Direct growth of gasb on Ge, Ge-On-Si and SIGE-On-Si platforms for integrated MID infra-red photonics

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DIRECT GROWTH OF GASB ON GE, GE-ON-SI AND SIGE-ON-SI PLATFORMS FOR INTEGRATED MID INFRA-RED PHOTONICS

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SUMMARY

We study the growth of GaSb on germanium-based platforms for mid-infrared photonics. Anti-phase domain are buried in a 500 nm GaSb buffer layer on Ge and Ge-on-Si templates thanks to slightly miscut substrates or chemicaly-mechanicaly polished surfaces.

1. INTRODUCTION

Integrated mid-infrared (MIR) photonics is of major interest for free-space communications, bio-sensing, etc. III-V antimony-based lasers are efficient MIR light sources that can be grown on passive Si photonic circuits. However, most Si-based materials absorb a large part of the MIR spectrum above 8 µm, in contrast to germanium which has a wide MIR transparency window [1]. The direct growth of III-Sb materials on Ge substrates or Ge-on-Si templates would allow the development of integrated photonic circuits operating at long wavelengths (up to 14 µm). Still, III-V heteroepitaxy on group-IV substrates is plagued by various crystal defects. In particular, anti-phase boundaries (APBs) are 2D defects delineating antiphase domains (APDs). They are particularly detrimental to devices because they act as short circuits. In this work, we investigated the growth of GaSb on Ge substrates and on Ge-on-Si templates grown by low-energy plasma-enhanced CVD (LEPECVD) [2].

2. ANTIPHASE DOMAINS BURYING

Recently, a growth strategy has been developed to bury APDs and thus suppress emerging APBs during the MBE growth of GaSb on (001) Si substrates [3,4]. It consists in using the residual miscut angle of the substrate (<0.5 °) to organize the Si surface and to grow GaSb in the step-flow mode. The anisotropic incorporation rate in III-V growth results in the Sb-polar phase progressively overgrowing the Ga-polar phase, resulting in APD burying (Fig. 1) [4]. In this work, we have adapted this strategy to the growth of APB-free GaSb layers on germanium substrates and Ge-on-Si templates.

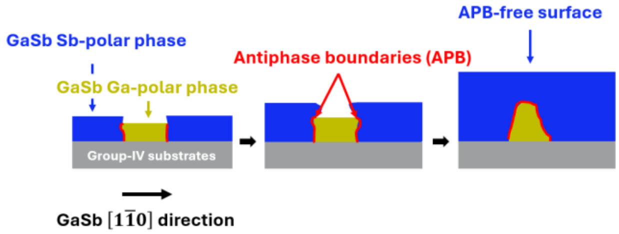

Figure 1 APB burying mechanism during GaSb growth on group-IV elements

3. RESULTS

The starting surface preparation is critical for growing APB-free GaSb films on group-IV substrates [4]. We found that APB-free GaSb layers can be achieved only when the Ge substrates are prepared by UHV annealing in a narrow temperature window. The Ge-on-Si and SiGe/Si templates, however, exhibit cross hatch patterns arising from strain relaxation during template growth, which prevents proper surface organization prior and during III-V growth. This, in turn, precludes APB annihilation. We found that this effect can be alleviated either by using slightly miscut (1° - 2°) Si substrates, or by smoothing the starting surface of on-axis Ge-on-Si templates by chemical-mechanical polishing. Under these conditions, APB-free GaSb layers can be achieved after 500 nm growth. They exhibit a rms roughness of 1.0 nm.

4. ACKNOWLEDGMENTS

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