Active metal brazing of different metals to aluminium nitride ceramics

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During recent years aluminium nitride ceramics for substrates, coolers and components have found more applications in micro- and power electronics.
Aluminium nitride ceramic with high thermal conductivity, small CTE and good thermal shock resistance is used in aeronautical equipment as well as in drive systems of undergrounds and high speed trains.
Different metals and alloys can be bonded to AlN by the so-called "AMB-process". The bonding mechanism is based on the use of so-called active metals like Ti, Zr, Hf. Copper conductor lines can be brazed onto AlN-substrates and components, resistor sheets can be applied on ceramic water coolers and a couple of other metals and alloys like Tantalium, Titanium, KOVAR and steel can be attached to AlN-ceramics by active brazing. Processing, analytical aspects and some special applications will be discussed.
Active Metal Brazing of Different Metals to Aluminium Nitride Ceramics

Dr. D. Brunner, B. Löser, ANCeram GmbH & Co. KG, Bindlach, Germany
Historical Background

W.D. Kingery and M. Humenik, 1954: Surface tension and wettability of metal-ceramic systems

Y. Naidich, 1981: Wetting induced by Titanium

Joints of Silicon Nitride and Carbide with Metals by Active Brazing (1982); Degussa, Hanau

Joints of AlN with Kovar® by Active Brazing (1984); Heraeus, Hanau

Joints of AlN with Copper by Active Brazing (1984); Toshiba


Joining AlN with Tantalum and Titanium (1993); ANCeram


# Physical Properties of AlN, BeO and Al₂O₃

<table>
<thead>
<tr>
<th>Properties</th>
<th>AlN</th>
<th>BeO</th>
<th>Al₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density [g/cm³]</td>
<td>3.26</td>
<td>3.0</td>
<td>3.99</td>
</tr>
<tr>
<td>Bending Strength [N/mm²]</td>
<td>350</td>
<td>320</td>
<td>450</td>
</tr>
<tr>
<td>Young's Modulus [kN/mm²]</td>
<td>310</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>TCE [ppm]</td>
<td>4.6</td>
<td>8.9</td>
<td>8.1</td>
</tr>
<tr>
<td>Thermal Conductivity [W/mK]</td>
<td>200</td>
<td>230</td>
<td>30</td>
</tr>
<tr>
<td>Volume Resistivity [Ωcm]</td>
<td>&gt; 10¹⁰</td>
<td>&gt; 10¹⁰</td>
<td>&gt; 10¹⁰</td>
</tr>
<tr>
<td>Dielectric Constant ε</td>
<td>8.6</td>
<td>6.6</td>
<td>10</td>
</tr>
<tr>
<td>Dielectric Loss * 10⁴ tan δ</td>
<td>8.0</td>
<td>1.7</td>
<td>2.0</td>
</tr>
<tr>
<td>Dielectric Strength [kV/mm]</td>
<td>&gt; 25</td>
<td>&gt; 22</td>
<td>&gt; 22</td>
</tr>
<tr>
<td>Specific Heat [J/kg K]</td>
<td>830</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Thermal Shock Behavior</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Active Metal Brazing of Different Metals to AlN

Historical Background of the AMB-Process

Aluminium Nitride

Active Metal Brazing of AlN

Analytical Aspects

Special Applications

Summary
4. Mikrocharakterisierung

Reaktionen:
- $4\text{Ti} + 3\text{AlN} \rightarrow 3\text{TiN} + \text{TiAl}_3$
- Ag-Cu-Eutektikum bei 780°C

Reaktionszonen:
- Ti-reiche Schicht (ca. 1-2μm)
- Eutektische Lotschicht (ca. 20μm)

Schliffbild:
Elementverteilung

[Diagramm: Phase diagrams of Ag-Cu]
- Historical Background of the AMB-Process
- Aluminium Nitride
- Active Metal Brazing of AlN
- Analytical Aspects
- Special Applications
- Summary
Soldering Metal

Alloy Junction

OFHC-Cu

Alloy junction

Alumina
Active Metal Brazing of Different Metals to AlN

Historical Background of the AMB-Process

Aluminium Nitride

Active Metal Brazing of AlN

Analytical Aspects

Special Applications

Summary

Aluminium Nitride Ceramics GmbH & Co. KG, Ebachgraben 21, Bindlach, Germany
Aluminium Nitride Substrates for Power Electronics

Active Brazed Copper (ABC)
Substrates developed by ANCertam
2. Neue Applikationen

AlN
Hohe Wärmeleitfähigkeit

Kupfer
Hohe elektr. Leitfähigkeit

Anwendungen:
Kühler, Wärmesenken
Schaltungsträger
Aluminium Nitride Water Cooler

Water-cooled inverter for underground trains, equipped with ANCeram modules

R. Hahn, ANCERAM, DOC. 21.11.1996, Hahn, TUB, Tel. 030 314 72833, Fax. 030 314 72 835
Summary

- AlN is wettable to different alloys activated by Ti, Zr, Hf, Ni, and Cr

- AlN is attachable to KOVAR, Titanium, Tantalum, stainless Steel and Copper

- AlN-Metal-Joints show high peel strength and sufficient thermal and electrical behavior

- AlN active brazed with Copper may become an alternative to the DCB-Process on Alumina for high power application