Multi-layer solar cells: State of the art and future perspectives

Beuckels Stijn, Diels Wouter, Leurs Tim

***Abstract*—**

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I. INTRODUCTION

THIS paper...

II. STATE OF THE ART: MULTI-LAYER SOLAR CELLS

Multi-layer solar cells can be monolithically, mechanically stacked or a combination of the two. This choice has some implications in the design of the solar cells.

A. Monolithically stacked

Monolithically stacked solar cells are in fact several layers (individual solar cells) that are mechanically and electrically connected. The photocurrent of the different cells needs to be carefully matched to prevent absorption between the layers. In order to obtain a optimal growth with high quality materials the subsequent layers must be lattice matched. Small mismatches cause growth imperfections, crystal defects and undesirable recombination centers. Due to the abrupt interface between the different cells, tunnel junctions are required.

Due to these restrictions growth is limited to lattice matched materials. The bandgaps of the different layers also have to fit some conditions for optimal efficiency. Also technological limitations in the growth procedures and the behavior of materials during growth must be take into account in the trade-off.

a) : The first attempts were two layer tandem solar cells based on GaAs, the best available material for single junction solar cells. A heterojunction could be made via the addition of an AlAs or combinations with In and P in a top layer. However GaAs substrates were very expensive, limiting the concept to high efficiency space applications because materials as InGaP turned out to be radiation resistant. Cheaper substrates such as Ge could be used for the growth of GaAs layers because of the small lattice mismatch.

B. Mechanically stacked

In mechanically stacked cells the different solar cells are externally connected. Due to the electrical connections, optical losses occur between the cells. Lattice matching is not necessary, so all existing materials that can be grown in thin layers can be used in principle. Current matching can be done outside the device or via the thickness of the layers.

C. Combinations

III. PRODUCTION TECHNIQUES

The growth of high quality thin layers on substrates is essential for the production of multi-junction solar cells. In order to limit the defect concentration epitaxial growth is required, which means that the growth orientation of the substrate (seed) crystal is continued in the new layers. The first simple deposition method used liquid precursors as source material and was called Liquid Phase Epitaxy (LPE). It suffered from non-uniformity and inflexibility. A second popular method was the Molecular Beam Epitaxy (MBE) capable of producing perfect interfaces under ultra-high vacuum conditions. Suffering from high cost and low throughput, it vanished in the multi-layer solar cell industry after the optimization of a superior method. The Metal-Organic Chemical Vapor Deposition (MOCVD) method is the most versatile and controllable method for the growth of III-V semiconductors. The procedure will be explained first with the used carrier and precursor materials. Additional production steps and methods are summarized in the second part.

A. Epitaxial MOCVD technique

For multilayer solar panels a MOCVD process is used in which a halogen metalorganic compound elimination reaction occurs.

B. Additional procedures

IV. NEXT GENERATION MULTI-LAYER SOLAR CELLS

V. CONCLUSION

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REFERENCES

[1] D. Adams, *The Hitchhiker's Guide to the Galaxy*. Del Rey (reprint), 1995, iSBN-13: 978-0345391803.