III-V/Ge Multijunction Solar Cell with Through Cell Via Contacts Fabrication

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1. Introduction

There is growing interest in using through cell via contacts (TCVC) to replace conventional grid-line and busbar top contacts on multijunction solar cells (MJSCs) to increase the cell efficiency [1, 2]. This new contact architecture uses insulated metallized vias to forward the front side emitter current to the cell back, where both contacts are located. Simulations have shown that this could reduce shading and resistive losses and result in higher cell efficiency [1]. Furthermore, front busbar elimination could maximize the active area and increase power yield per wafer by 20 % [1]. MJSCs with such contacts were fabricated on inverted GaInP/AlGaAs dual-junction solar cells [2], confirming the feasibility of this technology. However, this architecture has not been fabricated on III-V/Ge triple-junction heterostructures. This abstract proposes a microfabrication process for III-V/Ge MJSCs with through cell via contacts.

2. Process Flow and Results

The starting substrates are III-V/Ge triple-junction heterostructures. Schematics of the microfabrication process flow are presented in Fig. 1. Via holes are plasma-etched in the III-V/Ge layers (Fig. 1a), using a $SiCl_4/H_2/Cl_2$ plasma chemistry to obtain anisotropic etching. The vias are then electrically insulated by plasma-enhanced atomic layer deposition (PEALD) (Fig 1b); this process allows a 0.1 % leak defect rate, thus reducing the risk of creating short-circuits [3]. The vias are then metallized (Fig. 1c) by a single Ti/Ag evaporation. The insulation layer on the surface is then etched to reveal the contact layer (Fig. 1d). Cross-finger ohmic contacts are then deposited on both the via metallization and the contact layer (Fig. 1e). The cells are then electrically insulated by plasma etching (Fig. 1f) [4], and the contact layer is etched (Fig. 1g). Figure 2 is an optical microscope image of a TCVC MJSC showing the cross-finger ohmic contacts and the insulation trenches. The front side is then permanently fixed on a quartz superstrate with polydimethylsiloxane (PDMS) (Fig. 1h) [5] for backside processing. The Ge substrate is then thinned by plasma etching to reveal the vias (Fig. 1i). The results of scanning electron microscopy performed after Ge thinning (step i of Fig. 1) are presented in Fig. 3. Figure 3a) shows a ~20µm-thick triple-junction solar cell bonded on the quartz superstrate with PDMS. An insulated and metallized via crossing the III-V/Ge heterostructure can be observed, as can a shallower electrical-insulation trench that does not fully cross the Ge (to prevent cell singulation). An insulated and metallized via is presented on Fig. 3b) confirming that the thinning process is highly selective to the via insulation. After thinning, the Ge contact is then formed (Fig. 1j) before being cladded by a backside electrical insulating layer (Fig. 1k). The insulation layer is then etched to reveal the via metallization (Fig. 1l). To complete the via contact, a last metal evaporation is performed (Fig. 1m) and the insulation layer is opened over the Ge contact (Fig. 1n). After this last step, both emitter and base contacts can be accessed by the backside and the TCVC MJSC can be electrically characterized. The first TCVC III-V/Ge MJSC prototypes are currently being fabricated and they will be characterized using standard opto-electrical measurements to evaluate their performance under AM1.5 D spectrum and for high concentrations.

3. Conclusion

In conclusion, a full microfabrication process is proposed to fabricate multijunction solar cells with through cell via contacts on III-V/Ge heterostructures. The process proposed could allow the fabrication of III-V/Ge MJSCs with higher efficiency thanks to the lower shading and resistive losses [1]. The expected results from the ongoing experiments could demonstrate the potential of this new contact architecture on III-V/Ge multijunction heterostructures.

References

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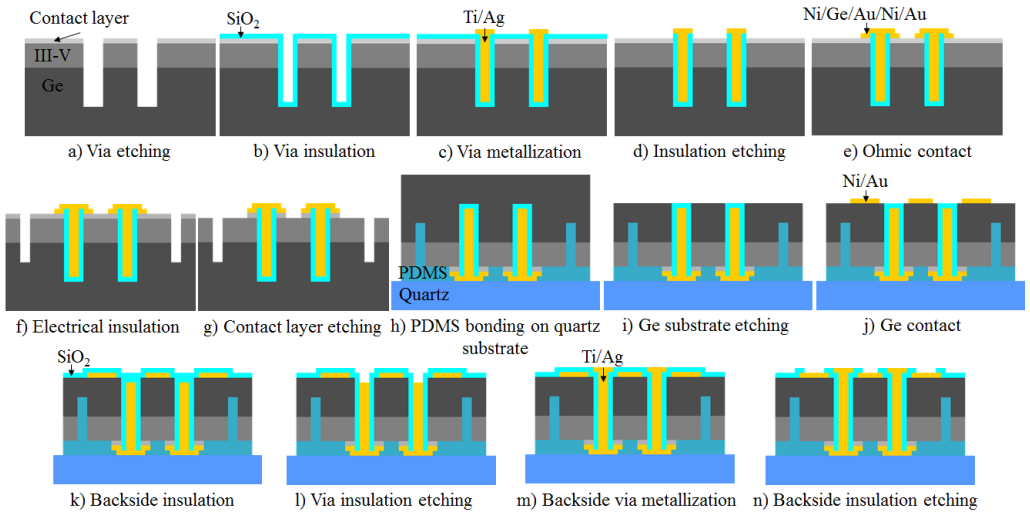

Figure 1. Schematics of the process flow for III-V/Ge multijunction solar cell with through cell via contacts fabrication

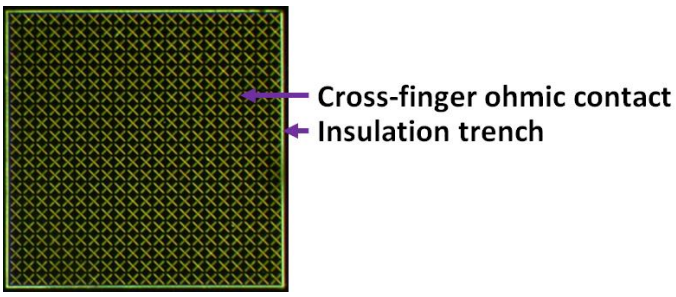

Figure 2. Optical microscope image of a 3mm x 3mm TCVC MJSC showing cross-finger ohmic contacts and plasma-etched insulation trenches

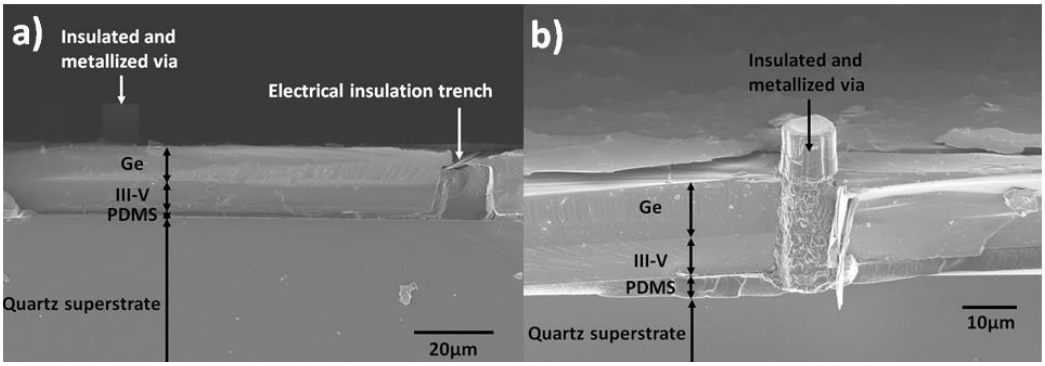

Figure 3. Scanning electron microscope image of TCVC solar after Ge thinning (step i on Fig.1)