

Nitrogen Plasma Doping of Single-Crystal ZnTe and CdZnTe on Si by MBE

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We have investigated *in situ* *p*-type doping of ZnTe and CdZnTe on Si(211) by molecular beam epitaxy using a radiofrequency (RF)-nitrogen plasma source for application to multijunction II–VI-based solar cells. CdZnTe would be used as a wide-gap top cell in a monolithic multijunction device, and ZnTe or CdZnTe could be used for the *p*-side of tunnel junctions. Highly *p*-type material is required for producing the high-quality tunnel junctions crucial for maintaining current flow, and *p*-doping of order 10^{17} cm⁻³ is required for the generation of a large built-in potential in the absorber region of solar cells. Our uniformly doped films exhibited good Hall characteristics, especially considering the large lattice mismatch between Si and either ZnTe or CdZnTe. Crystal quality was examined by x-ray diffraction. Nitrogen incorporation was examined as a function of the source-gas dilution with argon. A sample with layers of CdZnTe doped using 1% to 100% nitrogen was grown on nominally undoped CdZnTe and analyzed using secondary-ion mass spectrometry. The nitrogen incorporation differed by only a factor of 10, despite the factor of 100 difference in the nitrogen concentration in the plasma, indicating a saturation effect.

Key words: ZnTe, CdZnTe, *p*-type doping, MBE, RF-plasma source, nitrogen

INTRODUCTION

Based on previous technology to obtain high-quality CdTe and CdZnTe epitaxial buffer layers on silicon substrates for infrared (IR) applications, there is a potential for II–VI monolithic multijunction solar cells based on a Si bottom cell with the promise of a conversion efficiency as high as, if not higher than, that of their III–V-based counterparts.^{1,2} Compared with Ge or GaAs, Si has a more ideal band gap (E_g) for the bottom junction of a two-junction (tandem, 2J) or three-junction (3J) cell configuration.^{3,4} Theoretical values of both the Shockley–Queisser and “standard model” efficiency, assuming a fixed ideality factor, for III–V-based multijunction cells have been shown to be

lower than those of II–VI-based 2J or 3J cells.² Additionally, concentrator photovoltaic systems on the ground could become a viable possibility, especially with a low-cost crystal Si solar cell market.⁵

A possible II–VI-based triple-junction device configuration is shown in Fig. 1. Here, Cd_{1-x}Zn_xTe with a high *x*-value would be used for the large-gap top cell, Cd_{1-x}Zn_xTe with a low *x*-value would be used for the middle-gap center cell, and Si would be used as the small-gap bottom cell. To achieve such a device, high-quality CdZnTe grown on single-crystal Si needs to be fully understood. The improved efficiency of a multijunction photovoltaic device, compared with a single-junction device, relies on the voltage addition of the monolithic junctions. As such, high doping in the absorbers is desired to establish a high open-circuit voltage. Current management in a monolithic multijunction device is

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