The 20th International Conference on Metalorganic Vapor Phase Epitaxy (ICMOVPE XX)
Fellbach, Germany, June 14. – 19. 2020

Selective area epitaxy for electronic and optical device fabrication on Si

Philipp Staudinger, Svenja Mauthe, Noelia Vico Triviño, Clarissa Convertino, Cezar Zota, Lukas Czornomaz, Kirsten Moselund, and Heinz Schmid*

IBM Research Zurich, Säumerstrasse 4, 8803 Rüschlikon, Switzerland

Selective growth techniques became very popular in the scientific community thanks to the interest in nanowires and related topics that have flourished over the past 20 years. In this contribution we will review two activities that have been pursued in our group and which were enabled by selective area growth: integration of III-V semiconductors on Si for microelectronic applications, and second, a path for synthesis of III-V semiconductors in their thermodynamic less stable wurtzite crystal configuration.

III-V selective epitaxy is carried out in an MOVPE reactor on samples with hollow template structures made from silicon oxide and without the use of catalyst particles. The templates are patterned in various shapes to confine and guide the crystal growth. Growth on lattice mismatched silicon substrates is preferably carried out by reducing the area of the heterointerface to sub-micron dimensions to suppress the creation and propagation of threading dislocations into the active device area. While the mask size is not limited for homoepitaxial growth, submicron masks have the distinct advantage to result in highly anisotropic growth structures if properly designed. The materials of interest are In(Ga)As and GaSb as channel material for nanowire FET devices and GaAs and InP for optical devices [1]. We find that the structural quality of the integrated material yields high performance devices, and that details of the growth condition and involved growth surfaces can lead to undesired polytypic crystal phases.

Control over the crystal phase is obviously highly desirable to suppress defect formation from polytypes. Growth of the thermodynamically less stable (wurtzite) crystal structure could further enable new applications. Wurtzite phase phosphides light emitters could fill the "green gap" [2] or serve as substrates for hexagonal (lonsdaleite) phase SiGe having a direct bandgap [3]. We address these opportunities and show various selective area epitaxy approaches which enable to grow InP in its thermodynamically less stable wurtzite phase and with the additional goal of increasing the wurtzite sample dimensions beyond the nano(wire) size limit [4].

We received support from H2020 projects PLASMIC #678567, SiLAS # 735008, INSIGHT # 688784 and SNF project #200021_156746.

References:

[1] Schmid, H. et al. Electron Devices Meeting (IEDM) 3.6. 1 (2016)
[2] Gagliano, L. et al. Nano Lett. 18, 3543–3549 (2018)
[3] Fadaly, E. M. T., et al. arXiv:1911.00726 1–25 (2019)
[4] Staudinger, P. et al. Nano Lett. 20, 686-693 (2020)

Presenting author Email address: sih@zurich.ibm.com