Alloy for SOFC Interconnects ZMG™232G10

1. Role of Metallic Interconnects
   Electrical connection between cells

2. Required properties
   - Good long-term oxidation resistance
   - Good electrical conductivity
   - Thermal expansion close to electrode materials (ceramics)

3. Developed Fe-Cr ferritic alloys ZMG232G10

   - History of development
     - ZMG232 in 1997
     - ZMG232M1 in 2004
     - ZMG232L in 2005
     - ZMG232G10 in 2010

   - Feature of developed alloys
     - ZMG232G10 was developed as the other one of new alloys with reduced Cr-evaporation based on ZMG232L.

   - Sheet stock
     * Hitachi Metals Trading, Ltd. has inventories.

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
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<td>600</td>
</tr>
<tr>
<td>0.3</td>
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<tr>
<td>15.0</td>
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<td>1000</td>
</tr>
</tbody>
</table>

Oxidation resistance and electrical conductivity have been improved simultaneously.

- Appearance of metallic interconnects (an example of shaped components)

We can produce the shaped materials after ordered. (stamped metals, expanded metals, etc.)

4. Contact

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Properties in ZMG™232G10

- Chemical compositions of evaluated alloys

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Al</th>
<th>Zr</th>
<th>La</th>
<th>W</th>
<th>Cu</th>
<th>Fe</th>
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<td>2</td>
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</tbody>
</table>

- Oxidation resistance

- Compared with commercial alloy

- Oxidation resistance of our current alloy ZMG232G10 is better than 443ss.
- Oxidation weight gain of ZMG232G10 is increased with time under the parabolic relationship.

- Oxidation weight gain (mg/cm²) vs. Exposure time (hours)

- Electrical contact resistance

- Pre-oxidized at 850°C for 1,000 hours
- Measured at 750°C, in air
- ASR of ZMG232G10 is smaller than that of ZMG232L.

- Cr evaporation

- 850°C x 30Hours, in air
- The amount of Cr evaporation of ZMG232G10 is the smaller than that of ZMG232L.

- EPMA element map of the cross-sectional microstructure

- 850°C for 10,000Hours, in air
- Test piece: 3mm x 10mm x 10mm

- Surface morphology: Alloy/(Cr₂O₃) / (Mn,Cr,Cu)O₄
- Oxide layer of ZMG232G10 is thinner than that of ZMG232L.

- Thermal expansion

- Thermal expansion of ferritic alloys are close to electrode materials (ceramics).

- Chemical compositions of evaluated alloys

- Reducing Mn
- Increasing Cr
- Adding W
- Adding Cu

Note: The properties mentioned in this document are typical values (The experimental values in our laboratory). Please be noted that such properties for the actual product may be different from the data sheet. This document includes the results of the research and development supported by New Energy and Industrial Technology Research Development Organization (NEDO).