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Development of Qualification Tests for Glass-Less c-Si Modules

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INTRODUCTION

An increasing number of PV module start-up companies have developed glass-less silicon modules during recent years.

By replacing the glass front sheet with a thin transparent polymer sheet and using a back panel instead of an aluminum frame, the module weight can be reduced by as much as 85 % compared to a conventional PV module.

Glass-less lightweight modules have a number of **advantages** including:

- Enable PV on weight constrained buildings.
- Reduced transportation costs.
- Reduced installation time due to easier handling and new mounting methods.
- Attractive to military and transportation related applications.
- Lower glare allows the application around high traffic areas and airports.
- Innovative mounting approaches such as adhesives instead of a rack.

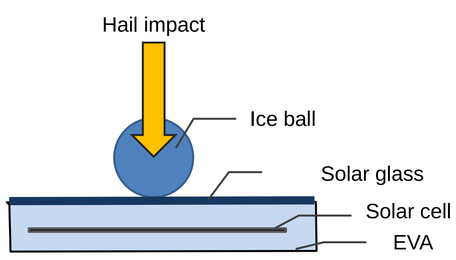
Glass-less modules attached using an adhesive approach

MOTIVATION

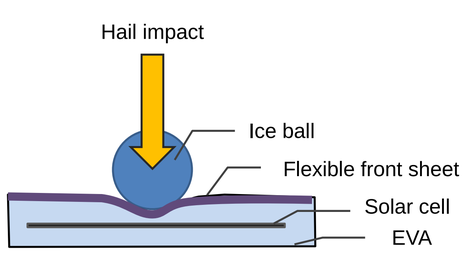
Before glass-less modules can be broadly adopted commercially, the market needs certainty about the long-term reliability.

One of the more challenging reliability requirements for modules without a glass superstrate is the ability to withstand hail storms.

In accordance with the IEC 61215 standards, the hail resistance test is mandatory for the qualification of PV modules.



Impact deformation of conventional PV module during hail impact

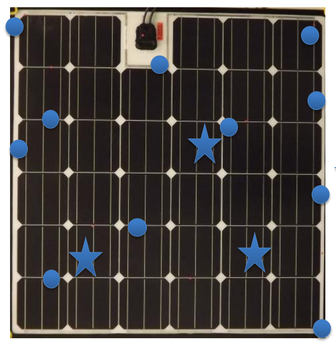


Impact deformation of glass-less PV module during hail impact

APPROACH

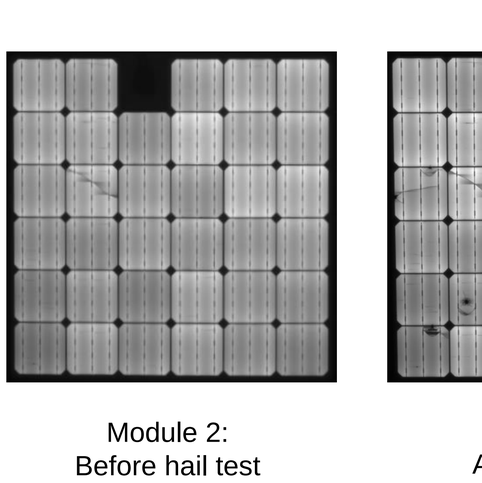
- Hail tests were performed on three glass-less modules of the same design. During the hail test modules were mounted according to the manufacturer's guidelines using an adhesives tape to attach the modules on a asphalt shingled test roof.
- In order to evaluate if the hail damage leads to further power decrease a subsequent thermal cycling sequence TC200 was carried out.
- Crack analysis using electroluminescence imaging after each test.
- I-V measurements under STC after each test.

RESULTS

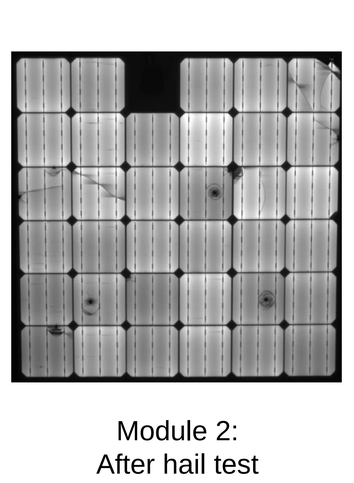


● : Hail impact locations in accordance with IEC 61215.

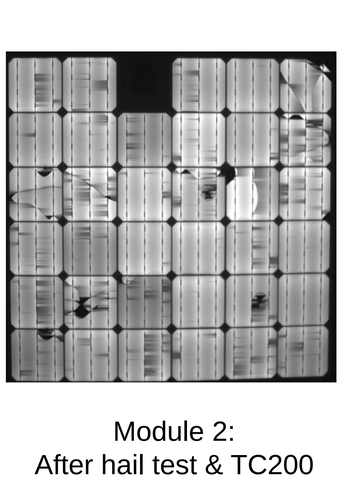
★ : Hail impact locations which go beyond IEC 61215.



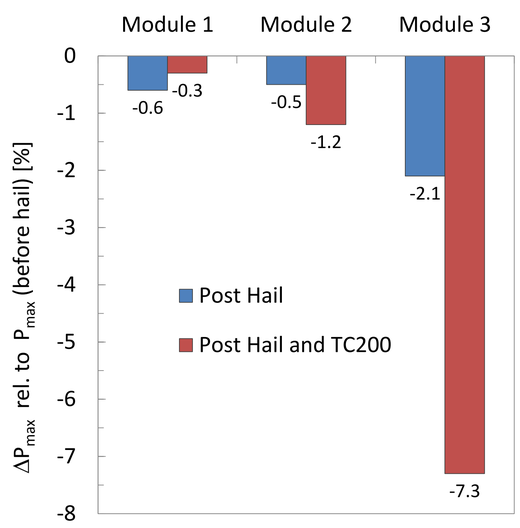
Module 2: Before hail test



Module 2: After hail test



Module 2: After hail test & TC200



Change in P_{max} after hail test and after hail &TC200 relative to P_{max} (initial value).

- After hail test: ΔP_{max}= 1.1 ± 0.7 % (5 % pass/fail criterion in IEC 61215).
- Cracks visible in the hail impact areas.
- After hail & TC200 ΔP_{max}= 2.9 ± 3.1 %.
- Due to the small sample size and the brittle nature of silicon there is a high statistical scatter in the results.

CONCLUSION

- The additional power loss after thermal cycling shows that thermal cycling after hail testing should be incorporated into a glass-less module durability test protocol.
- This work is part of a larger effort to establish an appropriate durability standard for glass-less modules which considers stresses during both degradation and damage caused by potential stresses during installation as well as operation.

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The experiments were carried out at the CFV Solar Test Laboratory.
This presentation contains no confidential information.