INVESTIGATION OF MONOCRYSTALLINE P-TYPE PERC CELLS FEATURING THE LASER ENHANCED CONTACT OPTIMIZATION PROCESS AND NEW LECO PASTE

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Laser Enhanced Contact Optimization

- new contact formation technology for improved metal-semiconductor contacts
- applicable for nearly all cell technologies that use co-firing:

  **P type:**
  - Full BSF
  - PERC *
  - PERC + SE**

  **N type:**
  - PERT**
  - TOPCon**

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**Figure 1:** Sketch of solar cell highlighting LECO region of impact

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*E. Krassowski et al., CE Cell Engineering, 2CO.13.3, EU PVSEC, 2020

**R.W. Mayberry et al., Heraeus Photovoltaics, 2DV.1.27, EU PVSEC, 2019*
Laser Enhanced Contact Optimization

• Laser scans cell exciting charge carriers

• free carriers are forced through metal-semiconductor contact

• high currents flow through local, very small conductive spots

→ contact resistance between metal and semiconductor decreases

→ while passivation is not harmed*

Figure 3**: Electroluminescence images before and after LECO process

**R.W. Mayberry et al., Heraeus Photovoltaics, 2DV.1.27, EU PVSEC, 2019
What has been reported on PERC cells...

Three levels of integration:

1. Use LECO Process
   → sharpen efficiency distribution*
   → increase yield*

2. Use LECO Process – adapt cell production process
   + benefit from larger process windows

3. Use LECO Process – adapt cell production process – Use LECO paste by Heraeus
   + additional gain efficiency through Voc gain (+6mV**)
Content

• Experimental setup

• Results

• Comment on LECO Equipment

• Summary and outlook
Experimental setup: LECO on PERC cells featuring LECO Paste

Figure 4: Image of frontside of test-sample -> robust print pattern used to compare metallizations, not to produce record cell
Comparability of pastes

- µLBIC used to determine shading (optical finger width/area) -> no significant difference

Figure 5: µLBIC image of metallization finger

Δ ~1µm
Both pastes are comparable in thickness and morphology

Figure 6: Scanning electron microscopy images of metallization fingers
No surface damage by LECO treatment

Figure 7: Scanning electron microscopy images of metallization fingers at different magnification and positions
Results: $V_{oc}$ gain confirmed

2019: reported $V_{oc}$ gain 6 mV**

LECO working principle
Voc gain results from less damage of passivation during contact formation.

**R.W. Mayberry et al., Heraeus Photovoltaics, 2DV.1.27, EU PVSEC, 2019
Results: Fill factor gap improved to FF gain

2019: reported FF gap -0.64%**

FF gap closed

LECO Paste & LECO Process development
LECO cells reach the same level of contact resistance as standard cells – resulting in at least equal FF.

**R.W. Mayberry et al., Heraeus Photovoltaics, 2DV.1.27, EU PVSEC, 2019
Results: additional $J_{sc}$ gain observed

Small gain, confirmed in multiple experiments!

$J_{sc}$ gain due to LECO paste development

**R.W. Mayberry et al., Heraeus Photovoltaics, 2DV.1.27, EU PVSEC, 2019**
Results: Efficiency increase due to LECO!

2019: reported Eta gain 0.14 %

results improved!

All together
Eta gain results from higher \( J_{sc} \) and \( V_{oc} \) while the same level of contact resistance can be achieved.

**R.W. Mayberry et al., Heraeus Photovoltaics, 2DV.1.27, EU PVSEC, 2019**
Update LECO Equipment

- First installation of LECO INTEGRATION-EQUIPMENT in pilot environment at Fraunhofer CSP
- High throughput industrial line tools including marking tool, LECO and LED flasher

Process optimization and development of data analytics for cell lines
Summary: New results for LECO on PERC cells feat. LECO Paste

- Study comparing standard paste and LECO Paste (+ LECO Process) on same cell material

- Analysis of print pattern
  - Comparable / damage free

- LECO Cells compared to standard cells
  - Increased efficiency

4BB LECO PERC cells

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Change</th>
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</thead>
<tbody>
<tr>
<td>Voc</td>
<td>679.7 mV</td>
<td>(+6.9 mV)</td>
</tr>
<tr>
<td>FF</td>
<td>79.73 %</td>
<td>(+0.42 %)</td>
</tr>
<tr>
<td>Isc</td>
<td>39.6 mA/cm²</td>
<td>(+0.08 mA/cm²)</td>
</tr>
<tr>
<td>Eta</td>
<td>21.46 % (_{absolut})</td>
<td>(+0.38 % (_{absolut}))</td>
</tr>
</tbody>
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(Compared to cells with standard paste)
Outlook

Research & Development

• Further improvement of LECO performance for PERC cells
• Currently main focus on testing LECO on different cell types:
  – Next step we focus on testing LECO on passivated contacts

Tools

• Volume tests of LECO INTEGRATION-EQUIPMENT on plattform at Fraunhofer CSP
• Offer integration of LECO Equipment in cell production pilot lines
Thanks for your interest!

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Stay safe and healthy!

SPECIAL THANKS TO

ERNST Project team at CSP
Heraeus HPT Team in Hanau
CE Cell Engineering Team

Dieses Forschungsvorhaben wird unterstützt durch:

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ZS/2018/07/93706