Degradation of III-V on Silicon Solar Cells After 1 Mev Electrons Irradiation

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Silicon solar cells were widely used and developed for space application since their first use on Vanguard 1 in 1958. However in 1990s GaAs/Ge followed by GaInP/GaAs/Ge multi-junction solar cells replace the silicon for their high efficiency and high resistance to space radiation (electrons and protons) [1]. Recent research showed that the degradation of this solar cells is due largely to germanium bottom cell for the specific Jupiter conditions [2]. Thus, research on alternative bottom cell materials is needed to find an appropriate power source in low temperature and low intensity (LILT) conditions.

The study of the behaviour of III-V/Si solar cells in deep space conditions seems promising, considering that the efficiency of III-V/Si is competitive to that of conventional III-V/Ge solar cells [3] and the low cost and low density of silicon compared to that of germanium.

In order to investigate the effect of the top or top/mid subcells on silicon degradation, we used a double and triple junction (TJ) in which the bottom subcell has the same characteristics (p-type-p, FZ and 1-5 Ohm.cm). The architecture of TJ cells used in this study is schematized in Figure 1, where the top and middle sub-cells were grown by Fraunhofer ISE, while the silicon bottom sub-cell p-type is developed at CEA INES. The bonding of III-V cells on Si was carried out at LETI by the surface active bonding process *« SAB »*.

These cells were irradiated at the LSI « Laboratoire des solides irradiés » with 1-MeV electrons, at room temperature and at three different fluences (1×10^{14} cm^{-2}, 3×10^{14} cm^{-2} and 1×10^{15} cm^{-2}). Figure 2 represents the spectral response of the GaInP/AlGaAs/Si cell before *« BOL »* and after *« EOL »* irradiation. It shows that the degradation is significant in the infrared spectrum (silicon absorption range). This is due to the degradation of the bulk minority carrier lifetime in silicon.

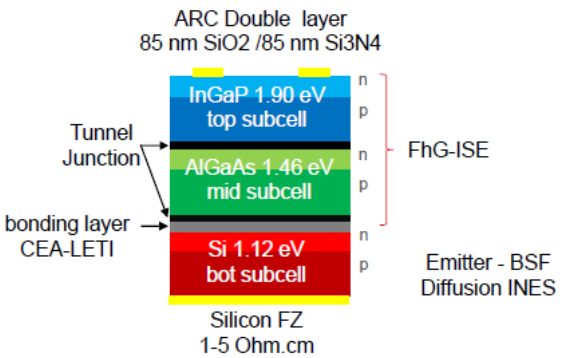

Figure 1: *Architecture of TJ solar cells III-V/Si used for the first electron irradiation*

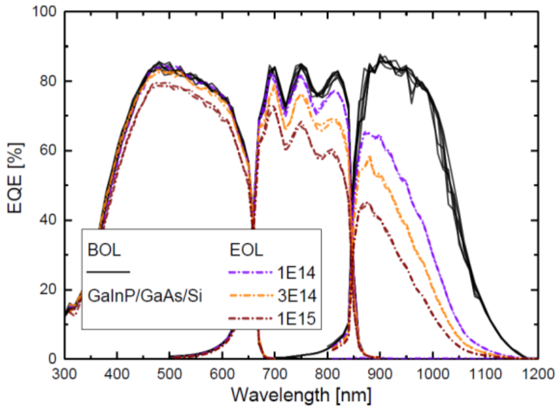

Figure 2: *EQE of the TJ cells after electron irradiation*

[1] P. A. Iles, « Evolution of space solar cells », *Sol. Energy Mater. Sol. Cells*, vol. 68, nº 1, p. 1–13, 2001.

[2] S. Park, J. C. Bourgoin, O. Cavani, V. Khorenko, C. Baur, et B. Boizot, « Origin of the degradation of triple junction solar cells at low temperature », in *E3S Web of Conferences*, 2017, vol. 16, p. 04004.

[3] R. Cariou *et al.*, « Monolithic Two-Terminal III–V//Si Triple-Junction Solar Cells With 30.2% Efficiency Under 1-Sun AM1.5g », *IEEE J. Photovolt.*, vol. 7, nº 1, p. 367-373, janv. 2017.