Growth and Characterization of GaAs (111) on 4H-SiC for Infrared Sensor

Subhashis Das,[1,2] Nirosh M Eldose,[1] Hryhorii Stanchu[1], Fernando Maia de Oliveira[1], Chen Li[1], Mourad Benamara[1], Yuriy I. Mazur[1], Gregory Salamo[1,2]

[1] *Institute for Nanoscience and Engineering, University of Arkansas, Fayetteville, AR, 72701, USA.*

[2] *Department of Physics, University of Arkansas, Fayetteville, AR, 72701, USA.*

Epitaxial growth of III-V semiconductors on 4H-SiC would potentially allow the integration of optical sensors on SiC based power devices. We report on the growth of high-quality crystalline GaAs layer on the SiC hexagonal substrate by molecular beam epitaxy (MBE). For fabrication on SiC, a 5 nm AlAs nucleation layer was grown at 700 °C followed by a 60 nm GaAs layer buffer grown at 600 °C. We will discuss the surface morphology, structural quality, and the optical properties of the MBE grown samples. The ω-2θ scan result (fig.1. (a)) corroborates the crystalline growth of GaAs (111) on 4H-SiC. The structural quality is further illustrated by the cross-sectional TEM image in fig. 1(b). It consists of a high-quality GaAs layer and a highly defected interface region between GaAs and the 4H-SiC substrate. This defect region is attributed to the lattice and crystal structure mismatch between substrate and film. Fig. 1(c) shows the temperature dependent photoluminescence properties of the grown structure. Good free-exciton (FE) emission has been observed at room temperature (300 K) and lower temperature (77 K). Excitingly, the optical results were comparable with the same structure grown on a GaAs substrate. Overall, these observations exhibit potential to achieve an optical emitter for sensors integrated on SiC based power device platform.

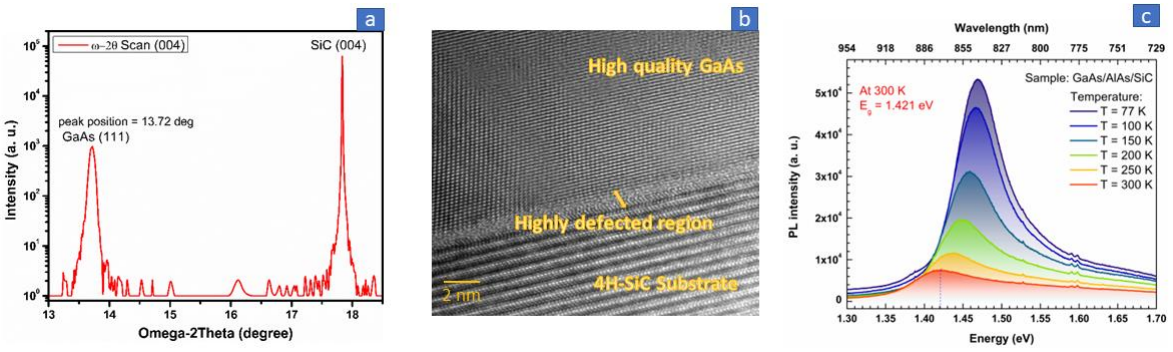

Figure 1. (a) XRD (ω-2θ) scan, (b) cross-sectional TEM image, (c) temperature dependent photoluminescence spectra of GaAs/SiC structure.

[1] S. K. Saha, R. Kumar, A. Kuchuk, M. Z. Alavijeh, Y. Maidaniuk, Y. I. Mazur, S.-Q. Yu, and G. J. Salamo, Cryst. Growth Des., **19**, 5088−5096 (2019).

+ Author for correspondence: subhashis.ds@email.com

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Fig. 2 depicts the nominal structure of the GaAs grown on 4H-SiC. A 5 nm AlAs nucleation layer was grown at 700 °C whereas, the buffer layer of 60 nm GaAs was grown at 600 °C. All the growth temperatures were measured by the thermocouple. Fig. 3 illustrates reflection high energy electron diffraction (RHEED) images before growth (fig. 3(a)) and after growth (fig. 3(b). A streaky RHEED image is evidence of high cleanliness and smoothness of substrate surface. The spotty pattern from fig. 3(b) indicates the 3D growth mode and the existence of twining.

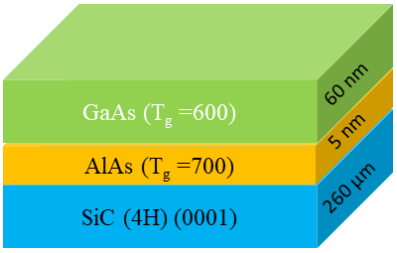

Fig. 2. Schematic structure of GaAs/SiC.

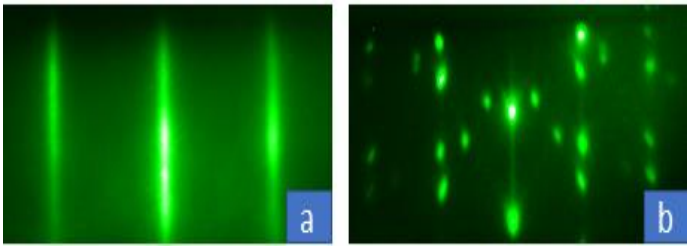

Fig. 3. RHEED images of GaAs/SiC structure (a) before growth and (b) after growth.