THESIS DEFENSE

Brett Ley/MS Candidate

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Wafer-Scale Controlled Spalling and Reuse of (100)-Oriented Germanium

Abstract

Despite having world record efficiencies, high costs associated with deposition and the substrate have barred III-V entry into terrestrial PV markets. Substrate reuse technology offers a promising route towards reducing III-V manufacturing costs where devices deposited on the substrate are lifted off to enable the substrate to be used for future growths. Controlled spalling is a potential substrate reuse method and is the focus of this work.

Controlled spalling is a method of exfoliating single-crystal sheets by propagating a crack parallel to the surface by applying an external force to a sub-critically stressed overlayer deposited on the substrate This work develops a method to reliably spall 2” (100)-Ge wafers in order to test the hypothesis that, despite having different geometries, the electroplating parameters used to controllably spall square test samples can be directly applied to the wafer-scale. An automated spalling jig is developed to enable safe wafer handling and facilitate controlled spalling at a constant velocity. Crack initiation is found to be a vital step to achieve controlled spalling at the wafer-scale.

As-spalled (100)-Ge wafers are also investigated as substrates for III-V device growth. A 12.8% efficient single-junction GaAs device without an antireflective coating is grown on an as-spalled (100)-Ge wafer using HVPE at NREL. Spall depth for full wafers is observed to be inconsistent. Crack arrest lines that are generated during controlled spalling are amplified by defects that form during the electroplating process. However, arrest lines in Ge appear to be morphological defects only, as dislocations are not observed to form as a result of electroplating or controlled spalling processes.

ADVISORS
Corinne Packard

COMMITTEE
Garritt Tucker
Ivar Reimanis

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