

Low cost Ge/Si virtual substrate engineering for III-V multi-junction solar cell

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Multi-junction III-V concentrator cells have the most important energy conversion efficiency, competing with any other solar cell technology. Various cell designs have been proposed to achieve the efficiency of over 40% [1], [2]. Germanium appears to be the material of choice for the bottom cell to cover the IR part of solar spectrum. A high efficiency of 40.7% was measured for a metamorphic three-junction GaInP/GaInAs/Ge cell at 240 suns [3]. This architecture has achieved system efficiency of 30% [4]. A road map based on the integration of Ge on Si wafers can be a solution to replace the bulk Ge substrates for significant cost savings. However, due to the important 4.2% lattice mismatch between Si and Ge, strain is introduced in epitaxial Ge layers on Si which leads to the generation of a misfit dislocations network. Dislocations act as recombination centers for carriers and strongly influence the solar cell performance [5]. Several techniques of dislocation reduction were reported in the recent years [6]. However, the threading dislocations density (TDD) in the Ge layer remains higher than 10^6 cm^{-1} .

In this work, we propose a new architecture of low cost virtual substrate engineering with acceptable TDD and surface roughness for III-V multi-junction solar cell. Ge/Si substrate was treated with post epitaxial process to create a denser nanovoids region in Ge layer according to the mass transport mechanism [7]. Fig 1. shows cross section SEM view of self-assembled nanovoids in Ge layer/Si obtained after electrochemical porosification [8][10] and thermal annealing. The idea here is to use voids as a barrier for threading dislocations propagation. In this presentation, we will present detailed optimization of the porosification and the annealing of Ge on Si and study the effect of different process parameters on TDD and on surface roughness. The resulting surface can be used as the starting point for the deposition of the III-V junctions in the 3J PV cell. This engineered substrate concept is promising for the fabrication of dislocation-free Ge on Si substrate and would result in a significant cost reduction in multi-junction solar cells cost.

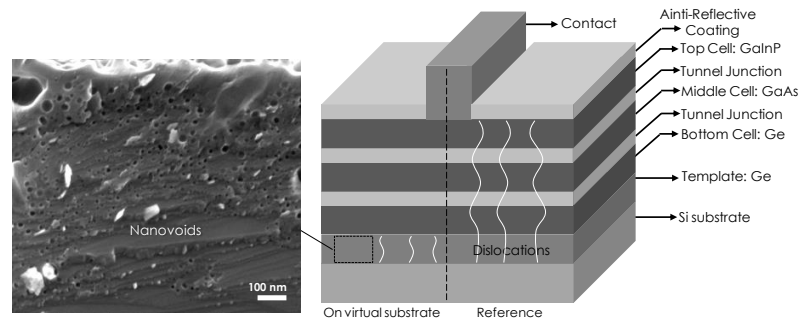


Fig 1. Cross section SEM view of Ge template with high nanovoid density (left) and Standard 3-J solar cell GaInP/GaAs/Ge/Si structure (right).

Keywords: CPV, solar cells, virtual substrate, nanomaterials.

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