Local analyses of strain relaxation in Ge-rich SiGe layers

Adam Arette-Hourquet [a], Anne-Flore Mallet [b], Olivier Gourhant [b], Christophe Duluard [b], Luc Favre [a], Isabelle Berbezier [a]

[a] STMicroelectronics, 850 rue Jean Monnet, 38920, Crolles, France
[b] Aix Marseille Université, CNRS, Université de Toulon, IM2NP, Avenue Escadrille Normandie Niemen, 13397, Marseille, France

The integration of germanium in the silicon technology would lead to the production of superior photonic integrated circuits. A new high temperature and ultra low speed oxidation process is paving the way to defect-free, fully relaxed Germanium On Insulator (GOI) film. In this study a partially relaxed $Si_{1-x}Ge_x/SiO_2$ thin films with Ge concentrations higher than $x \geqslant 0.4$ were obtained by the combination of epitaxy and condensation. As demonstrated recently [1], at these concentrations the $Si_{1-x}Ge_x$ relaxes through the viscous deformation of SiO_2 and the undulation of the $Si_{1-x}Ge_x$ layer embedded in the oxide. The viscous deformation of the oxide allows to relax the strain accumulated during the oxidation and preserves the crystal quality contrary to what is obtained with dislocation nucleation. However, the swelling of the silicon oxide layer should be well controlled since it can be an impediment for reepitaxy. We show that after condensation, the relaxation of the $Si_{1-x}Ge_x$ layer is achieved with very limited swelling of SiO_2, as shown by Geometric Phase Analysis of High Resolution Transmission Electron Microscopy cross-section images. However, the relaxation is increased by high temperature annealing, Reepitaxy of same concentration Ge-rich $Si_{1-x}Ge_x$ layer was performed on this partially relaxed buffer layer. Defect density is determined by XRD and TEM. A density of dislocations lower than $10^5/cm^2$ was obtained with this process. This study brings closer to the synthesis of thick monocrystalline GOI layers with very low density of defects, suitable for optoelectronic devices. Such thick layers can be used as efficient photodetector and can be coupled with a bipolar transistor on the same wafer to produce vanguard devices for facial recognition or LIDAR.

[1] Elie Assaf, Isabelle Berbezier, Mohammed Bouabdellaoui, Marco Abbarchi, Antoine Ronda, Damien Valenducq, Fabien Deprat, Olivier Gourhant, Andreas Campos, Luc Favre, Local defect-free elastic strain relaxation of Si1-xGex embedded into SiO2, *Appl. Surf. Sci.* 2022, 590, 153015, https://doi.org/10.1016/j.apsusc.2022.153015