n-Type doping GaSb using DMTe by metalorganic chemical vapor deposition (MOCVD)

Ari Handono Ramelan*a, Pepen Arifinb, and Ewa Goldys*c
aPhysics Department, Sebelas Maret University (UNS), Surakarta 57126, Indonesia.
bElectronics Material Laboratory, Institut Teknologi Bandung (ITB), Bandung 40132, Indonesia.
cPhysics Department, Macquarie University, Sydney NSW 2109, Australia.

BIOGRAPHY
Dr. Ari Handono Ramelan received his M.Sc. (Honours) degree in Physics from Macquarie University, Australia in 1992 and Ph.D. degree also in Physics from Macquarie University in 2002. Dr. Ramelan is a senior lecturer at Sebelas Maret University (UNS) in Indonesia. His current research is focused on the design and fabrication of photodetectors, nanomaterials for photovoltaics, and ferroelectrics materials for ultrasonic transducers and memory applications. Dr. Ramelan’s group at Sebelas Maret University has an ongoing research and development program on GaSb and GaN quantum dots grown using a MOCVD reactor.

TECHNICAL ABSTRACT
Antimony-based III-V semiconductors grown either lattice matched or slightly strained on GaSb substrates have received much attention both due to their potential applications as optical devices in the wavelength of 1-4 μm, and for their potential use in tunneling structures, exploiting the heterojunction offset. Although investigations in laser diodes have been carried out by many groups, problems still remain with the growth of device-quality GaSb layers, most significantly with doping.

Undoped GaSb usually exhibits p-type conductivity, owing to native lattice defect including Sb vacancies, antisite defects i.e., Ga atoms on Sb site, V_{GaGaSb}. The group-VI elements such as S, Se, and Te are commonly used as n-type dopants in GaSb because the group-VI elements such as Si and Sn are amphoteric and lead to heavily compensated p-type layers. Researchers have investigated the n-type doping of GaSb by all major techniques. In the course of this work, it was identified that group-VI elements have high vapour pressure and segregation coefficient, making it difficult to control the electron concentration. Therefore, the growth of GaSb doped with Te is still a challenging and worth in-depth exploration. In this work, dimethyltelluride (DMTe) has been used as a dopant for the MOCVD growth of GaSb. The physical properties of MOCVD grown Te-doped GaSb on SI-GaAs substrates are reported. The effects of dopant flow rate on surface morphology, electrical and optical properties have been determined.

Dimethyltelluride has been used as a dopant source for GaSb epilayers grown by atmospheric pressure metalorganic chemical vapour deposition (MOCVD). It has been observed that the electron concentration (n) is proportional to the Te partial pressure in the vapour phase, until n saturates at high Te partial pressure. Electron concentrations as high as 1.36 × 10^{18} cm^{-3} have been measured with imperfect morphology, and as high as 1.22 × 10^{18} cm^{-3} with excellent, mirror like, morphology. These appear to be the highest electron concentrations reported to date for any MOCVD-growth epitaxial n-type GaSb doped with DMTe and grown at 540 °C with a V/III ratio of 1.4. The absorption spectra of GaSb doped with DMTe show that the heavily doped samples have a less abrupt edge. The absorption coefficient (α) strongly depends on the free carrier concentration. PL spectra of the epilayers are also reported.

Keywords: GaSb, DMTe doping, III-V semiconductors, MOCVD, PL

The financial support from the Directorate General of Higher Education (DIKTI) the Ministry of Education and Culture (KEMENDIKBUD) the Government of Indonesia Republic is gratefully acknowledged.

*Email address : aramelan@mipa.uns.ac.id ; Phone /Fax : +62 271 663375

Fig. 1. Mobility of Te doped n-GaSb with different DMTe flows as a function of temperature.

Fig. 2. Carrier concentration of Te doped n-GaSb with different DMTe flow as a function of temperature.

Fig. 3. Optical absorption spectra of four GaSb samples with different concentration of DMTe at 300 K.

Fig. 4. PL spectra of GaSb doped with different concentrations of DMTe.