting (PC) antennas fabricated on Fe-doped bulk $Ga_{0.69}In_{0.31}As$ substrate. The research is aimed at evaluating the impact of physical properties of a semi-large aperture $Ga_{0.69}In_{0.31}As$ PC antenna upon its THz generation efficiency, and is motivated by the ultimate goal of developing a pulsed THz radiation source with MHz repetition rates, capable of operating at wavelengths between 1 – 1.5 μm, and having an average output power of 1mW.

The bulk $Ga_{0.69}In_{0.31}As$ crystals employed in this dissertation were grown using a hybrid vertical Bridgman and gradient freezing directional solidification process. The crystals were uniformly doped with Fe atoms to obtain high resistivity ~ 10^7 Ω. The carrier lifetimes in bulk $Ga_{0.69}In_{0.31}As$ crystals estimated using transient photoreflectivity measurements is in the subpicosecond range. The ultrafast carrier mobility in this material, estimated from THz emission measurements in about two orders of magnitude higher than that reported in $Ga_xIn_{1-x}As$ thin films grown by molecular beam epitaxy. The high ultrafast carrier mobility along with high resistivity and subpicosecond carrier lifetimes make $Ga_{0.69}In_{0.31}As$ an excellent candidate for semi-large aperture PC antenna based THz emitter. Further, the band gap of $Ga_{0.69}In_{0.31}As$ is low enough (~ 1 eV), thus making it possible to use compact Yb-based multiwatt laser systems operating at 1.1 μm for photoexcitation of $Ga_{0.69}In_{0.31}As$ based PC antennas for high power THz emission.

Our simulations based on experimental results of THz emission from $Ga_{0.69}In_{0.31}As$ PC antenna (photoexcited at 810 nm) predict that an output THz power of 51 μW can be extracted from a semi-large $Ga_{0.69}In_{0.31}As$ PC antenna with electrode gap spacing of 0.8 mm when it is operated with an external bias voltage of 11.5 kV/cm and photoexcited with 1 W of incident laser power (obtained from a Yb:KYW laser). This result is promising in that it is a factor of ten within the range of half a milliwatt of output THz power, and is about two orders of magnitude higher than the output of an InAs crystal which is a commonly used emitter in most THz time-domain spectroscopy systems.