Active metal brazing of different metals to aluminium nitride ceramics

B. Loeser and D. Brunner

ANCeram GmbH & Co.KG, Bindlach, Germany

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.

- **Historical Background of the AMB-Process**
- **Aluminium Nitride**
- **Active Metal Brazing of AlN**
- **Analytical Aspects**
- **Special Applications**
- **Summary**

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

H. Krappitz, H. Thiemann, W. Weise, 1989 :
Reactive brazed Ceramic-Metal-Joints for Automotive Applications

Joining AlN with Tantalum and Titanium (1993); ANCeram

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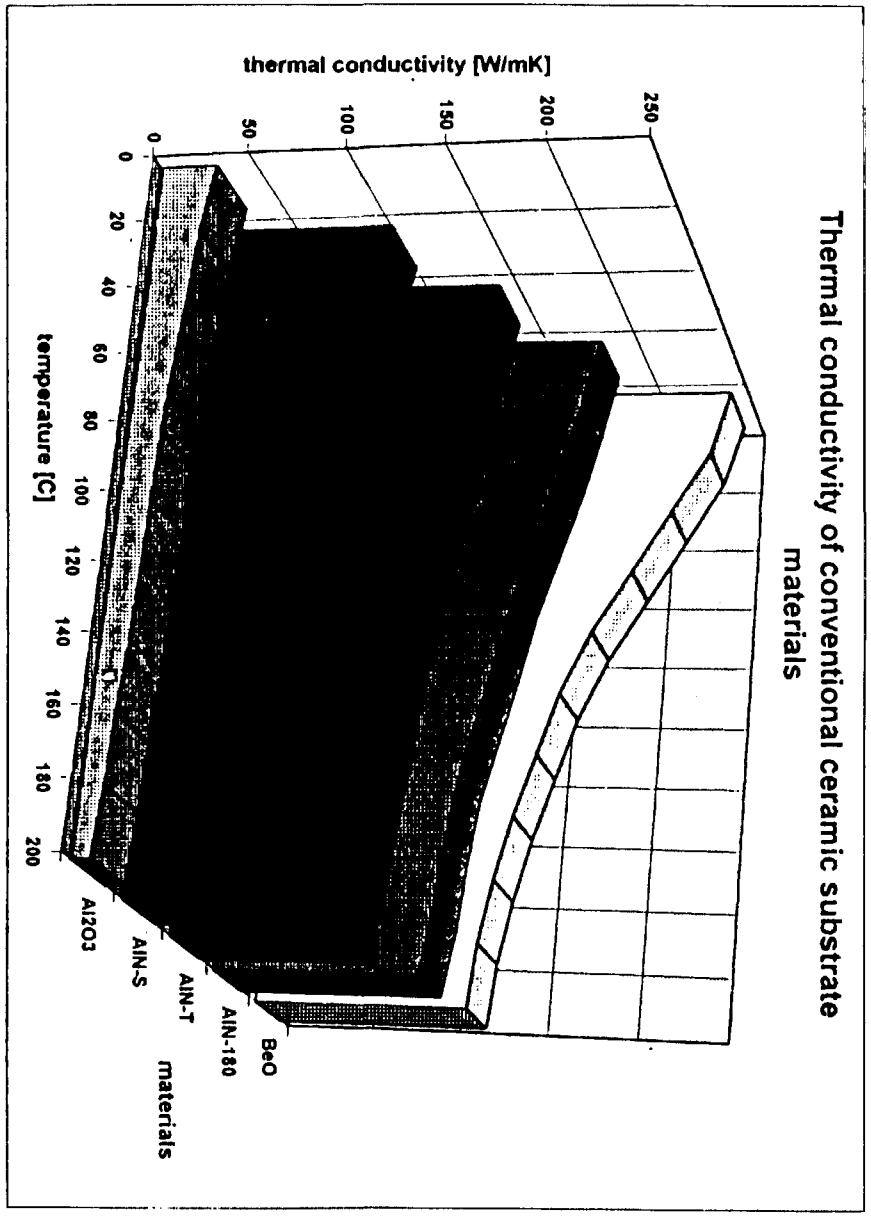
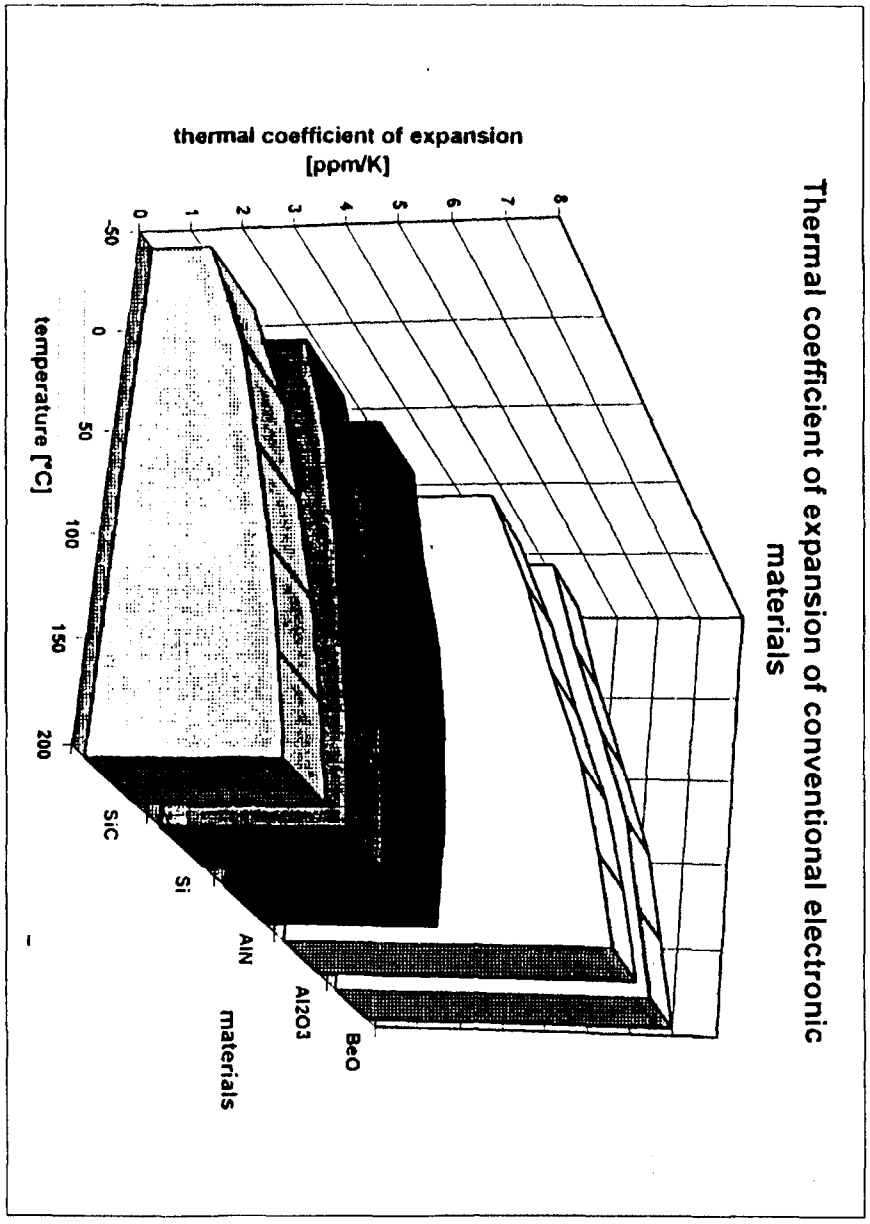
Physical Properties of AlN, BeO and Al_2O_3

Properties	AlN	BeO	Al_2O_3
Density [g/cm³]	3,26	3,0	3,99
Bending Strength [N/mm²]	350	320	450
Young's Modulus [kN/mm²]	310	400	400
TCE [ppm]	4,6	8,9	8,1
Thermal Conductivity [W/mK]	200	230	30
Volume Resistivity [Ωcm]	$> 10^{13}$	$> 10^{13}$	$> 10^{13}$
Dielectric Constant ε	8,6	6,6	10
Dielectric Loss * 10^{-4} tan δ	8,0	1,7	2,0
Dielectric Strength [kV/mm]	> 25	> 22	> 22
Specific Heat [J/kg K]	830	-	-
Thermal Shock Behavior	++	+	+





Thermal coefficient of expansion of conventional electronic materials

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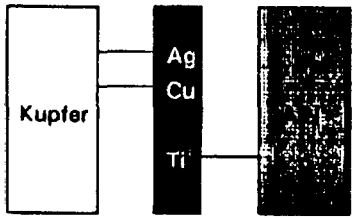
4. Mikrocharakterisierung

Reaktionen:

- $4Ti + 3AlN \rightarrow 3TiN + TiAl_3$
- Ag-Cu-Eutektikum bei 780°C



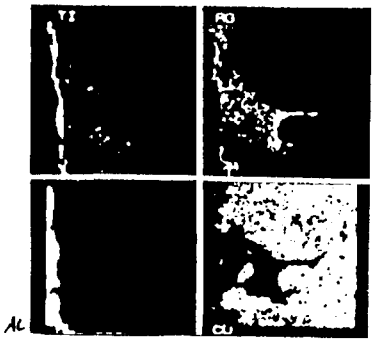
Reaktionszonen:

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

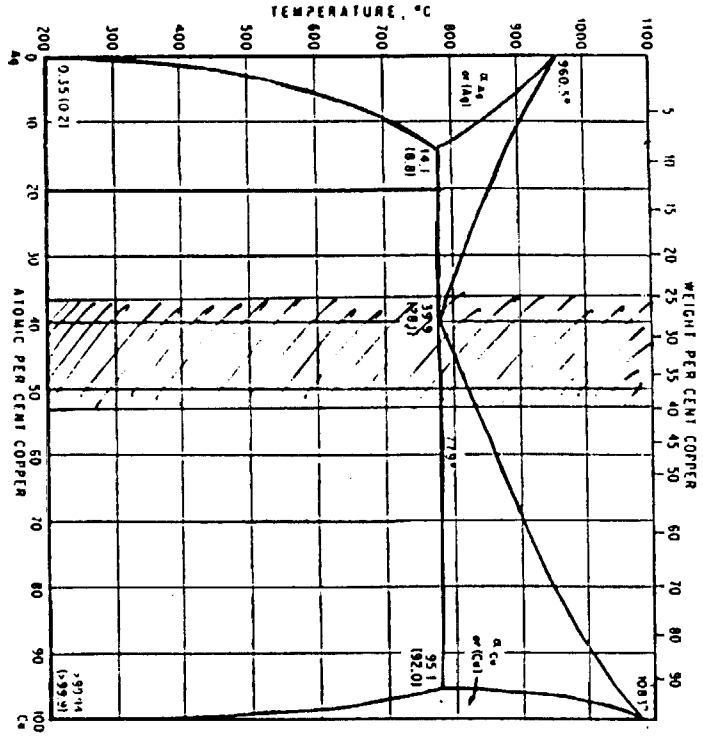
Schliffbild:

20μm

Elementverteilung



10μm



- **Historical Background of the AMB-Process** ✓
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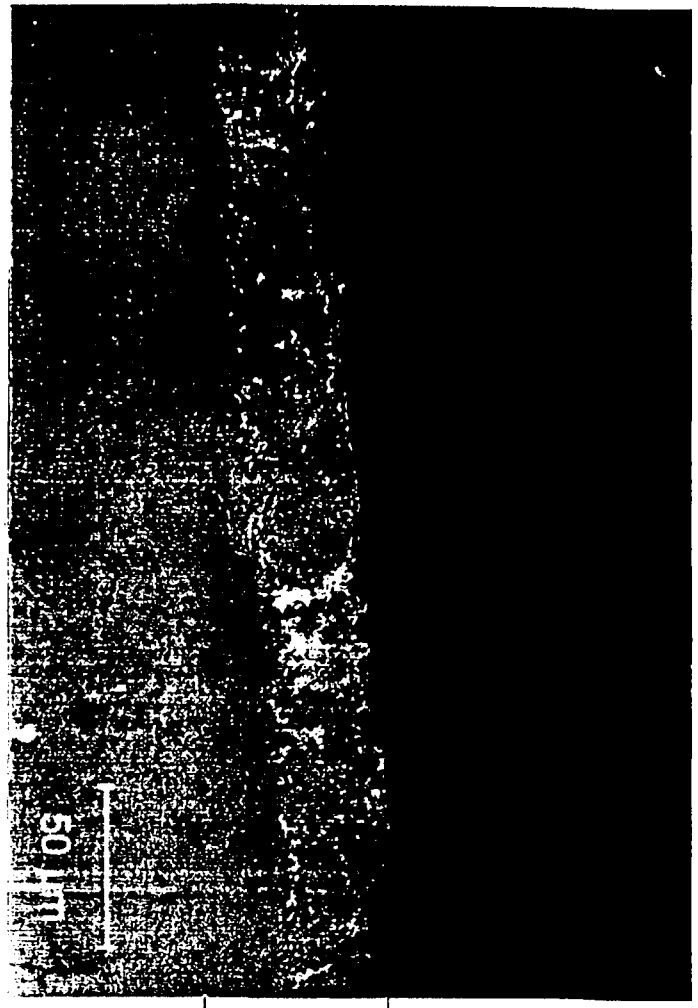
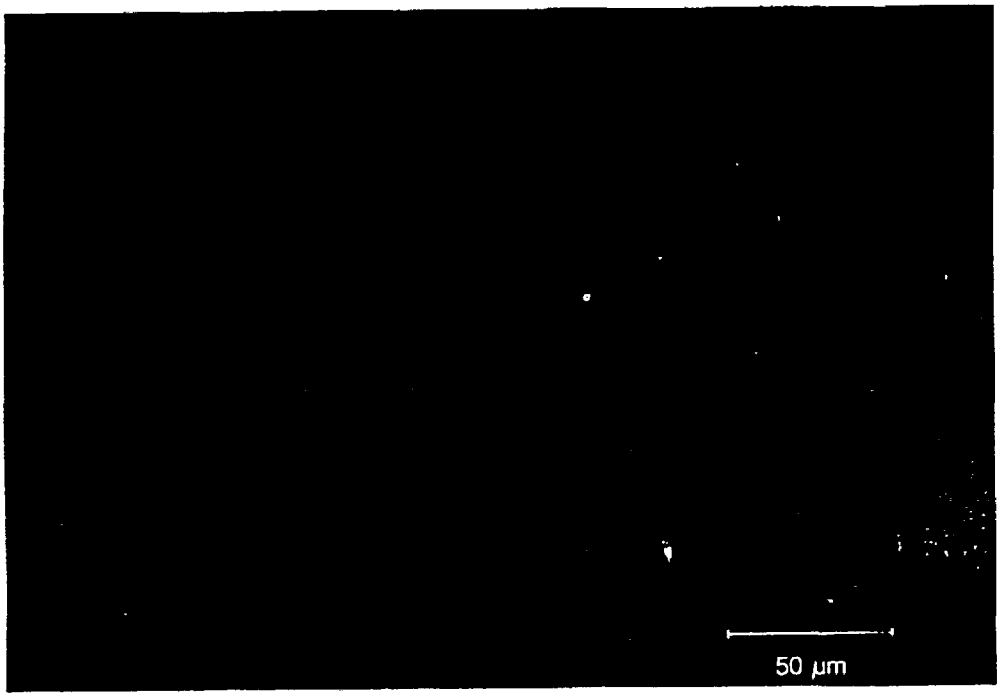
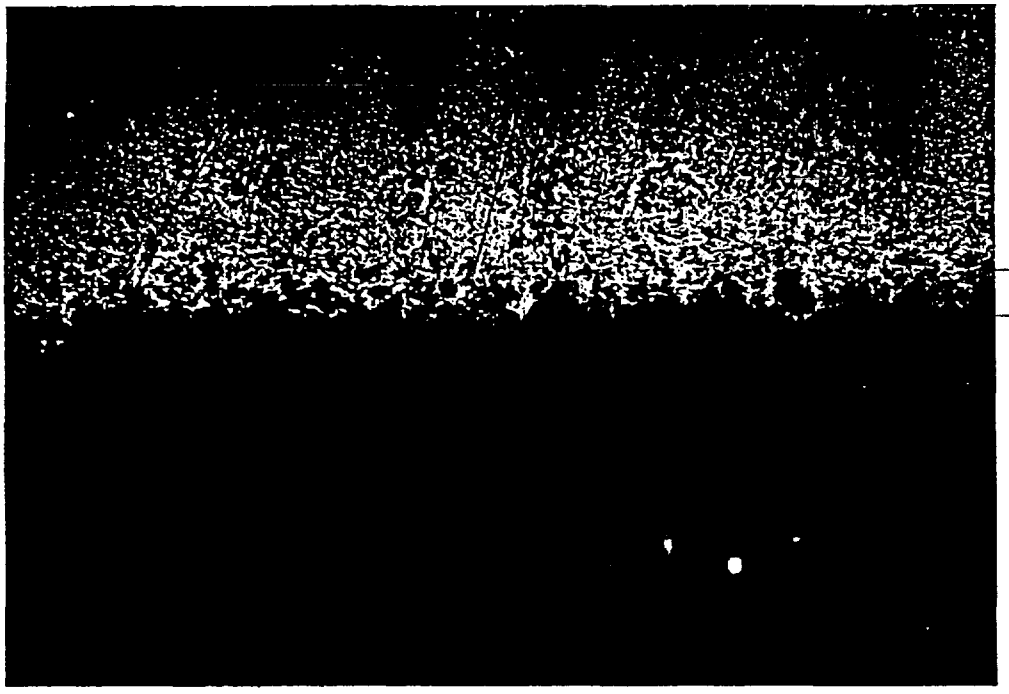




AlN

Soldering Metal

Alloy Junction

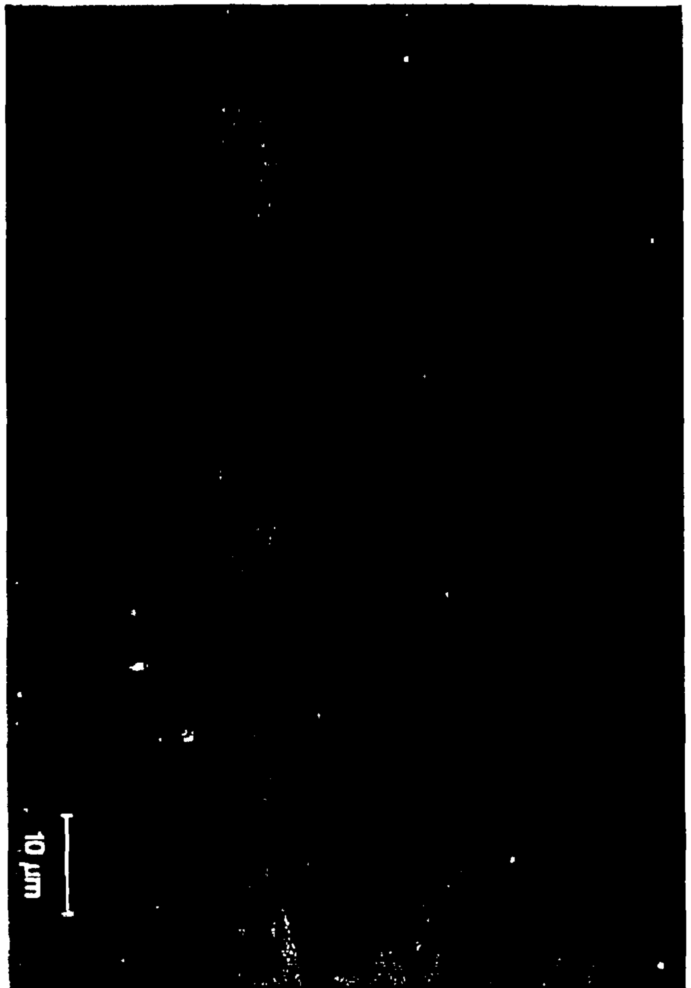


OFHC-Cu

Alloy junction

Alumina

Austenitic Steel on AlN



- **Historical Background of the AMB-Process** ✓
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- **Active Metal Brazing of AlN** ✓
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Aluminium Nitride Ceramics GmbH & Co. KG, Esbachgraben 21, Bindlach, Germany

Active Brazing Process

AlN Substrate

⇓

Rinsing

⇓

Screen Printing of Metal Paste

⇓

Adjusting of Copper Foils in Solder Fixture

⇓

Reactive Brazing

⇓

Screen Printing of Etch Resist

⇓

Baking

⇓

Etching

⇓

Resist Stripping

Copper Foil

⇓

Punching

⇓

Cleaning

⇓

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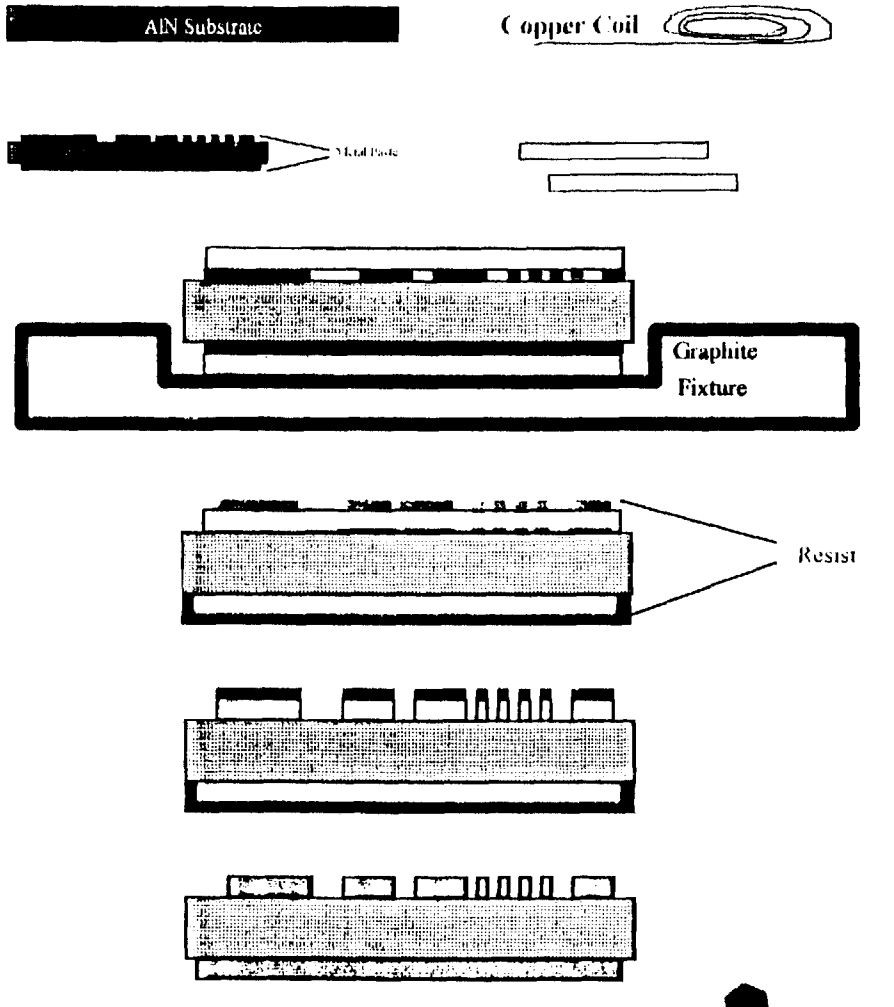
Active Brazing Process



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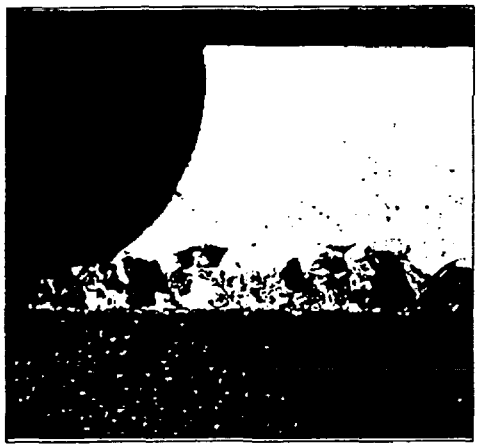
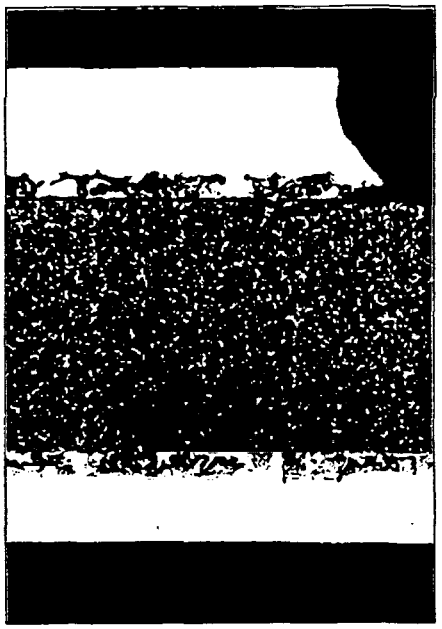
AlN/AMB Fa. ANCeram

Gefügeausbildung



Kante 5



Kante 6

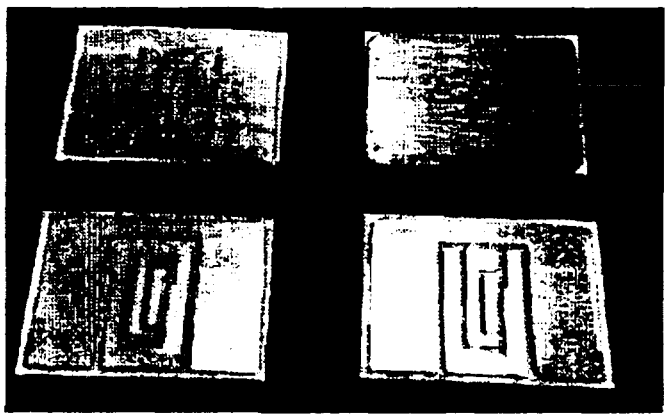
Kante 4

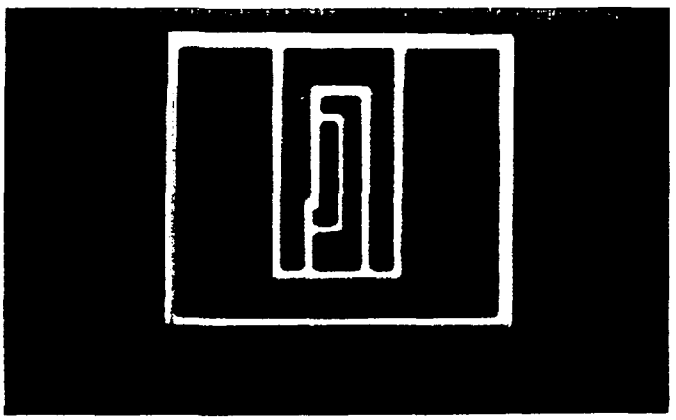
Faust

Fraunhofer IZM Institut Zuverlässigkeit und Mikrointegration

Department:
MECHANICAL RELIABILITY
AND MICRO MATERIALS
Head: Prof. Dr. Bernd Michel

Aluminium Nitride Substrates for Power Electronics





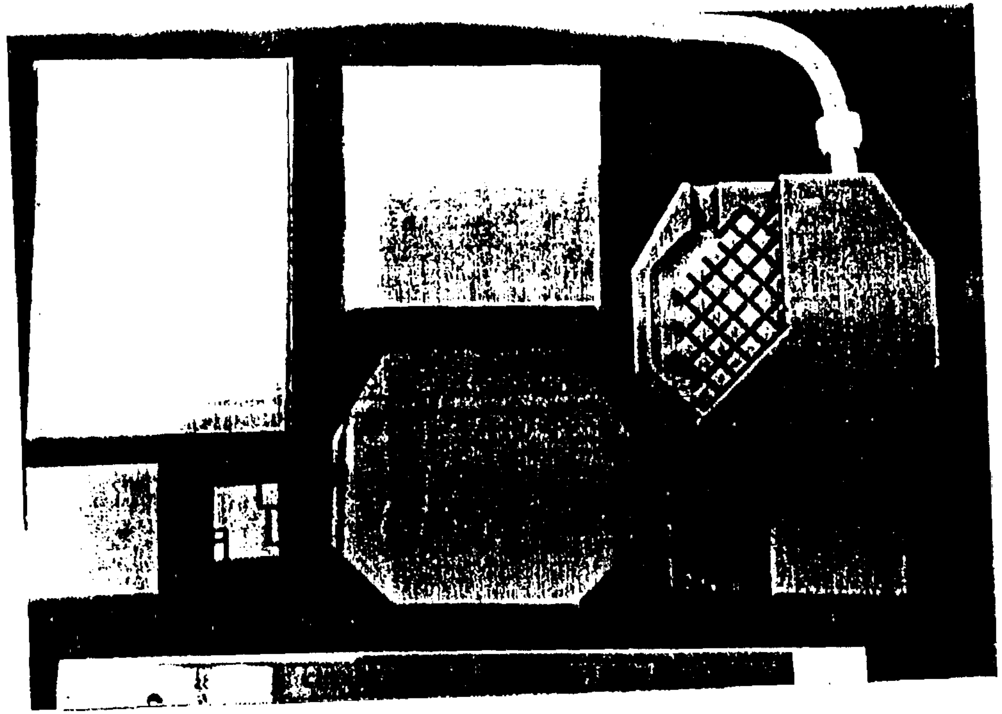
Active Brazed Copper (ABC)
Substrates developed by
ANCeram

R.Hahn, ANCERAM2.DOC, 21.11.1996, Hahn, TUB, Tel. 030 314 72833, Fax. 030 314 72 835

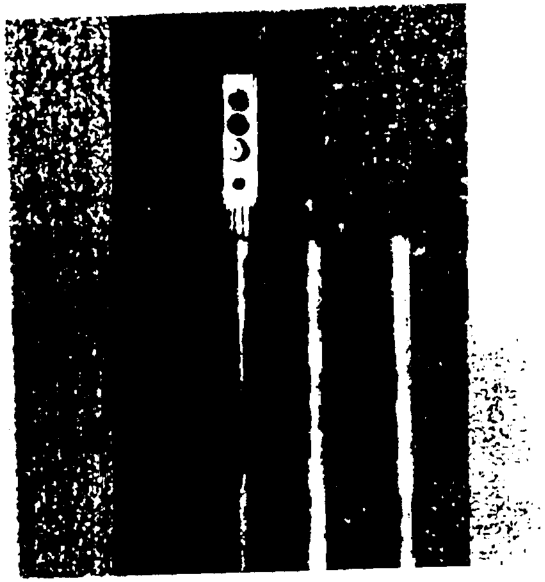
2. Neue Applikationen

AlN	:	Hohe Wärmeleitfähigkeit
Kupfer	:	Hohe elektr. Leitfähigkeit

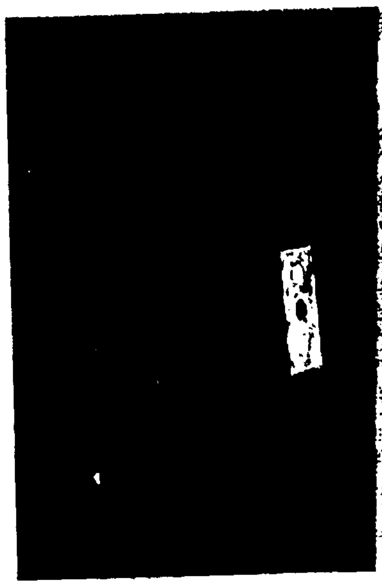
Anwendungen: Kühler, Wärmesenken
Schaltungsträger



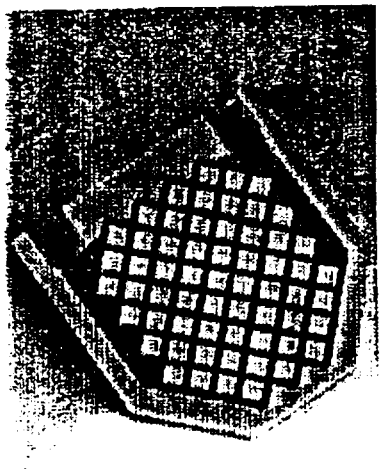
Ti on AlN Rods
Ti on AlN Rods

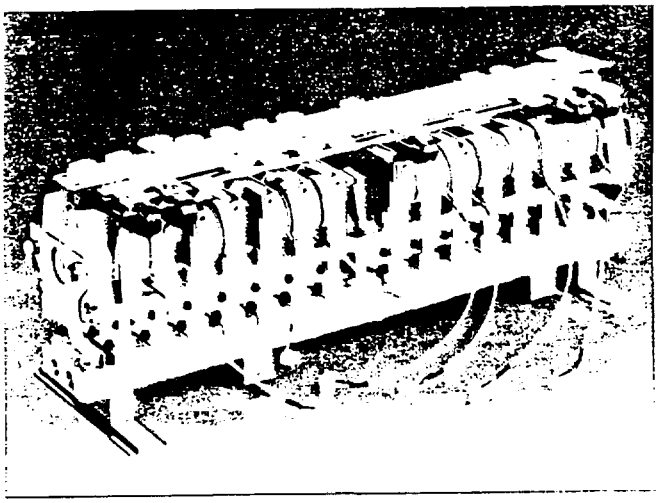


Laser Diode Heatsink



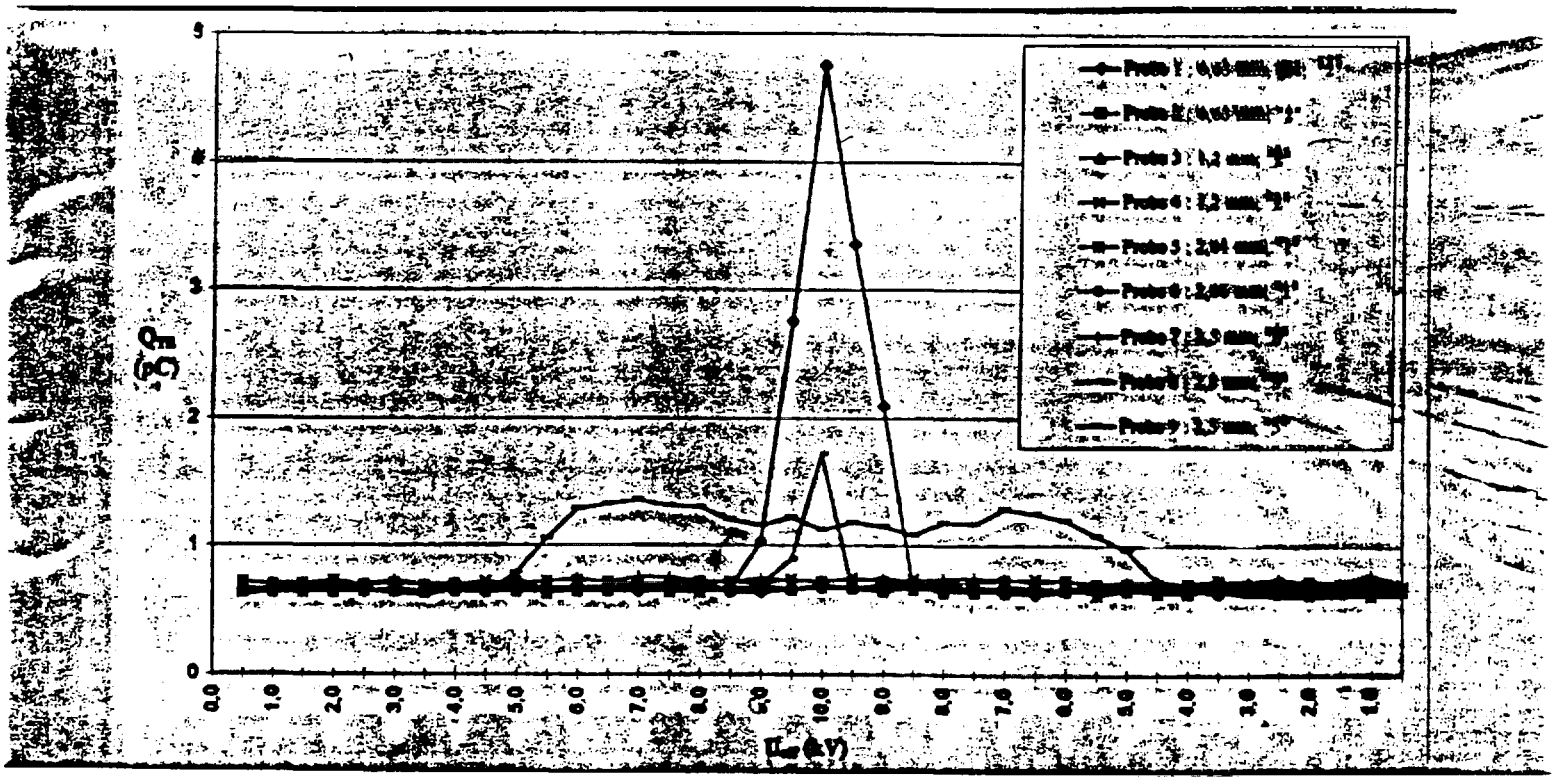
Aluminium Nitride Water Cooler





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

R.Hahn, ANCERAM1.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**

Aluminium Nitride Ceramics GmbH & Co. KG. Esbachgraben 21. Bindlach. Germany