Photoconductivity in LT-GaAs-on-Si studied by optical pump terahertz probe

FIR Center, Univ. Fukui [1], Nat'l Inst. Of Physics, Univ. Philippines [2], °Jessica Afalla[1], Alexander De Los Reyes[2], Maria Angela Faustino[2], Gerald Catindig[2], Elizabeth Prieto[2], Karl Cedric Gonzales[2], Valynn Mag-usara[1], Armando Somintac[2], Arnel Salvador[2], Elmer Estacio[2], Masahiko Tani[1]

E-mail: jessica@fir.u-fukui.ac.jp

Low temperature grown GaAs (LT-GaAs) has become the choice material for THz photoconductive antennas (PCA) designed for 800 nm applications. Its ultrafast response, high carrier mobility, and high resistivity make it ideal for THz applications. Motivated by the possibility of widening the detection bandwidth and reducing production cost, we explore the use of LT-GaAs grown on Silicon substrates as a material for THz PCAs [1]. Silicon is less absorbing in the THz region compared to GaAs, and can thus reduce THz absorption by the substrate material. Growing GaAs on Si substrates is difficult. Often the GaAs layers grown are riddled with defects such as dislocations, anti-phase boundaries, among others [2]. However, for THz applications, the photoconductive material does not have to be pristine. In this work, optical pump terahertz probe technique was used to measure the complex conductivities of LT-GaAs-on-Si to understand its conduction mechanism and ultimately its suitability as photoconductive material.

The complex conductivity of two LT-GaAs-on-Si samples grown using different growth temperatures and substrate orientations are shown in Fig. 1. We find that one sample, "off-axis" (grown at 280˚C, substrate: (100) with 4˚ tilt toward (110)) has high conductivity (max ~3000 S/cm) in the THz region, compared to only max ~1000 S/cm for the other sample (grown at 440 ˚C, substrate: Si(100)). Using known models to fit the data [3], the conductivity of the "off-axis" sample appears to follow the Drude model, similar to ordinary GaAs. The conductivity of the "on-axis" sample was better modeled using the phenomenological extension "Drude-Smith" which includes a backscattering term. This implies that defect density in "on-axis" sample is higher, with electrons encountering boundaries that cause backscattering.

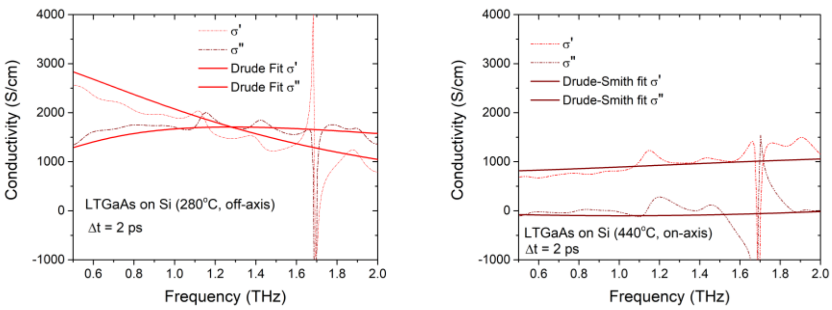

Fig.1 Complex conductivity of LT-GaAs on Silicon samples grown under different conditions, calculated from differential waveform measurements using optical pump terahertz probe spectroscopy

[1] J. Afalla, et al, *Semicond. Sci. Technol.* **34,** 035031(2019)

[2] Yu. B. Bolkhovityanov and O. P. Pchelyakov *Phys. Usp.* **51,** 437 (2008)

[3] J. Lloyd-Hughes and T.-I. Jeon, *J. Infrared Millimeter Terahertz Waves* **33**, 871 (2012)