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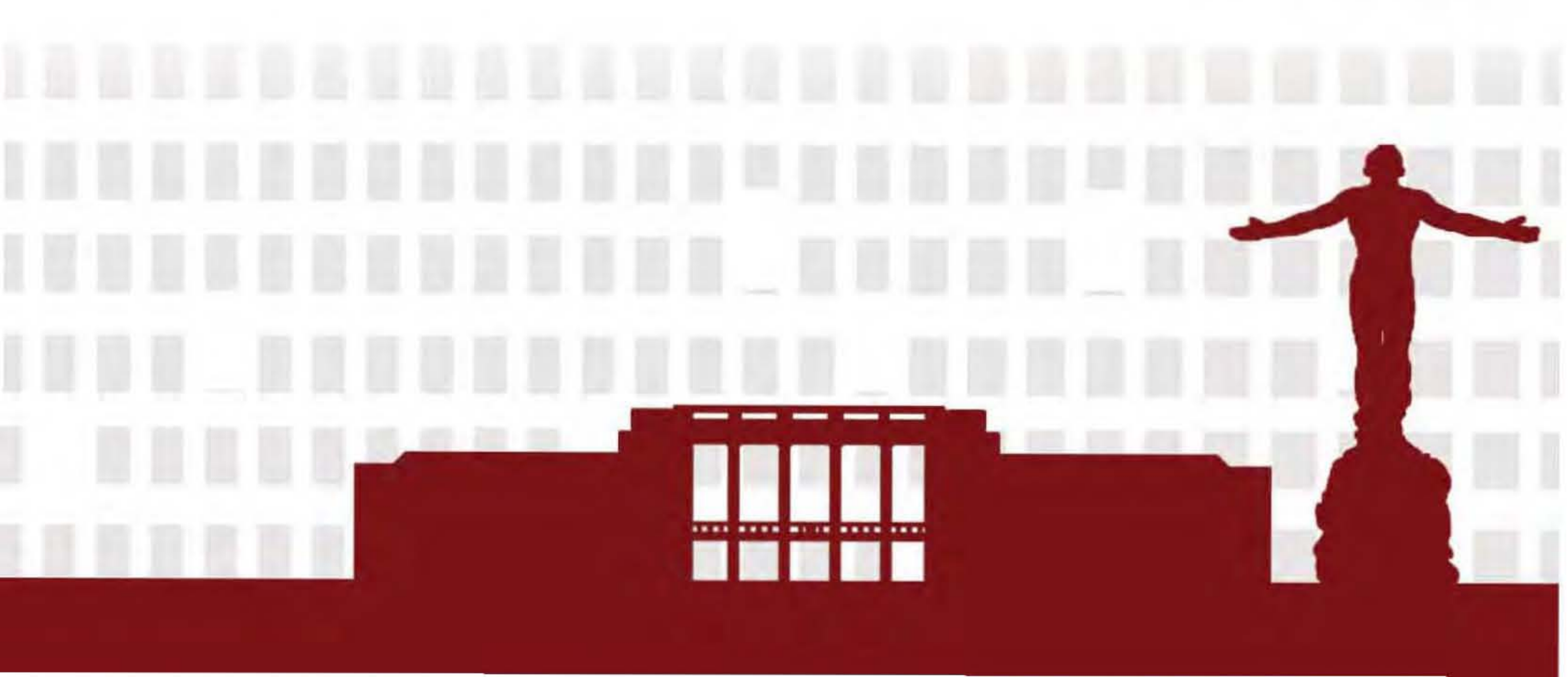

**Proceedings of the 8th AUN/SEED-Net RCEEE 2015 and 11th ERDT Conference on Semiconductor and Electronics, Information and Communications Technology, and Energy**

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Dr. Joel Joseph S. Marciano Jr.
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ISBN: 978-616-406-075-3

Published by: ASEAN University Network / Southeast Asia Engineering Education Development Network (AUN/SEED-Net) JICA Project
Faculty of Engineering, Bldg. 2
Chulalongkorn University, Bangkok
Thailand 10330

Printed in the Philippines by: ERZALAN PRINTING PRESS
45 Cotabato Street, Luzviminda Village, Batasan Hills, Quezon City, Philippines

# 8th AUN/SEED-Net Regional Conference
## on Electrical and Electronics Engineering 2015

co-located with

# 11th ERDT Conference
## on Semiconductor and Electronics, Information and Communications Technology, and Energy

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Published by: ASEAN University Network / Southeast Asia Engineering Education Development Network (AUN/SEED-Net) in partnership with Engineering Research and Development for Technology (ERDT) and University of the Philippines Diliman.


ISBN: 978-616-406-075-3

# GROWTH MECHANISM OF TYPE II GaSb/GaAs QUANTUM DOTS ON (001) Ge SUBSTRATES

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## ABSTRACT

We have investigated type II GaSb/GaAs quantum dots (QDs) grown on (001) Ge substrates. GaSb/GaAs has a lattice mismatch of 7.8% which is reasonable to create QDs with molecular beam epitaxy by Stranski-Krastonov growth mode. When GaAs buffer layer is grown on Ge, anti-phase domains (APDs) are created by polar/non-polar effect. The quality of GaAs APD is a crucial parameter for GaSb QDs formation. It is found that when APD layer is too thick (600 nm) and at rather high substrate temperature (580°C) for buffer layer growth and at high substrate temperature (~450°C) for QD growth, GaSb QDs are preferable to form at APD grain boundary rather than inside the APD grains. This is due to Sb atom mobility at high substrate temperature and accumulated strain at thick APD grain boundary. When thinner GaAs layer (500 nm) is grown on (001) Ge substrate at lower buffer layer growth substrate temperature (~500°C) for buffer layer growth and low QD growth temperature (~407°C), Sb atoms are spread on the whole GaAs APD surface during Sb soaking because of Sb high sticking coefficient. This leads to high density GaSb QD formation (~ 8.2×109 dots/cm2) on the whole sample surface which is desirable for photovoltaic device application.

Type II GaSb/GaAs QD has a high potential for photonic devices like memory, photo-detectors, solar cells due to long carrier life time and low recombination rate [1]. Ge is a good semiconductor material for infrared detection [2]. Most of high efficiency tandem solar cells are also grown on Ge substrates [3]. The objective of this research work is to combine quantum nanostructures with (001) Ge substrates using type II GaSb/GaAs QDs. High quality of dot structure with good dot uniformity and dot distribution are required for high performance photonic devices. The technical difficulty of growing compound semiconductors on (001) Ge substrate is the existence of APDs. Therefore, it is necessary to investigate the growth parameters to prepare high quality both of GaAs APD layer on Ge and GaSb QDs on top. 2

All the experiments are conducted by molecular beam epitaxy (Riber Compact 21 TM) with Sb cracker cell. Atomic force microscopy (AFM) is used to observe surface morphology of the samples. When thick GaAs buffer layer (600 nm) is grown on (001) Ge substrate and GaSb QDs are grown at ~450°C, it is found that GaSb QDs are created at APD grain boundary as shown in figure 1(a). The dot density is ~ 9.3 × 108 dots/cm2 with average dot diameter and height of 56 nm and 4.5 nm respectively.

When we decrease the GaAs buffer layer thickness from 600 nm to 500 nm and the QDs growth substrate temperature is also reduced to ~ 407°C, the top surface of APDs become flatten and the QDs can be formed on the whole surface mostly inside the APDs. Some QDs are still formed on the APD grain boundary. By adjusting these growth parameters, the dot density increases to ~ 8.2 × 109 dots/cm2, and QDs sizes are uniform with larger average dot diameter of 65 nm and smaller average dot height of 2.3 nm as shown in figure 1(b).

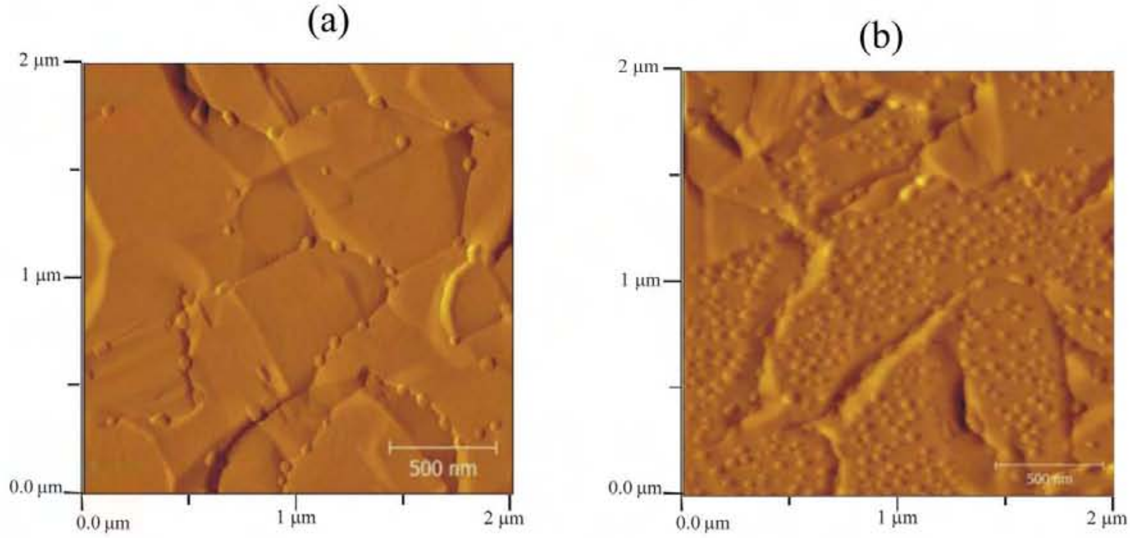


**Figure 1.** AFM images of QDs formation on GaAs buffer layer (a) 600 nm, (b) 500 nm and QDs growth temperature at (a) 450 °C, (b) 407 °C.

**Keywords:** Anti-Phase Domains, Antimony, Atomic Force Microscopy, Molecular Beam Epitaxy, Quantum Dots Nanostructure, Germanium.

**Acknowledgments**

The authors would like to express appreciation for the support of the sponsors; Nanotechnology Centre of Thailand (Nanotech), Office of the High Education Commission, Thailand Research Fund (TRF) [Grant no. DPG 5380002], Asian Office of Aerospace Research and Development (AOARD) [Contact no. FA2386-14-1-4081], Chulalongkorn University, Research University Program of office of High Education Commission in Energy Cluster of Chulalongkorn University (EN264A) and ASEAN University Network/Southeast Asia Engineering Education Development Network (AUN/SEED-Net).

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