DuraMAT
Durable Module Materials Consortium

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

Laser Welded Edge Seals for 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 explores the use of femtosecond laser welding to form strong, hermetic seals for glass/glass modules. If successful, the welded seals will enable a polymer-free module that will avoid polymer degradation, leading to extended warrantees and an easily-recycled product.

Project Overview

Polymers used in module construction are often involved in degradation mechanisms and hamper recycling. This project explores femtosecond (fs) laser welding of glass/glass modules to enable polymer-free modules. We are utilizing 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 welds are input into a COMSOL model of a full-size module to test weld failure under static loading. If successful, fs laser welding could enable modules that are polymer-free that will extend module warrantees, allow hermetically sealed glass/glass modules for moisture-sensitive semiconductors, and improve module recyclability.

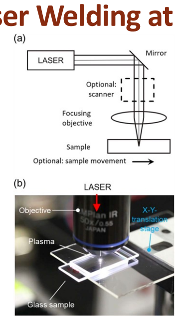
1) Experimental Steps

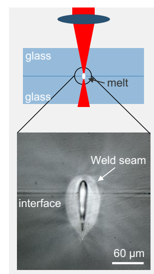
- Glass/glass laser welding
  - IPG Laser (July, Sept)
  - Trumpf Laser (July, Sept)
  - NREL's fs laser (Aug, Oct)
- Weld testing
  - Measure weld stress intensity factors (Oct-Dec)
- COMSOL module model (March, August, Dec)
  - 1 m x 2 m module
  - Input weld stress intensity factors
  - Framed and supported module
  - Welded embossed glass features
  - Contour maps of static deflection
  - Weld failure line graphs

3) Glass/Glass Laser Welding at Industrial Labs

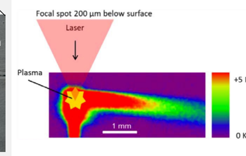
Laser Specs:
20 W fiber laser
1030 nm, 400 fs – 200 ps pulse

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

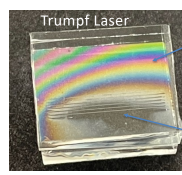




Semiconductor remains as room temp during glass/glass laser welding

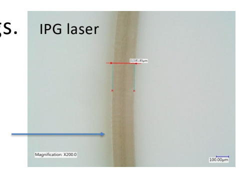


Jig to hold glass pieces together

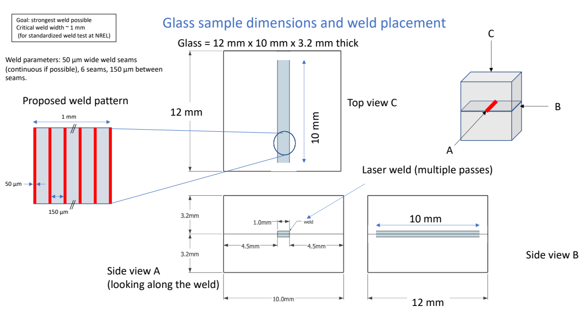


Newton's rings. Optically flat

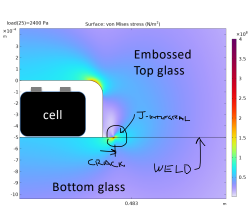
Solite glass
Welded lines



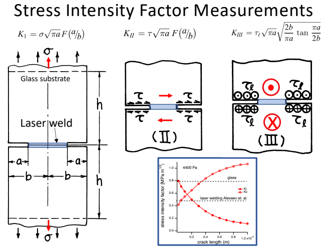
2) Glass and Weld Pattern Test Design



COMSOL model of weld



Stress Intensity Factor Measurements

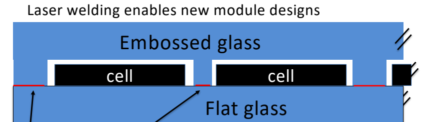


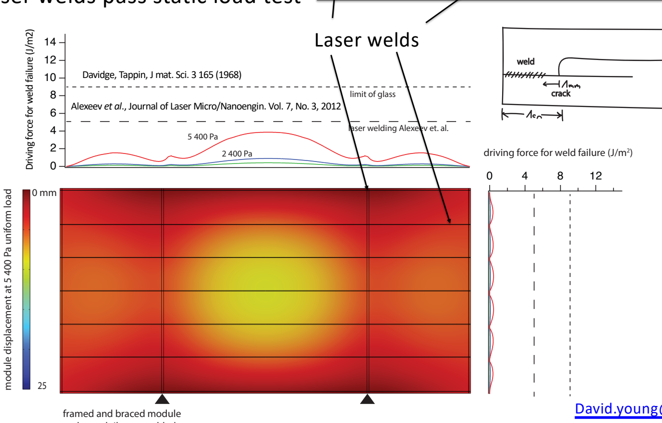
4) Weld Stress Intensity Factor Measurements: Oct-Dec

5) COMSOL Finite Element Model of Laser Welded Module Under Static Load

- Displacement contours
- J-integral line graphs
- Laser welds pass static load test

Laser welding enables new module designs





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Breckenridge, Colorado
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