Laser Fired Emitter on n-type Silicon Using Amorphous Silicon Passivation

A. H. Fischer[1], M. P. Maier[2,§], Z. R. Chowdhury[1], G. Hahn[2], N. P. Kherani[1,*], S. Zukotynski[1]

[1] University of Toronto, Toronto, Ontario, Canada

[2] University of Konstanz, Konstanz, Germany

INTRODUCTION

MOTIVATION

- High conversion efficiency of c-Si photovoltaics
- Excellent surface passivation using a-Si:H
- Low-thermal-budget fabrication process
- Amenable to thinner wafers
- Simple fabrication process

OBJECTIVES

- Demonstrate a-Si:H based LFE PV concept using SiO_x isolation layer
- Perform 2D modeling to evaluate the cell concept
- Conduct proof of concept experiments

CELL CONCEPT

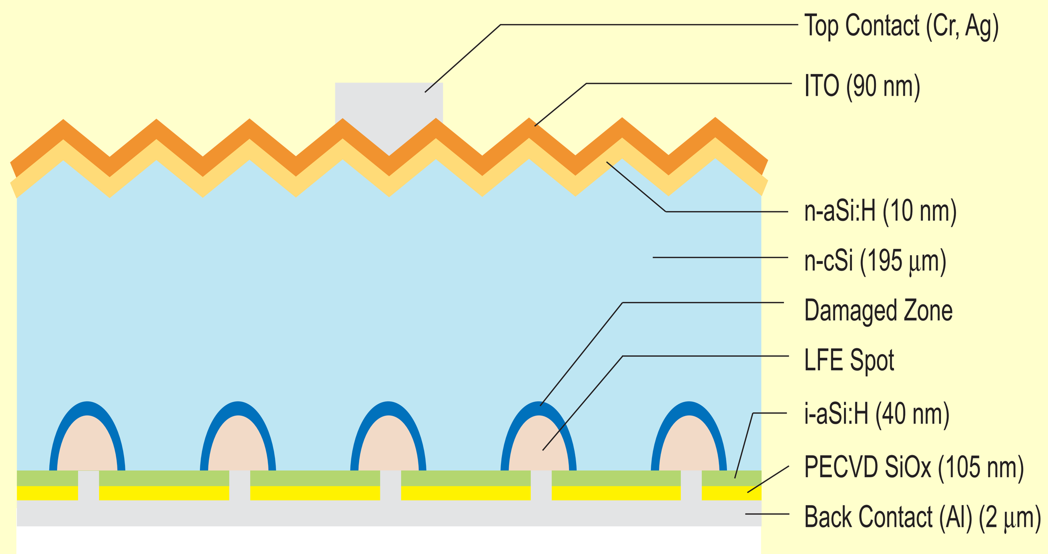

FIG. 1: Schematic of the photovoltaic device with LFE, a-Si:H layers and isolation (oxide) layer.

- Inverted cell
- n-type substrate
- Double-sided hydrogenated amorphous silicon (a-Si:H) passivation
- PECVD SiO_x Isolation layer
- Q-Switched Nd:YAG laser fired emitter (LFE)

SIMULATION OF THE CELL

- 2D modelling using Sentaurus
- a-Si:H representation with band-tail and band gap defects
- Lambertian front surface and completely reflective back surface

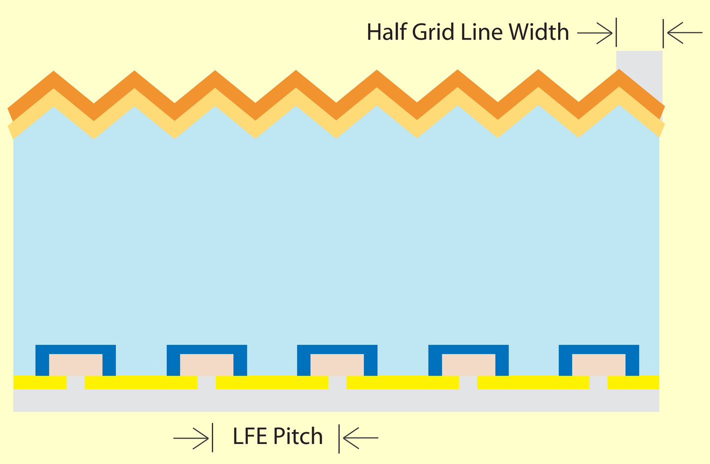

FIG. 2: A unit cell to represent the cell for 2D simulation. Surface passivation at the back is represented by low SRV between c-Si and SiO_x layer

SIMULATION RESULTS

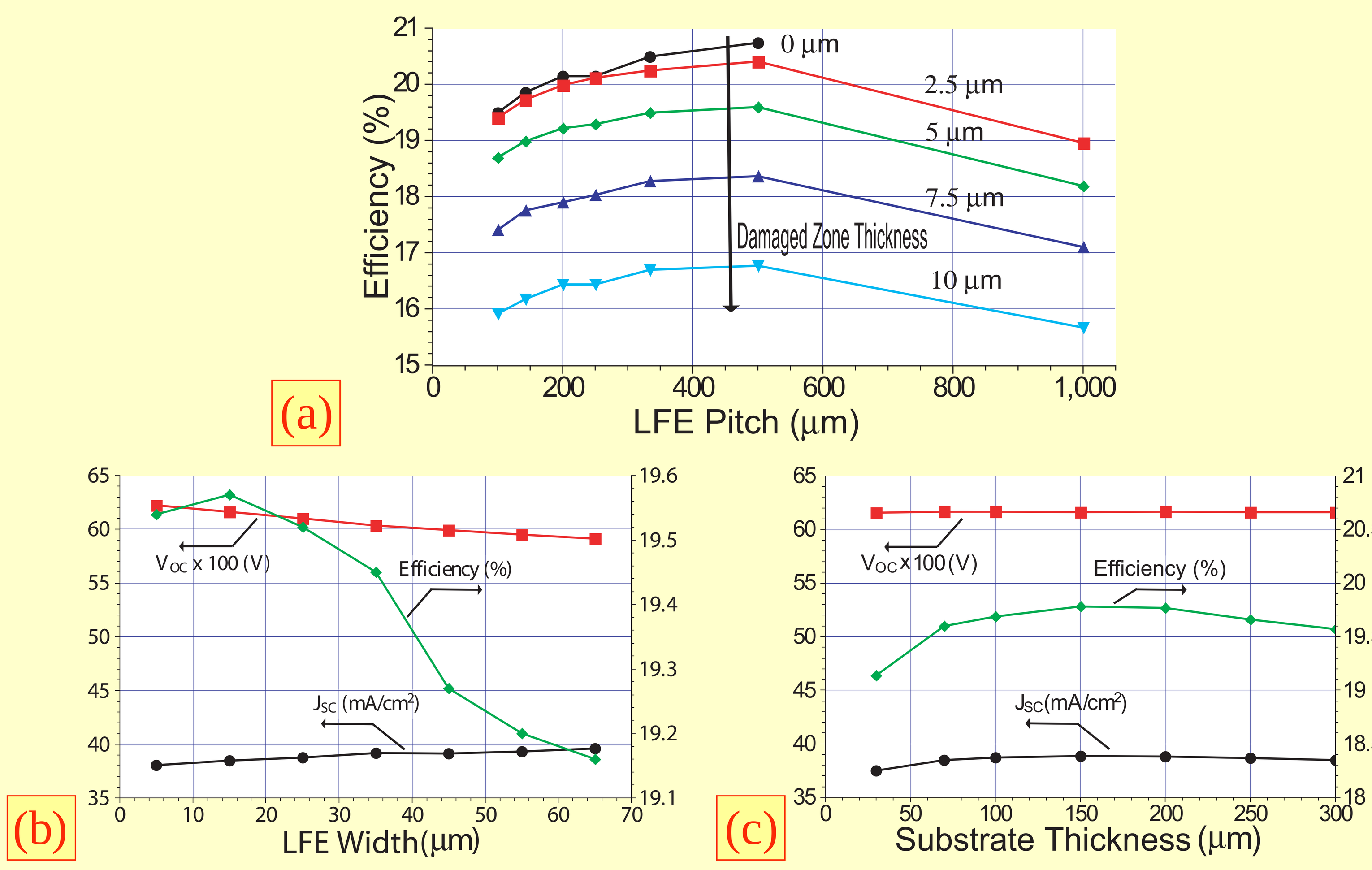

FIG. 3: Performance variation with (a) LFE pitch and damaged spot thickness (b) LFE diameter (c) Substrate thickness

SUMMARY

- Potential efficiency of 20%
- The cell structure is suitable for thin wafers
- Optimal LFE width is 15 µm with 5 µm thick laser-damaged zone

PROOF OF CONCEPT

FABRICATION DETAILS

- Wafer: n-type FZ 20 Ω-cm, (100) orientation
- DC saddle field for a-Si:H deposition 170° C
- Ambient atmosphere 240°C anneal after amorphous deposition
- E-beam metallization
- Post device fabrication annealing in nitrogen atmosphere

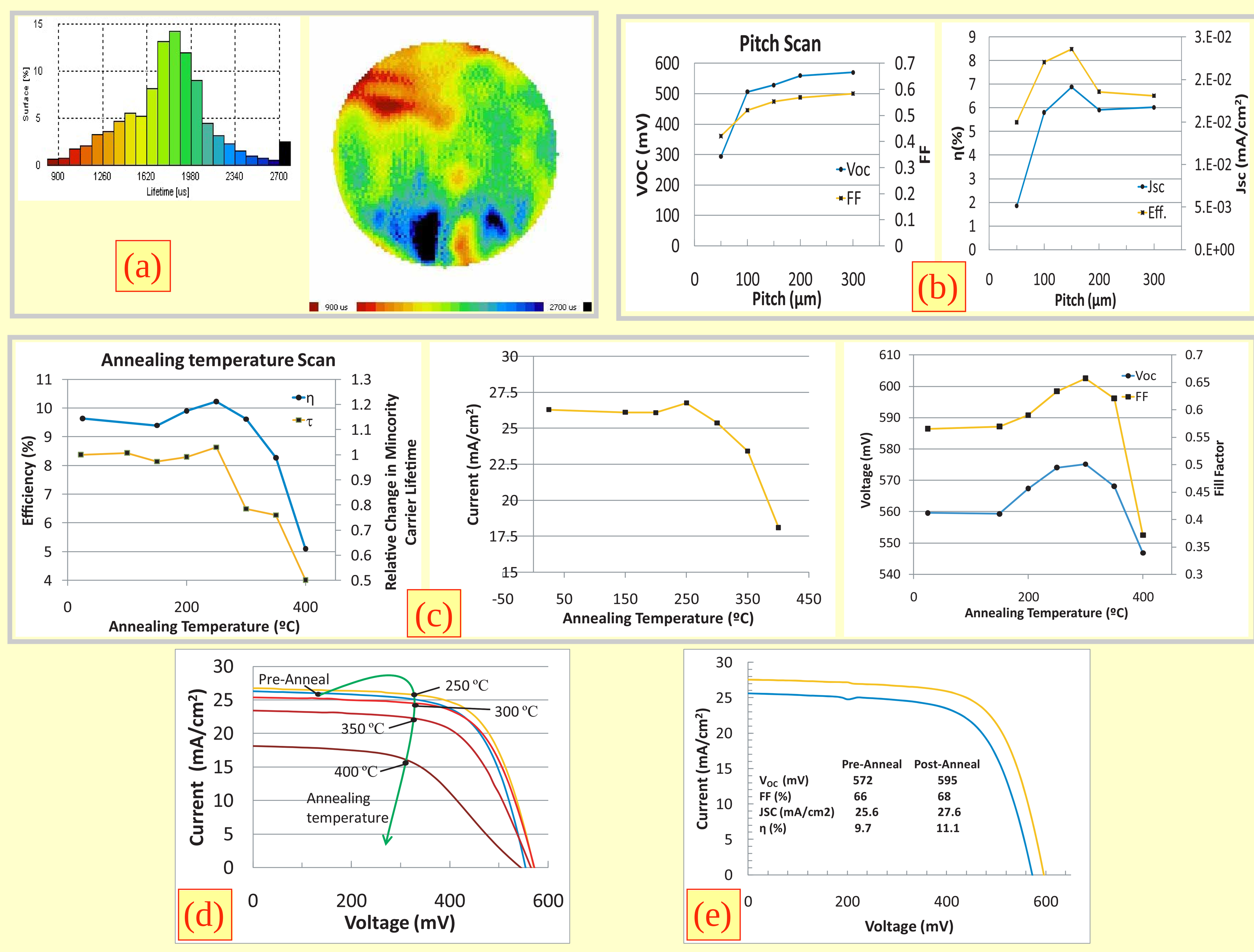

FIG. 4: (a) Life time profile using µ-PCD (b) cell performance variation with LFE pitch (c) cell performance for annealing at different temperature, (d) IV characteristics for different annealing temperature (e) best cell performance after annealing.

SUMMARY

- Demonstrated cell efficiency of >11%
- Optimum cell performance found at 150 µm LFE pitch
- Annealing up to 250°C increases cell performance with minimal lifetime gain, suggesting a mitigation of the laser-damaged zone

CONCLUSIONS

- Demonstrated viability of a-Si:H/SiO_x rear stack in an LFE PV device
- Proof of concept cell efficiency of >11% demonstrated
- Cell configuration has 20% efficiency potential

References

1. Schneiderlochner, E., et al., Laser-fired rear contacts for crystalline silicon solar cells. Progress in Photovoltaics: Research and Applications, 2002. 10 (1): p. 29-34.
2. Glunz, S.W., et al. Analysis of laser-fired local back surface fields using n+ np+ cell structures. in Photovoltaic Energy Conversion, 2003. Proceedings of 3rd World Conference on. 2003.
3. Granek, F., et al., Optimization of Laser-Fired Aluminum Emitters for High Efficiency N-Type Si Solar Cells, in 21st EU PVSEC. 2006, WIP-Munich: Dresden.
4. Hofmann, M., et al., Stack system of PECVD amorphous silicon and PECVD silicon oxide for silicon solar cell rear side passivation. Progress in Photovoltaics: Research and Applications, 2008. 16(6): p. 509-518.
5. Munoz, D., et al., Development of LASER fired contacts on silicon heterojunction solar cells for the application to rear contact structures. PhysicaStatus Solidi (C) Current Topics in Solid State Physics, 2010. 7(3-4): p. 1029-1032.

ACKNOWLEDGEMENTS: This research was supported by Natural Sciences and Engineering Research Council (NSERC) Canada, Ontario Centres of Excellence, Ontario Research Fund—Research Excellence, Canadian Foundation for Innovation, Arise Technologies Corporation, and University of Toronto.

§Currently at neonsee GmbH; *kherani@ecf.utoronto.ca