Properties and Stability of Low-Firing Thick-Film Resistors
Effect of Composition and Processing Parameters
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Low-firing thick-film resistors (TFRs) are useful for:
- Piezoresistive sensing with metallic (steel, Al, ...) substrates
- High-power electronics on Al or Al-Si
- Thick-films on glass for displays

High firing temperatures are incompatible with high-strength steel substrates, due to disruptive phase transformations (austenite - martensite, left), excessive softening (right), or melting (Al).

→ Firing temperature ideally in 500...600°C range

Glass frits

<table>
<thead>
<tr>
<th>Ref</th>
<th>PbO</th>
<th>B₂O₃</th>
<th>SiO₂</th>
<th>Tₑ₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>V2</td>
<td>63</td>
<td>25</td>
<td>12</td>
<td>500°C</td>
</tr>
<tr>
<td>V6</td>
<td>75</td>
<td>10</td>
<td>15</td>
<td>450°C</td>
</tr>
<tr>
<td>V8</td>
<td>85</td>
<td>10</td>
<td>5</td>
<td>370°C</td>
</tr>
</tbody>
</table>

Studied glass frit compositions (% mass) +2% Al₂O₃ to suppress crystallisation

+ RuO₂ powder (40 & 400 nm) + binder

Sheet resistance & its temperature coefficient TCR, and longitudinal gauge factor Kᵥ vs. RuO₂ volume fraction & firing temperature

Low-firing 550…600°C resistors
- Excellent piezoresistive properties
- Compatible with high-strength steels
- Good stability at 250°C
- Additives needed for TCR adjustment

Ultra low-firing 475…525°C resistors
- Compatible with steel, glass, Al-Si, Al
- Reasonable gauge factor (ca. 6)
- Limited stability at 250°C