Growth and Characterization of Epitaxial Ge on As-Passivated (211)Si by Chemical Vapor Deposition for HgCdTe Based Infrared Detector Applications

by

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the degree of

MASTER OF SCIENCE

Major Subject: Electrical Engineering

The original of the complete thesis is on file
In the Rensselaer Polytechnic Institute Library

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Troy, New York

April, 2011
(For Graduation May 2011)

ABSTRACT

Mercury Cadmium Telluride (MCT or HgCdTe) is presently the material of choice for the fabrication of infrared (IR) detectors used in night vision based military applications. Till recently, growth of MCT was carried out on lattice matched bulk CdZnTe substrates that are available only in small sizes (~7 cm × 7 cm) and are expensive to produce. The use of Si as an alternate substrate has emerged as a viable option for the growth of HgCdTe because it offers some distinct advantages such as low cost and availability of large area (up to 12 inches) high quality wafers. Moreover, devices fabricated on MCT grown on Si substrates have relatively less thermal mismatch issues with the Si readout chip.

(211) oriented Si substrate is preferred in the Unites States for the growth of epitaxial HgCdTe as it has been observed to suppress twinning and hillock formation in the layers grown by molecular beam epitaxy (MBE). But due to the ~19% lattice mismatch between HgCdTe and Si, generation of misfit dislocations (MDs) at the HgCdTe/Si interface is unavoidable. These and other defects may extend deeper into the thick layers and may substantially degrade the performance of the devices. To reduce this problem, usually buffer layers of Ge, ZnTe and CdTe are grown on Si prior to HgCdTe growth.

Most of the work on Ge growth on (211)Si has been done by MBE and very few results on chemical vapor deposition (CVD) growth are found in the literature. The present work focuses on achieving epitaxial growth of Ge on As passivated (211)Si by CVD. The need to have As passivation arose to deal with the problem of cross contamination of the starting Si substrate with the residual species present inside the reactor chamber. Arsenic passivation not only resulted in preventing Si surface contamination but also changed the growth mode of Ge on Si by prolonging its layer-by-layer evolution during the initial growth phase.

Growth of ultra thin (~1-3 nm) and thick (~250 nm) Ge was achieved by single and double step growth processes and the layers were characterized by techniques such as scanning electron microscopy (SEM), atomic force microscopy (AFM), transmission electron microscopy (TEM) and x-ray diffractometry (XRD). This work, which highlights the need to have epitaxial Ge and As passivation of (211)Si, is the first ever

report on the CVD growth of epitaxial Ge on As passivated (211)Si, with the intention of using these layers for subsequent growth of CdTe/HgCdTe. Further efforts that could be implemented towards improving the crystal quality of Ge, for example, by employing new techniques such as nanopatterning have also been presented in the end.