DuraMAT
Durable Module Materials Consortium

Accelerating a sustainable, just, and equitable transition to zero-carbon electricity generation by 2035.

# Laser-Welded Seals for Polymer-Free Glass/Glass Modules

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Module Materials Solutions

**Awarded FY22**
**SPARK**

**Period of Performance: 1/22 - 12/22**
**Funding: $65k**

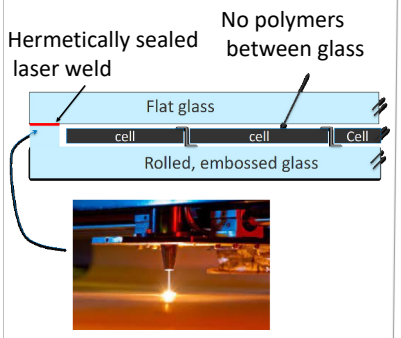
## Contributing to DuraMAT Consortium Goals

This project explored the use of femtosecond laser welding to form strong, hermetic seals for glass/glass modules. The results showed that glass/glass fs laser welds, when coupled to a new module design, are strong enough to enable a polymer-free module, potentially extending warrantees and forming an easily-recycled product.

## Project Overview

Polymers used in module lamination are often involved in degradation mechanisms and hamper recycling. This project explored femtosecond (fs) laser welding of glass/glass modules to enable polymer-free modules. We utilized the knowledge base of the industrial laser community to apply glass/glass fs laser welding technology to solar modules. Experimentally measured stress intensity factors for glass/glass welds were inputs to a COMSOL model of a full-size module to test weld failure under static loading. The data and model showed that fs laser welding is strong enough to enable modules that are polymer-free when coupled with a new module design. The new module design could extend module warrantees, allow hermetically sealed glass/glass modules for moisture-sensitive semiconductors, and improve module recyclability.

## New module design

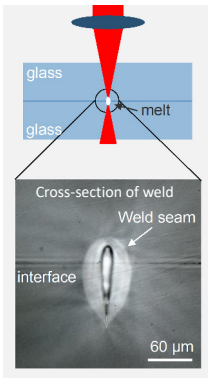


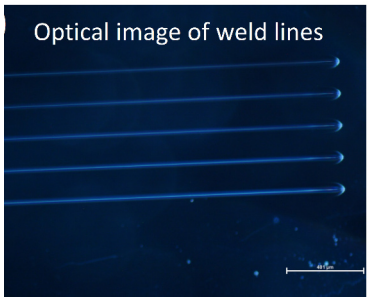

## 1) Glass/Glass Laser Welding at Industrial Laser Labs

Laser Specs:
20 W fiber laser
1030 nm, 400 fs – 200 ps pulse

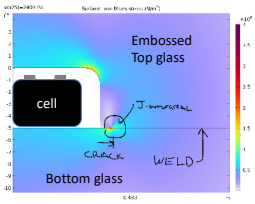
Welding specs:
2.6 W, 400 fs pulse, 200 Hz
10 mm/s translation
Gaussian to Bessel beam shape

Jig to hold glass pieces together



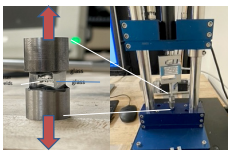




Model of weld area

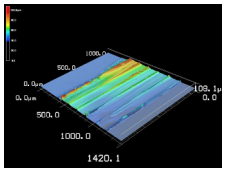


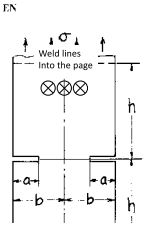

## 2) Weld Stress Intensity Factor Measurements

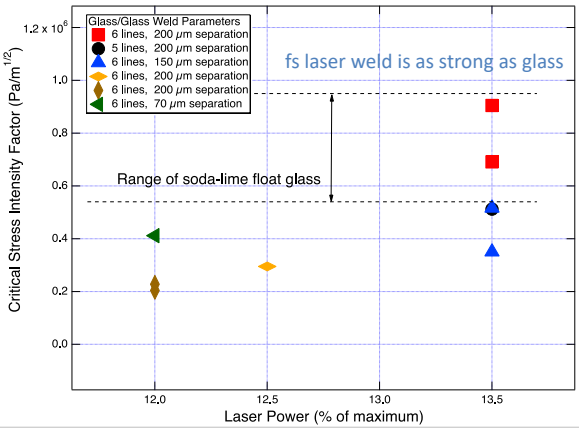
Pull to weld failure



3D image of glass surface after breaking weld

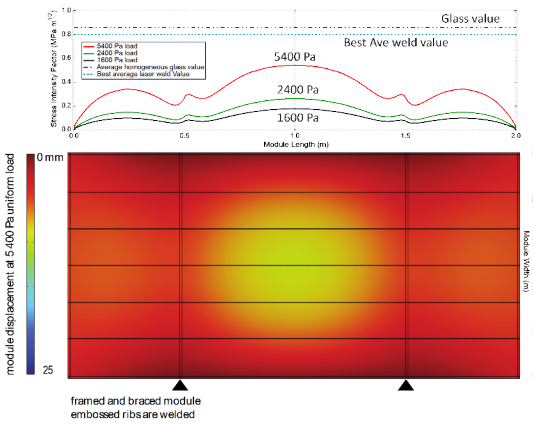




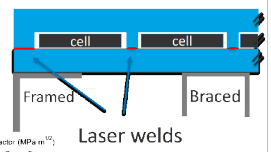




## 3) COMSOL Model of Laser Welded Module Under Static Load

Simulated laser welded 1 m x 2 m module




Embossed, ribbed glass module design




Laser welds

Simulated laser welded module passes IEC static load test.

## 4) Conclusions

- Glass/glass fs laser welds can be as strong as the glass
- Glass/glass fs laser welded module could pass IEC static load test
- Benefits: Hermetic edge seals, polymer-free module, easily recyclable
- Next Steps: Mini-modules for full IEC testing (pending funding)

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