EUCARD II - RHP presentation
10/12/2013

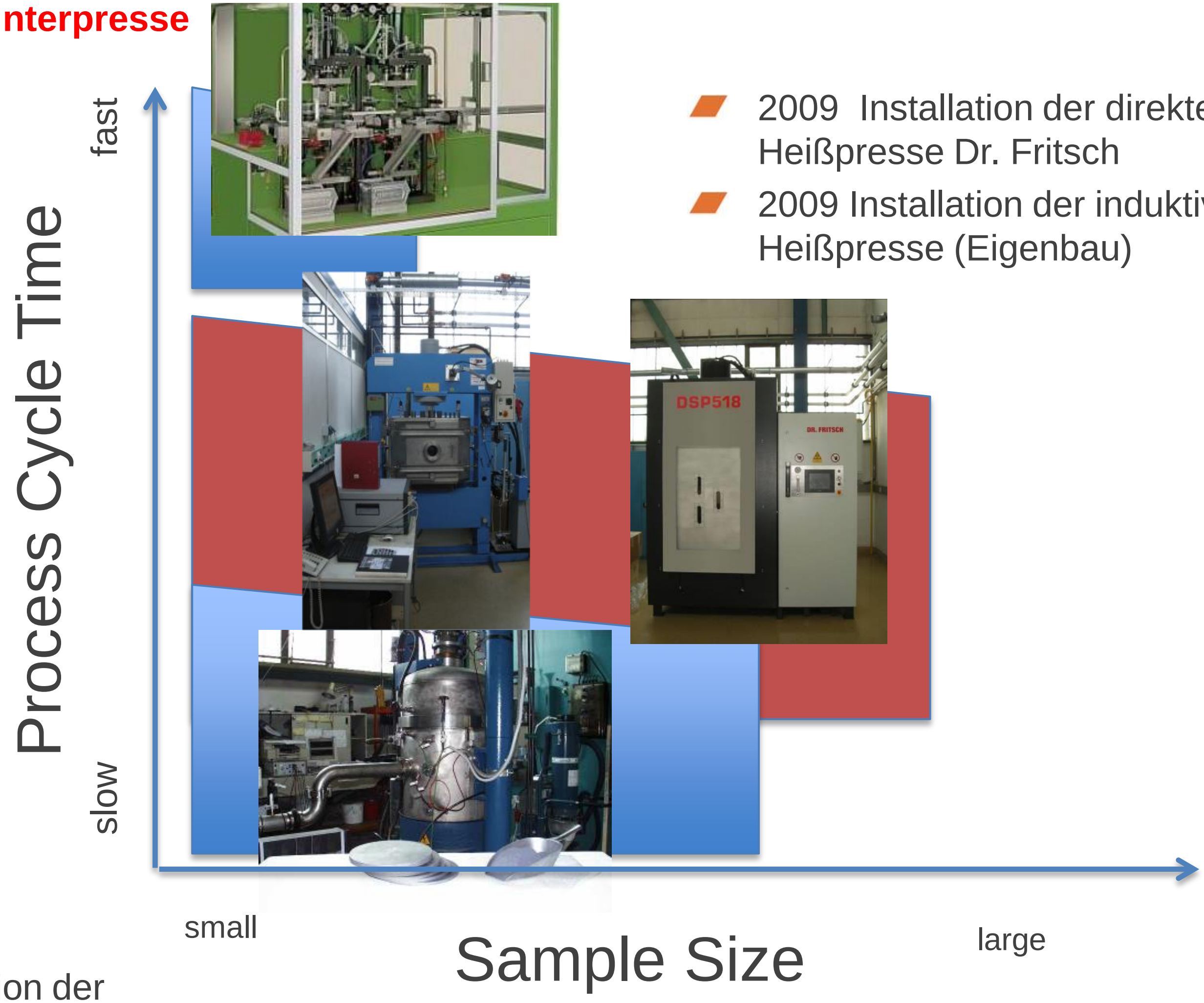
RHP-Technology GmbH & Co KG
A-2444 Seibersdorf, Austria

Overview

- Updated of processing technologies available at RHP
- Overview on possible geometries and size of parts which can be realized by our available sintering and hot pressing facilities
- Overview on possibilities to develop ceramics with customized composition
- Possible contribution of RHP

Hot Pressing Technologies at RHP:

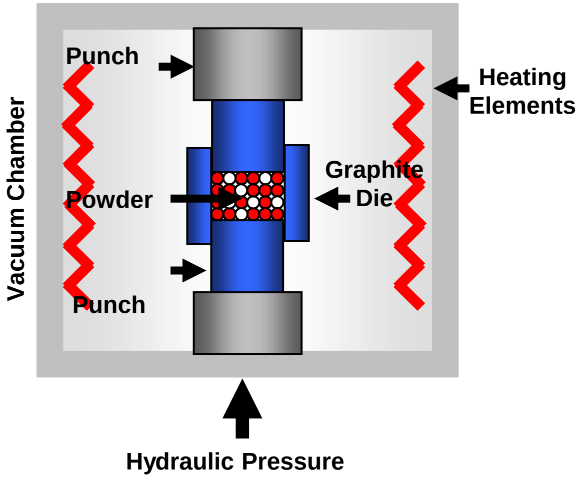
- **2012: Installation einer Einzelsegment Sinterpresse**



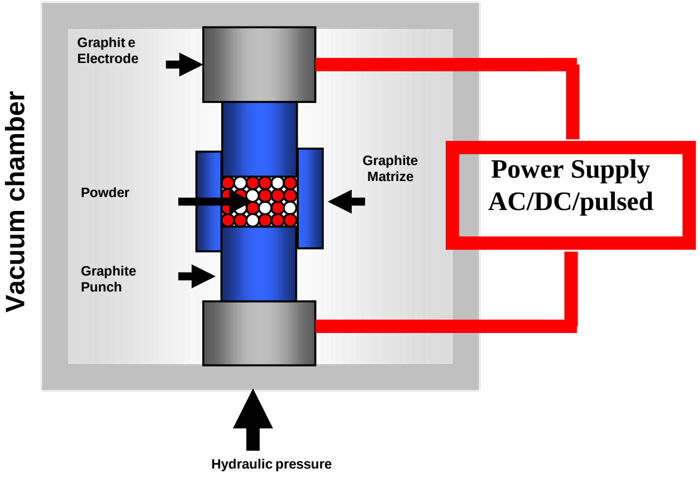
- 2009 Installation der direkten Heißpresse Dr. Fritsch
- 2009 Installation der induktiven Heißpresse (Eigenbau)

- 1996 Installation der konventionellen Heißpresse (FCT)

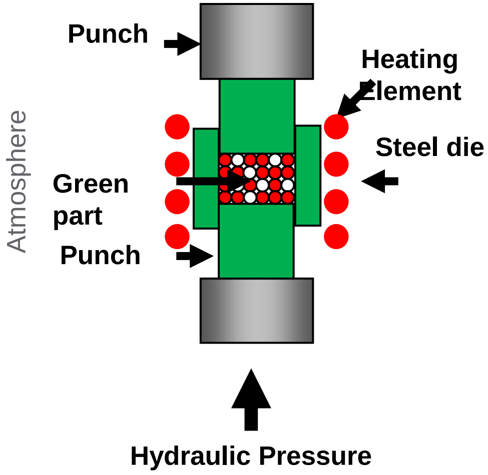
Overview: hot pressing technologies



Coventional Hot Pressing



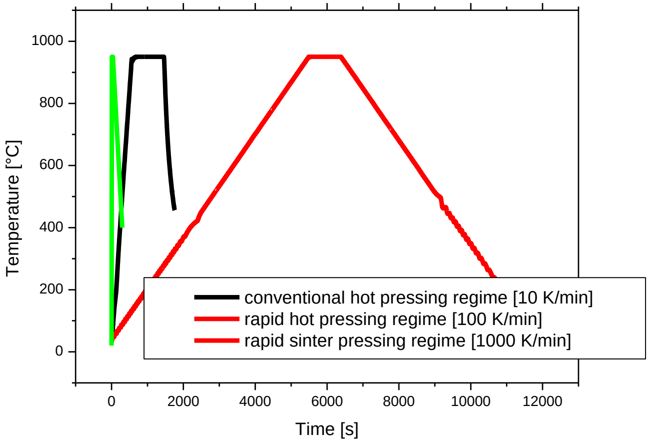
Direct heated hot pressing/ Spark Plasma Sintering



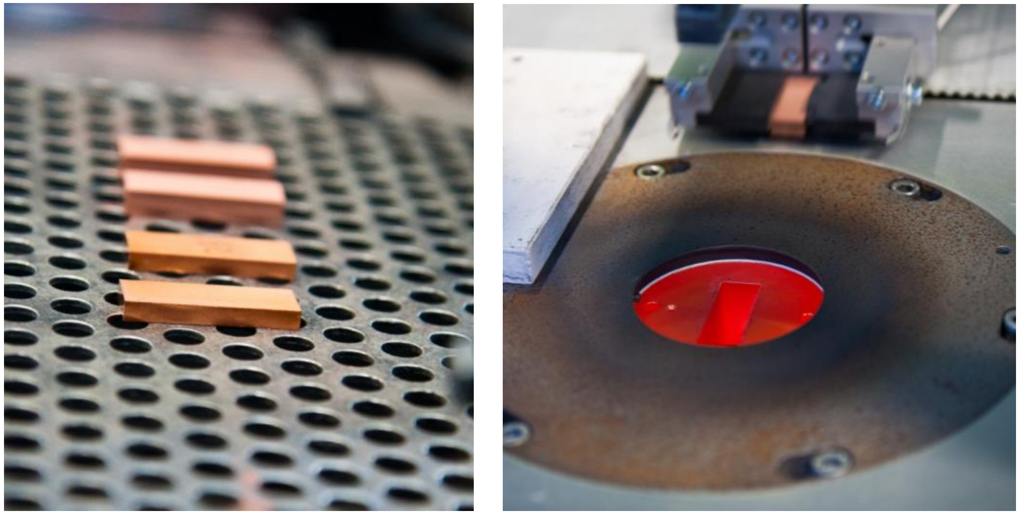
Rapid Sinter Pressing

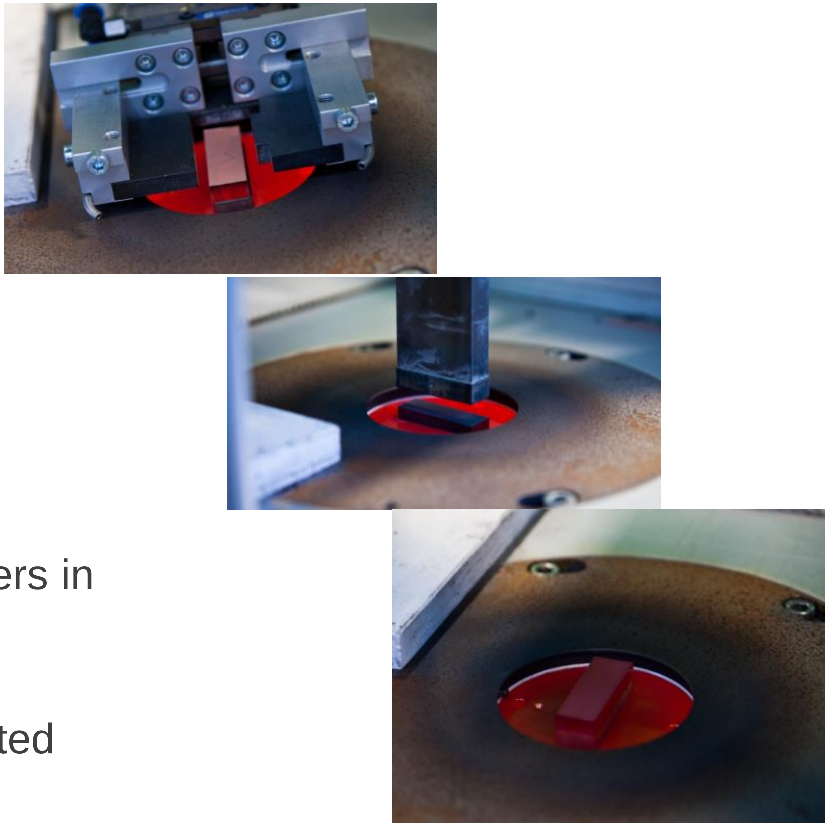
3 different pressure assisted Sintering Techniques:

- Conventional Hot Pressing: Heating of graphite die using a heating element (indirect)
- Direct Hot Pressing or Spark Plasma Sintering (pulsed): Heating of graphite die via current
- Rapid Sinter Pressing: Placing of a pre-compacted green part in a permanently heated pressing die



Processing steps of Rapid Sinter Pressing



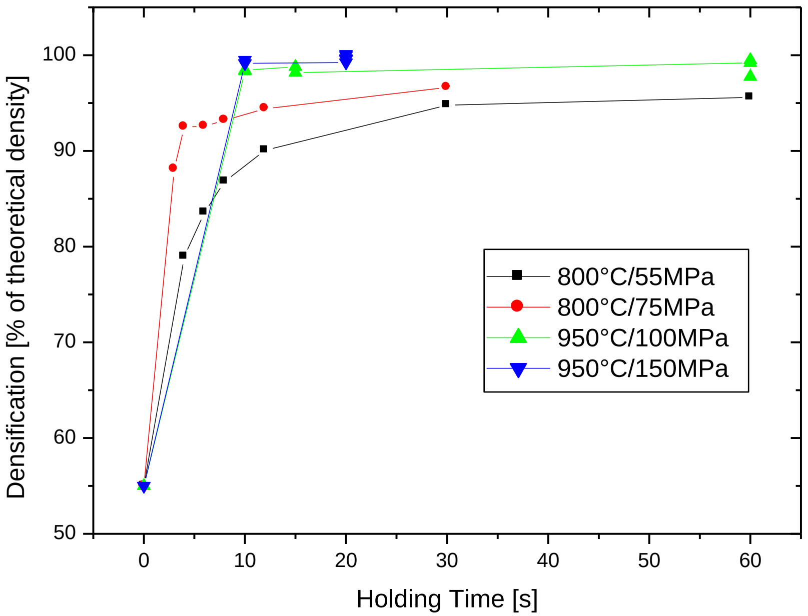


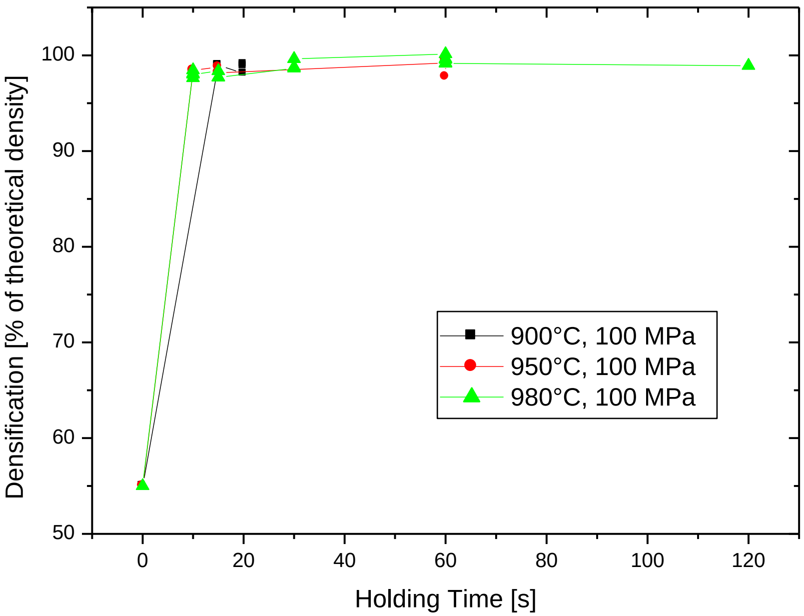
- RSP-Technology allows the densification of powders in seconds
- RSP uses a permanently heated cavity (e.g. up to 950° C) in which a compacted green part is inserted and densified by pressure (up to 150 MPa)
- RSP is a method which is suitable for the manufacturing of parts in large volume

Figure 1: Left image shows the green part and in the right image the automatic handling system is bringing the green part to the permanent heated hot pressing die

Figure 2: The sequence of images shows a) insertion of the green part in the pressing die b) consolidation of the green part and c) ejection of the part after hot pressing

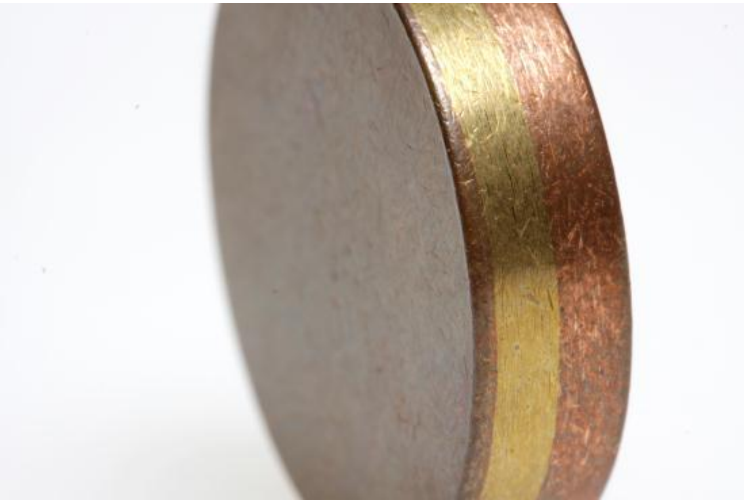
Parameter Studies: Densification of Copper (I)



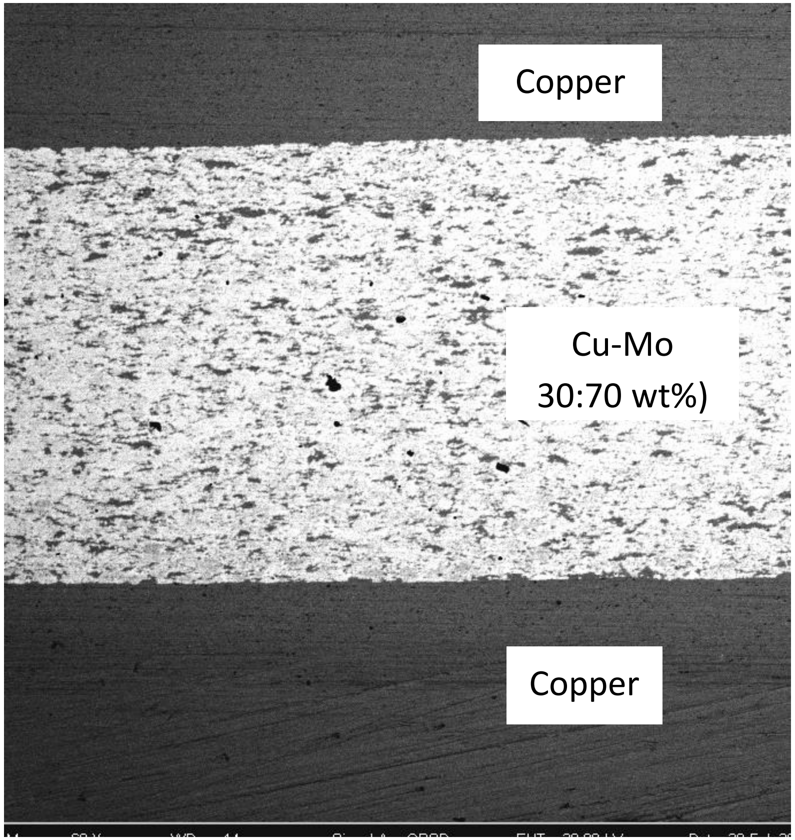


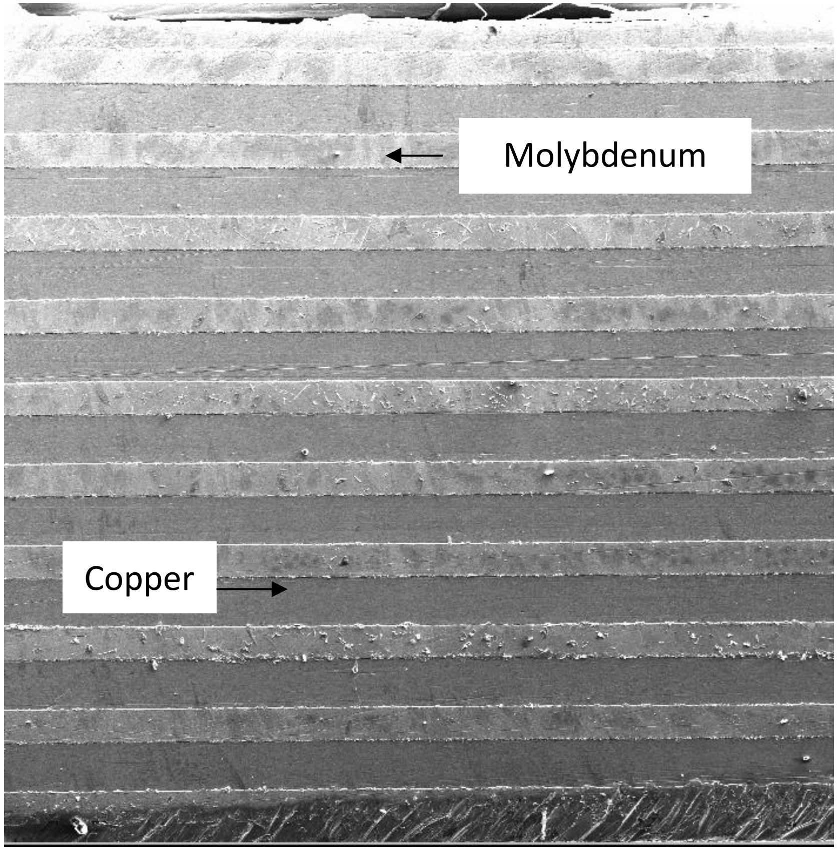
- By using significant higher pressures compared to conventional hot pressing it is possible to obtain a densification in copper within 10 seconds or less

„Design“ Possibilities using RSP Technology (I)



„Design“ Possibilities with RSP Technology (II)





Sandwich Structure

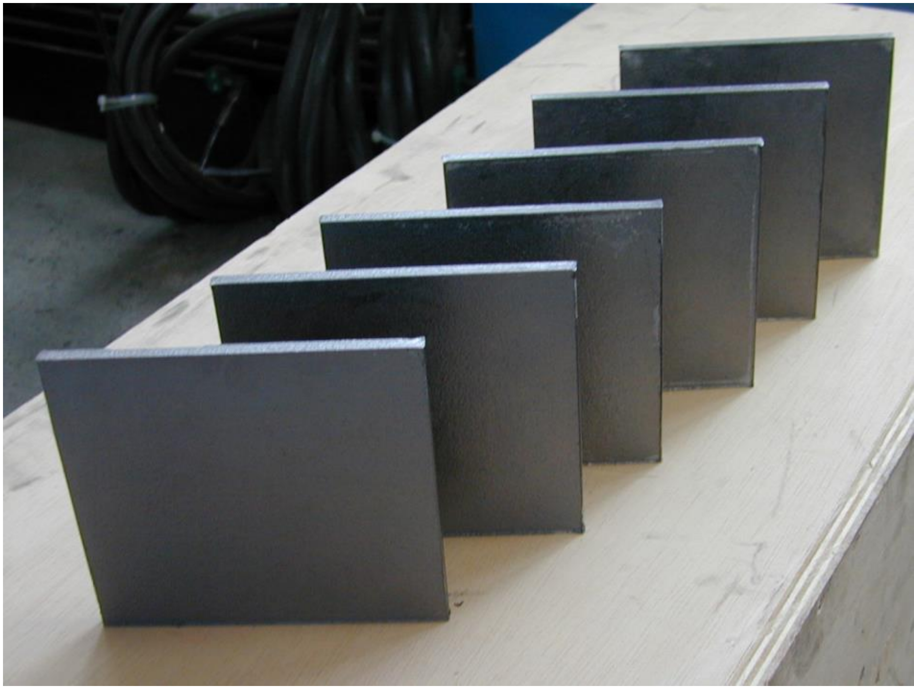
Multilayer Structure

Functionally Graded Structures are also possible

Typical geometries of hot pressed plates

Target/Plate size (examples) for hot pressing and direct hot pressing:

- Plates with diameter: 53 mm, 65mm, 76mm, 102mm, 153mm, 175mm, 205mm, 240mm, (for some materials 300 and 350 mm)
- Squares mit 40mmx40mm, 62mmx62mm, 140mmx140mm, 150mmx150mm
- Rectangular e.g. 171mmx76mm, 182 mm x 91 mm, 320mmx80mm (for materials up to 1.200° C hot pressing temperature)



Rectangular targets

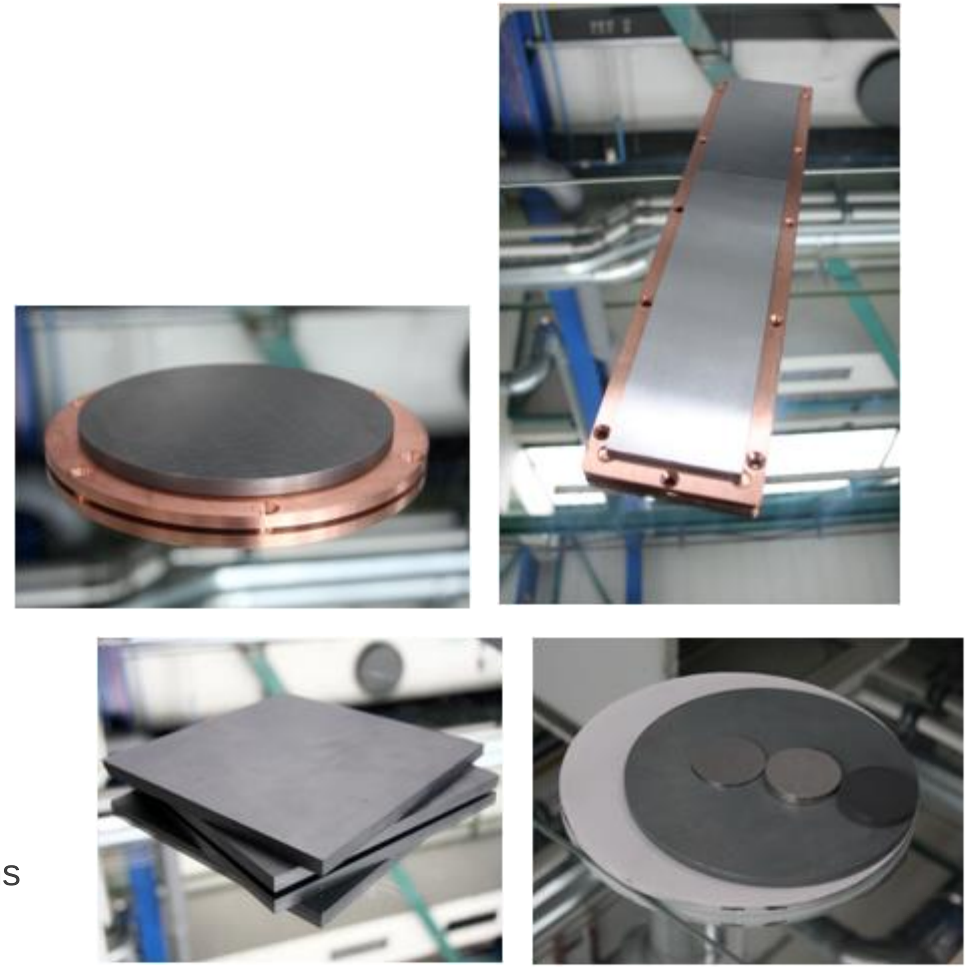
CUSTOMIZED TARGET MATERIALS

- Individual Material Compositions
- Single Samples, Prototypes
- Small Series
- Ceramics, Metals and Composites
- Fine-tuned Microstructure

- Magnetron Sputtering, Arc-Deposition, Pulsed Laser Deposition, ...

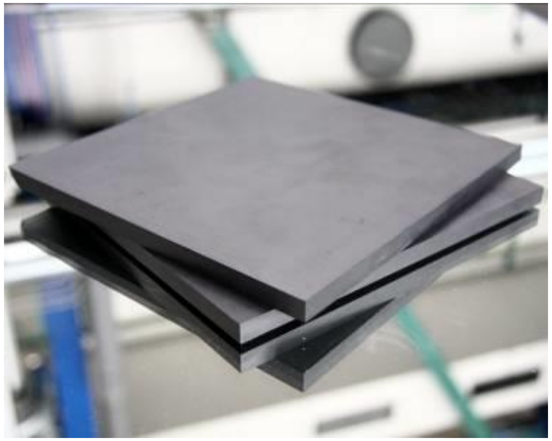
- Hard metals, ultrahard coatings, magnetic layers, photovoltaic applications, solid lubricants, advanced ceramics

- WC without binder
- W, Mo, Nb andTa-Oxide
- Ti Carbide, Boride or Nitride
- Cr or Ti Silicide
- ZnS/SiO_2
- Sulfides such as MoS_2, WS_2
- Various alloys or metal/ceramic combinations



Advanced Ceramics – Customized products

TiB2 tube



B4C plates

HfO2 target segments with size of 200 mm x125 mm

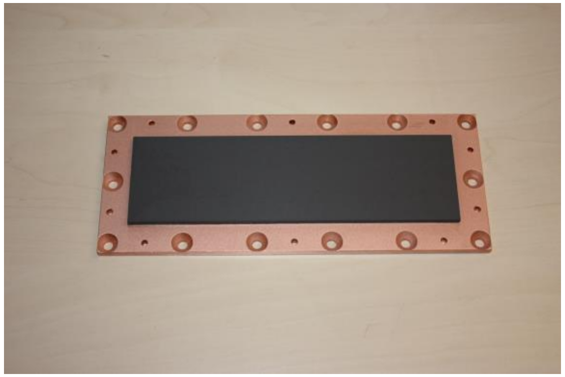
Materials:

- Various Oxide, Nitride, Carbide ceramics in customized shape and size
- High temperature borides such as TiB2, ZrB2, HfB2, HfC etc.
- Size of up to 300 mm possible

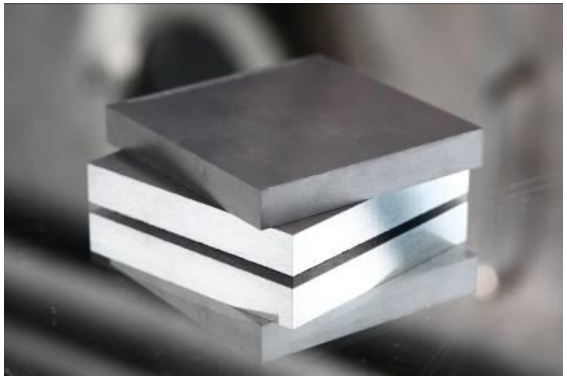
AlN compound target with size of 300 mm

Target materials for PVD processes

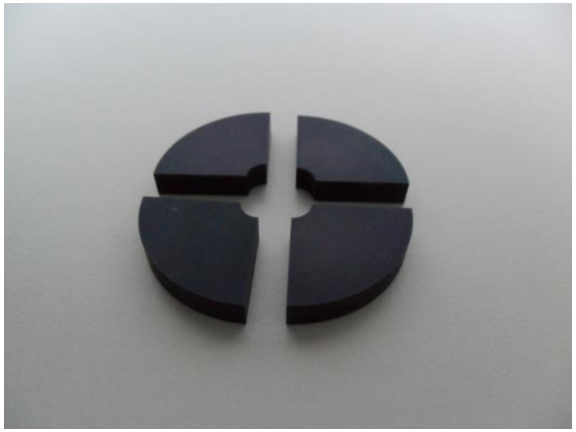
Hot pressed Boron Target



Hot pressed SiC-C Target on Cu backing plate



Tungsten Carbide
without binder

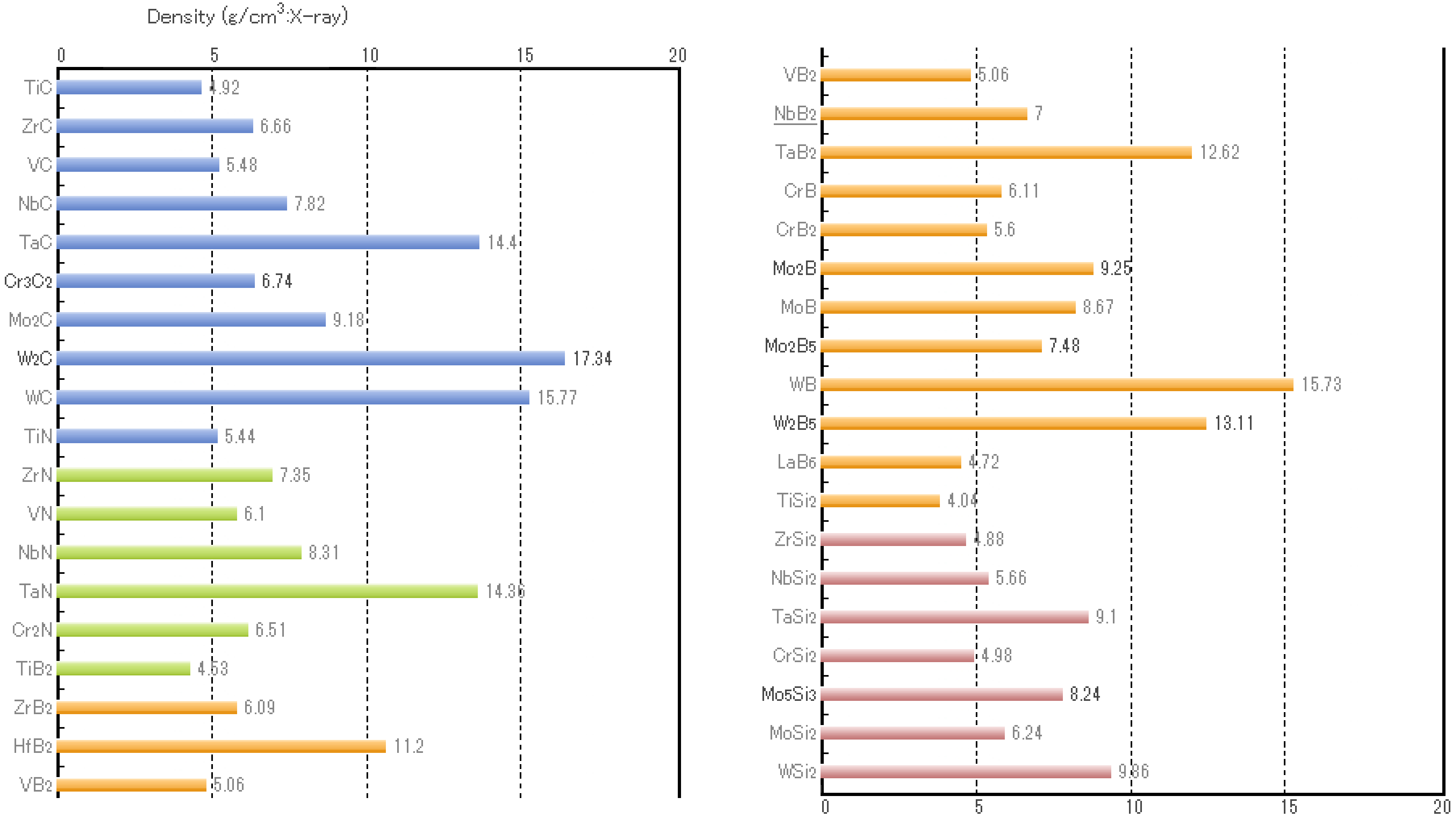


Lanthanum Hexaboride

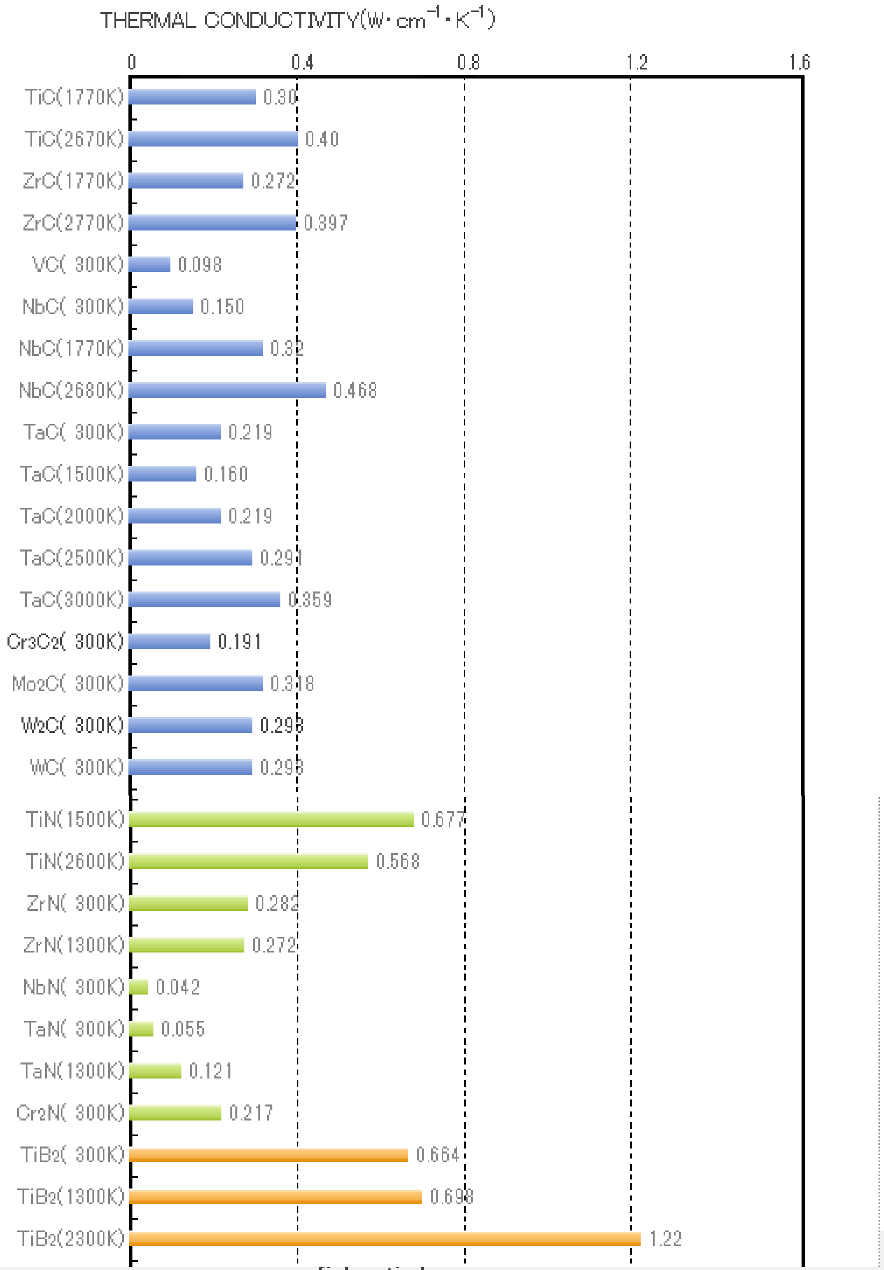
B4C (enriched B10) Target on Cu back plate

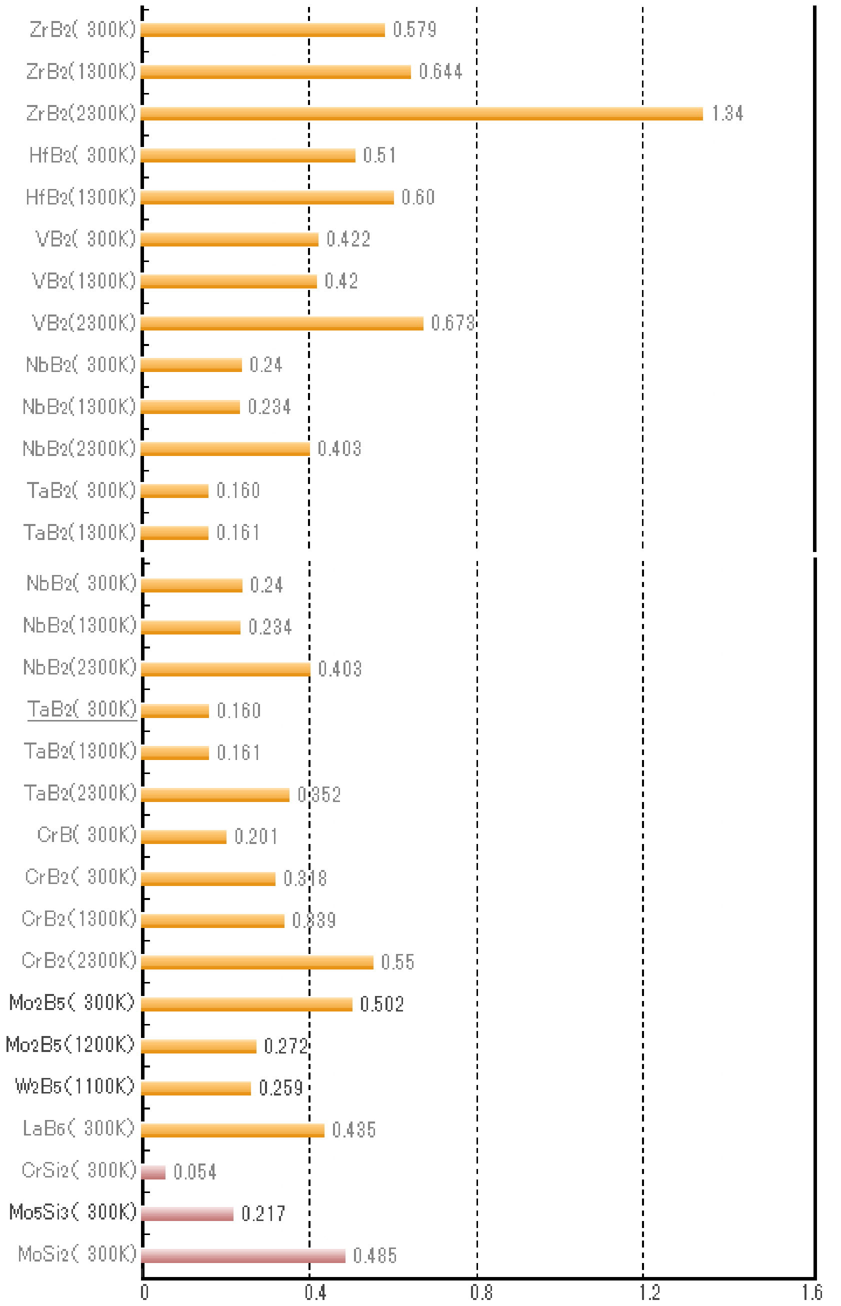
AlMgB14 Target

Density of Borides, Nitrides, carbides



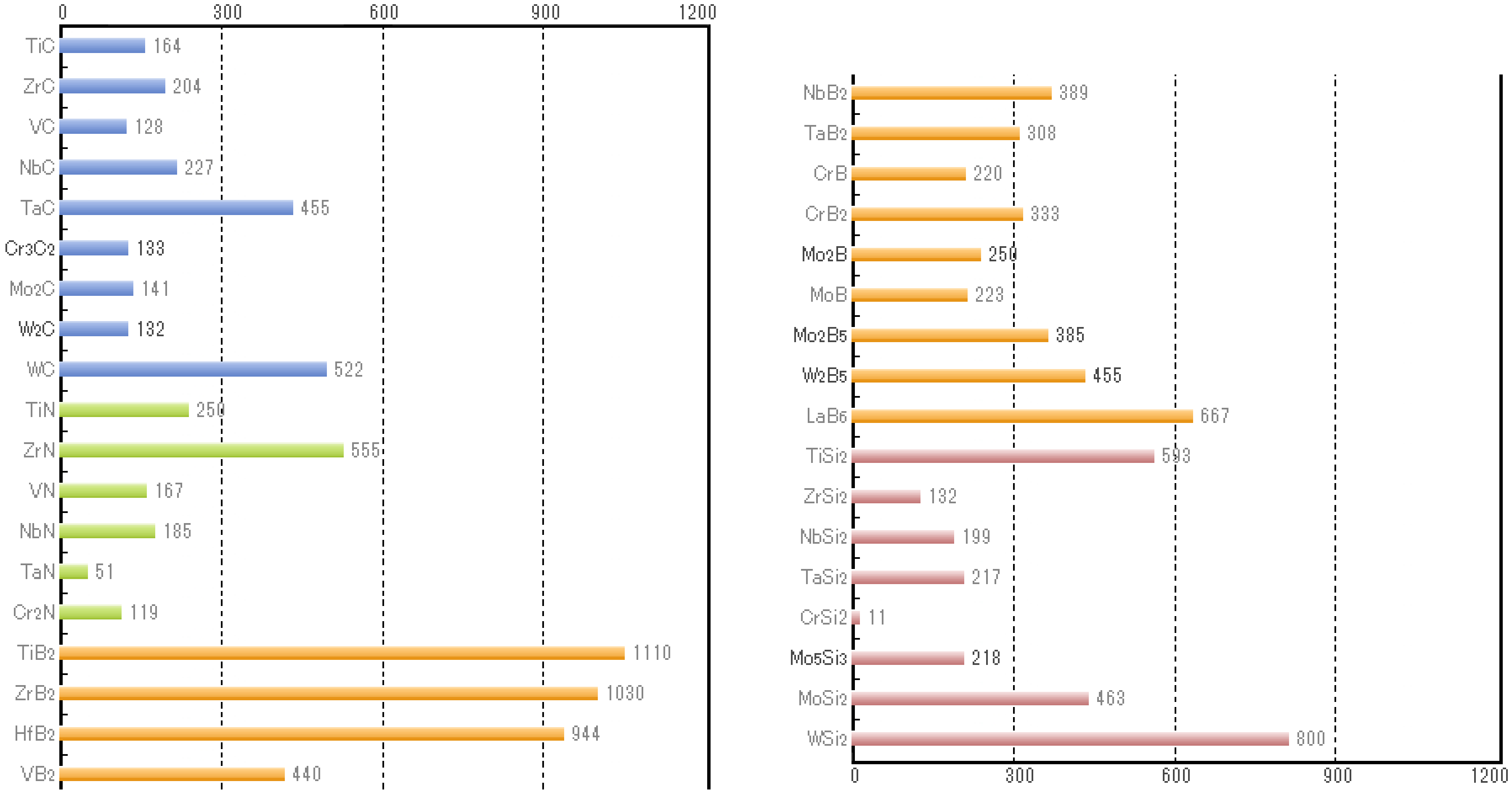
Thermal Conductivities of Borides, Carbides, Nitrides





Electrical properties

SPECIFIC ELECTRICAL CONDUCTIVITY (×$10^4 \cdot \Omega^{-1} \cdot m^{-1}$)

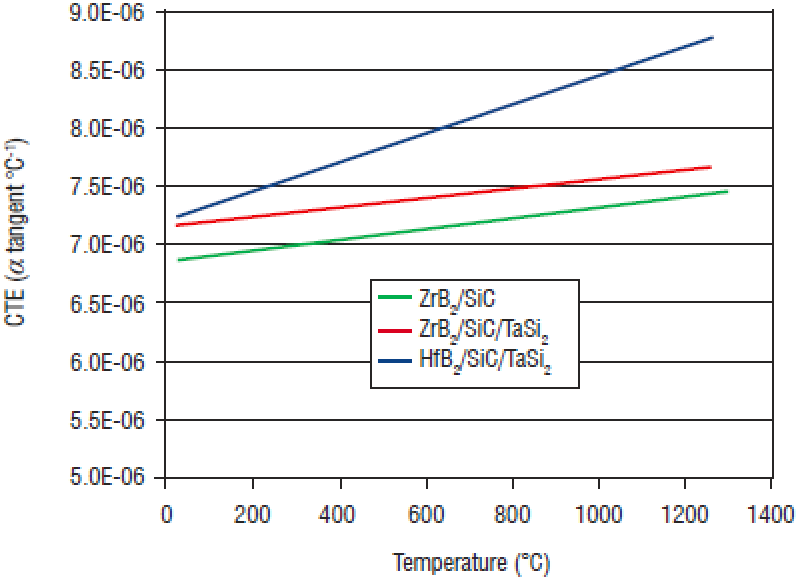


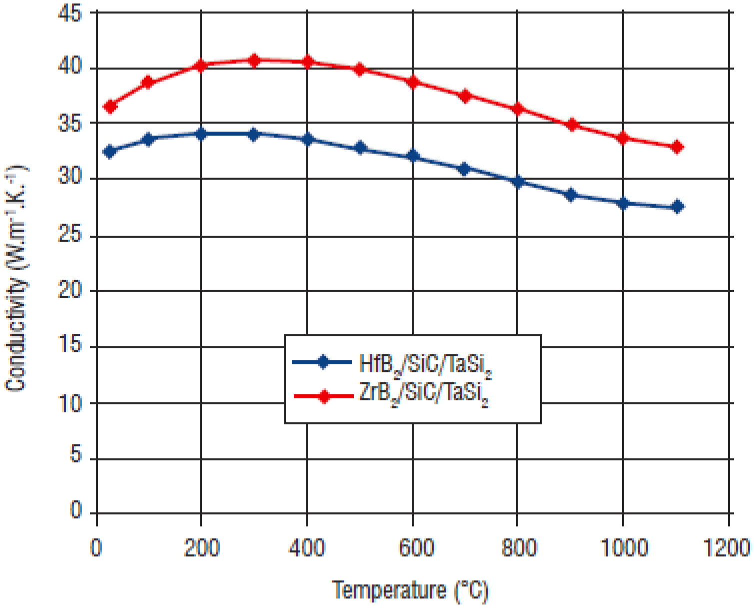
Material Combinations : e.g. ZrB_2/SiC & HfB_2/SiC

Composition	**Property**	**20°C**	**Test temperature** **1000°C**	**1150°C**
ZrB_2/SiC	σ_f (MPa)	451 ± 90	331 ± 270	286 ± 177
	E_f (GPa)	194 ± 6	137 ± 48	101 ± 48
	ε_f (%)	0.23 ± 0.04	0.23 ± 0.12	0.28 ± 0.04
$ZrB_2/SiC/TaSi_2$	σ_f (MPa)	688 ± 79	801 ± 40	864 ± 96
	E_f (GPa)	211 ± 13	181 ± 14	133 ± 13
	ε_f (%)	0.32 ± 0.02	0.45 ± 0.04	0.65 ± 0.02
$HfB_2/SiC/TaSi_2$	σ_f (MPa)	869 ± 170	882 ± 146	1055 ± 189
	E_f (GPa)	245 ± 13	203 ± 24	178 ± 22
	ε_f (%)	0.36 ± 0.09	0.43 ± 0.05	0.56 ± 0.13

Composition	H_{v10} **/ GPa**	K_{1c} **/ MPa.m$^{1/2}$**	E **/ GPa**
ZrB_2/SiC	20.9 ± 1.9	4.3 ± 0.2	465 ± 15
$ZrB_2/SiC/TaSi_2$	18.1 ± 0.4	4.4 ± 0.3	446 ± 9
$HfB_2/SiC/TaSi_2$	18.1 ± 0.6	4.6 ± 0.2	498 ± 6

Table 5 – Hardness, toughness and Young's modulus of the three sintered materials





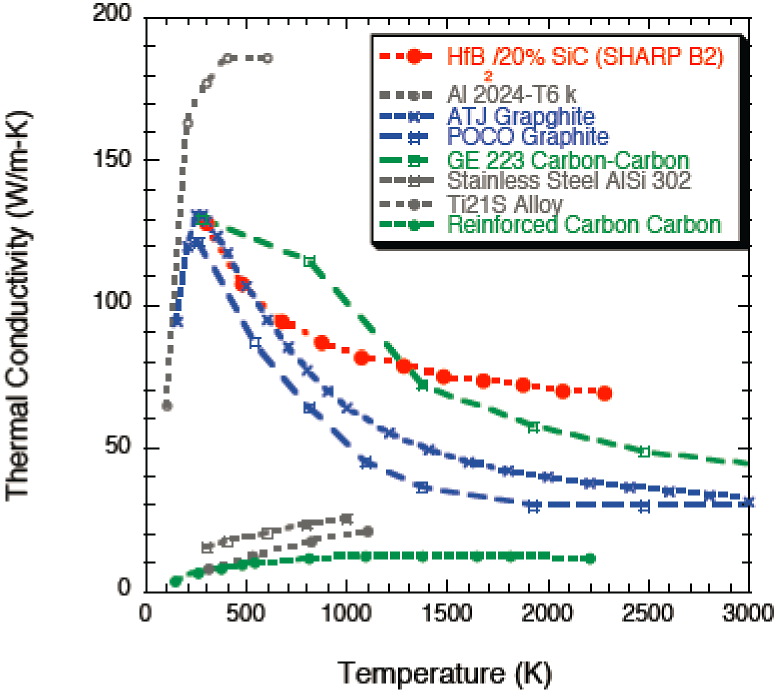
ZrB_2/SiC & HfB_2/SiC

Property	HfB_2/20vol%SiC	ZrB_2/20vol%SiC
Density (g/cc)	9.57	5.57
Strength (MPa) 21°C	356±97*	552±73*
1400°C	137±15*	240±79*
Modulus (GPa) 21°C	524±45	518±20
1400°C	178±22	280±33
Coefficient of Thermal Expansion (x10^{-6}/K) RT	5.9	7.6
Thermal Conductivity (W/mK)$^{\#}$ RT	80	99

Source: ManLabs and Southern Research Institute

* Flexural Strength

- High thermal conductivity (directional)
- High fracture toughness/mechanical strength/hardness
- Oxidation resistance (in reentry conditions)

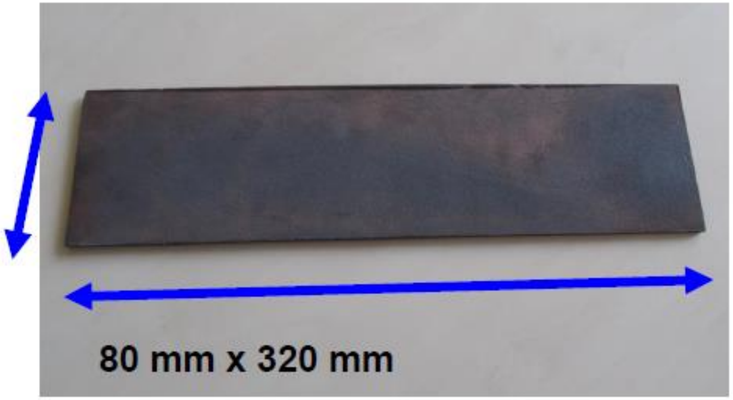


Topics

- 1. Presentation of advanced ceramics produced at RHP Technology (WC, MoC, SiC, TiC, ecc) with specific focus on highly conductive materials
- 2. Proposals for new heavy and conductive refractory materials (e.g. WC- or Mo2C- based) as an alternative to present tungsten heavy alloys
- 3. Proposals for other SiC- based materials and their bonding to metallic substrates
- 4. Type and number of material samples to be produced.

Possible contributions of RHP

- 1. Continue Work on Copper-Diamond composites (sandwich structure; include a Mo oder W cladding layer by direct bonding)
- 2. Prepare ceramic materials/customized composition for screening tests and further characterization
- 3. Screening of SiC – Metal bonding technology
- => to discuss: type and number of material samples to be produced.



Copper-diamond composites

Cu-Mo-Cu-Mo-Cu Multilayer

Thank you for your attention!

Further information:

www.rhp-technology.com

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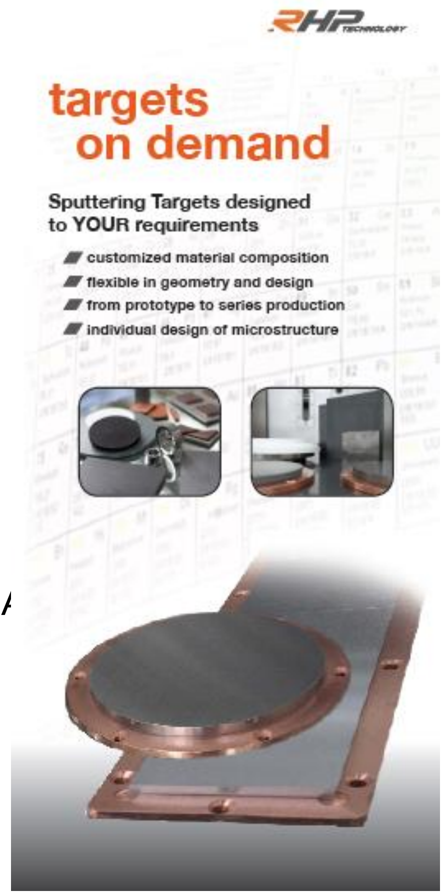

targets
on demand

Sputtering Targets designed
to YOUR requirements

- customized material composition
- flexible in geometry and design
- from prototype to series production
- individual design of microstructure

dia cool

high performance cooling

350 - 500 W/mK thermal conductivity
6 - 10 ppm/K thermal expansion
Ra < 3µm high surface quality

a product by RHP Technology