

CuB/Diamond Composites for Heat Sink Applications

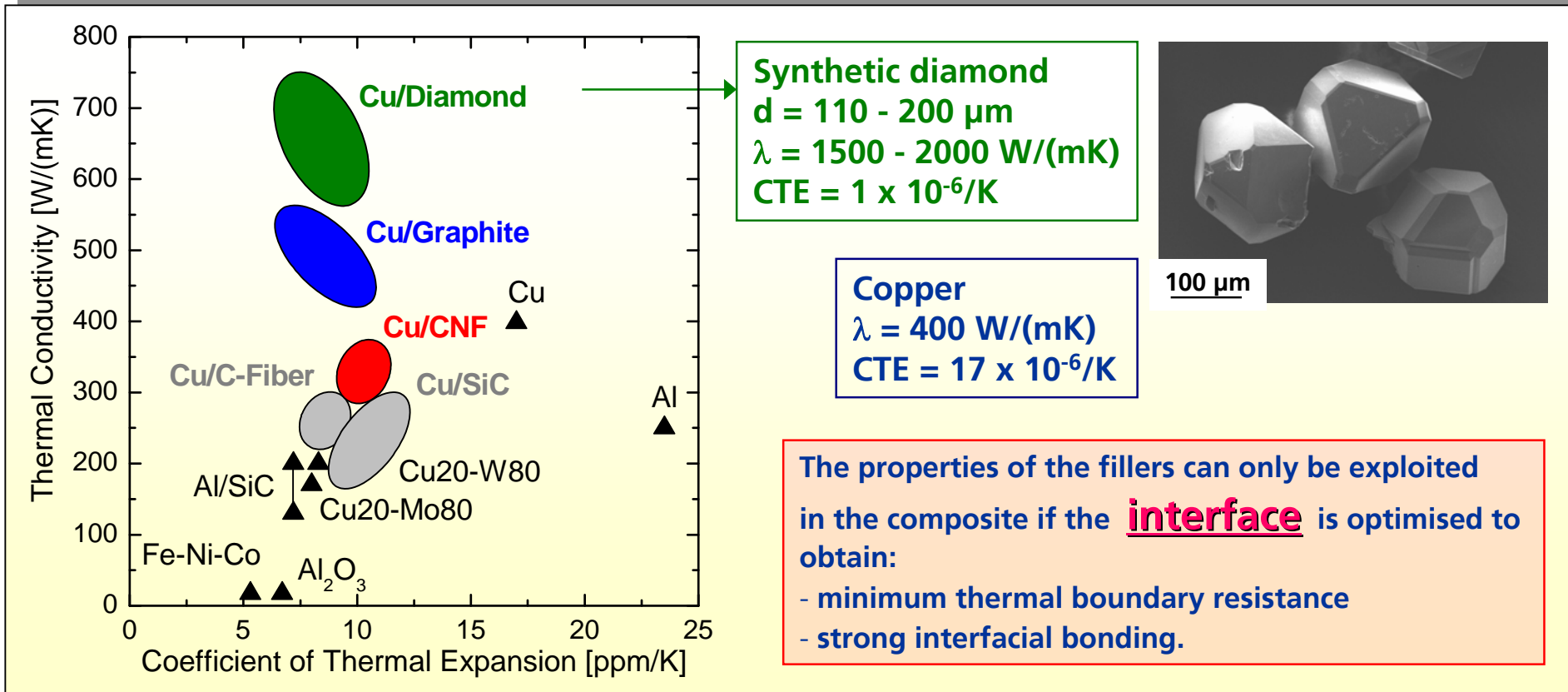
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Advanced Material Concept for Heat sinks - Composites



Powder Metallurgy

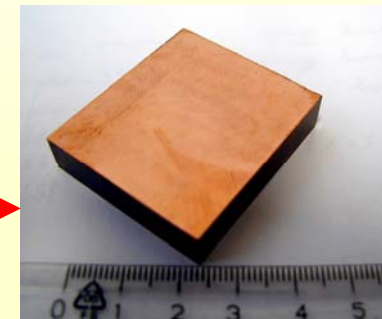
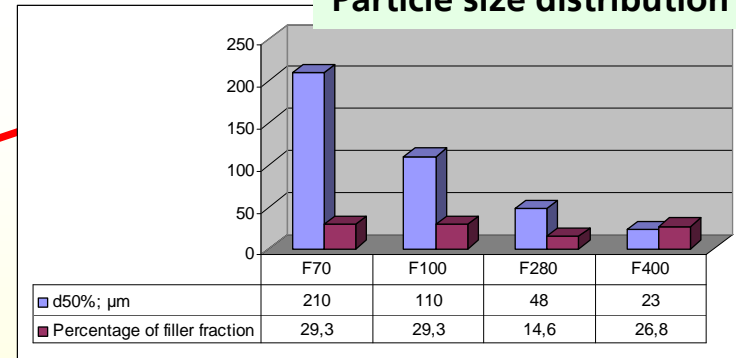
Cu powder
or
Cu+X powder
(X=Cr, B, Ti....)

Filler
Powder

Mixing

Hot Pressing,
SPS, (HIP)

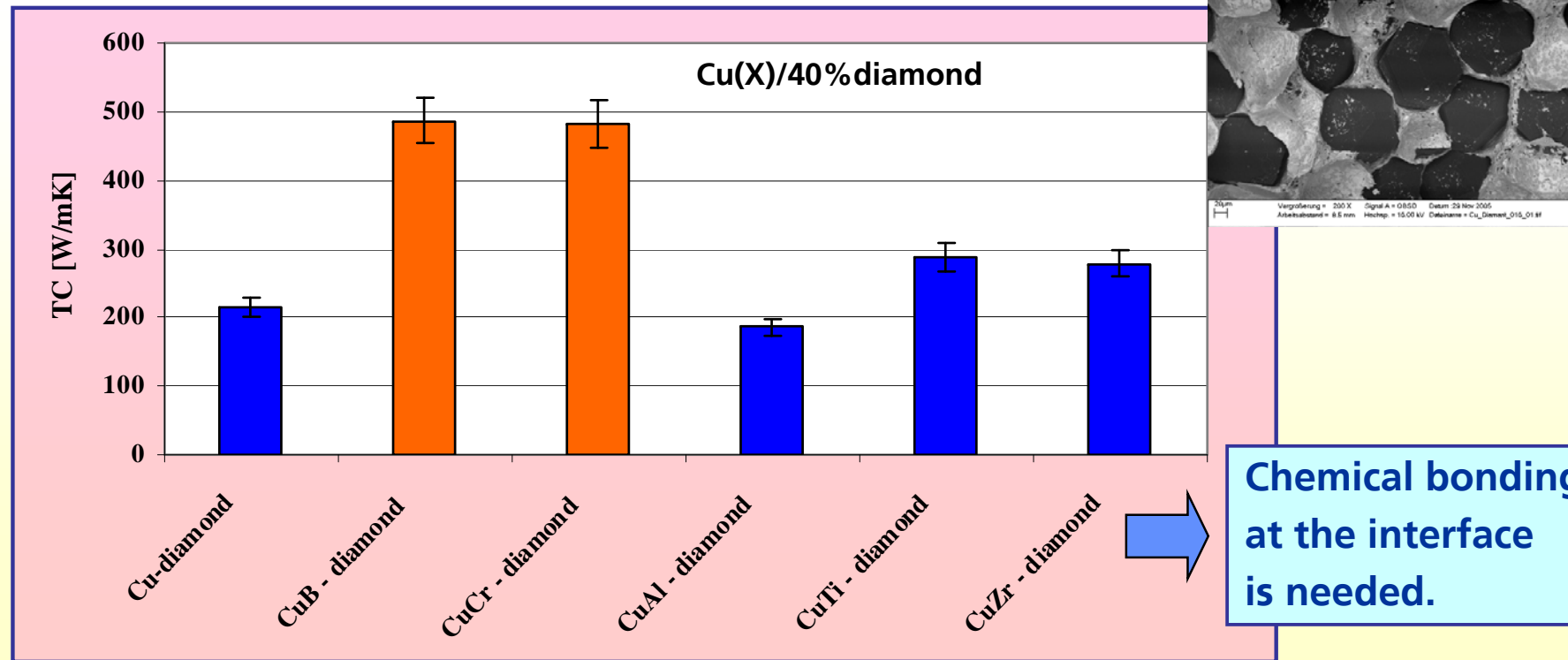
Particle size distribution



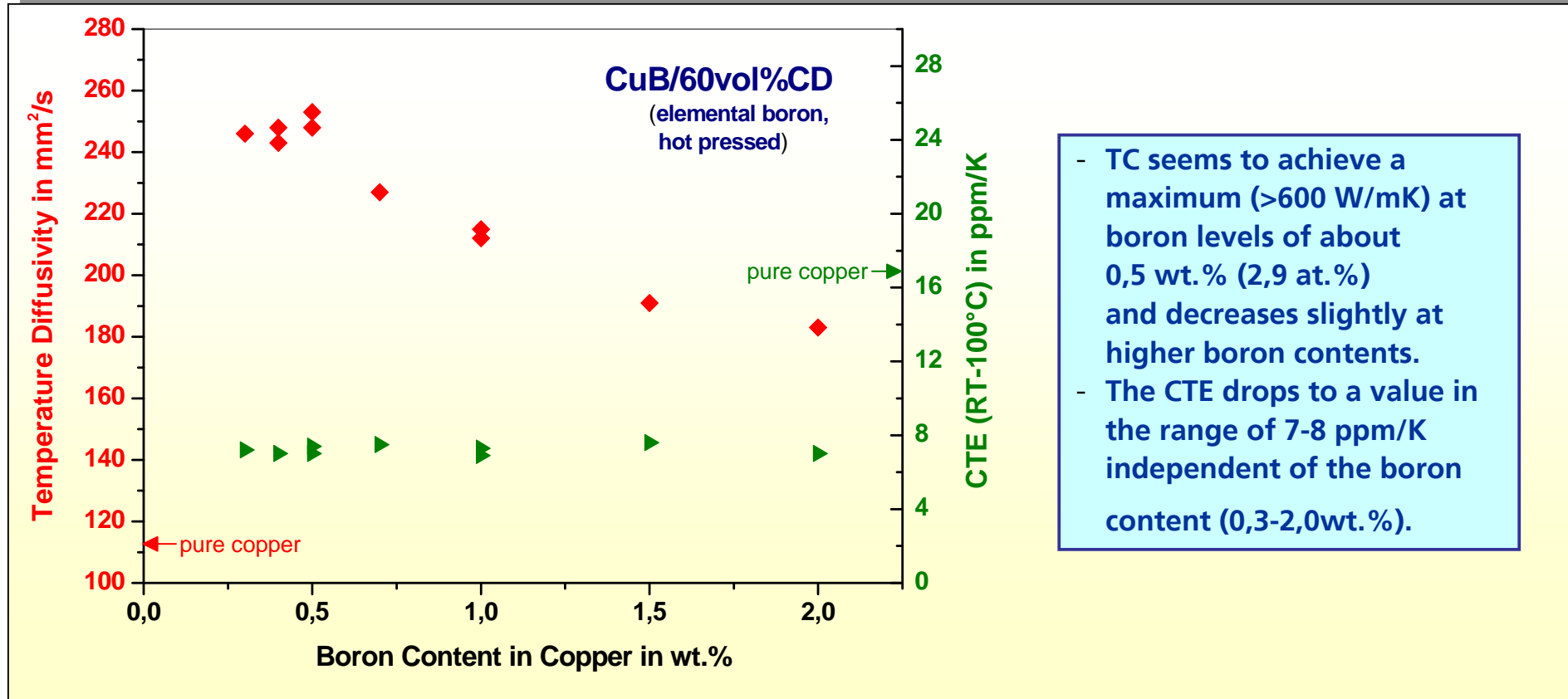
Composites
or
Laminates
with
different
sizes
and
thicknesses

Cu - Diamond

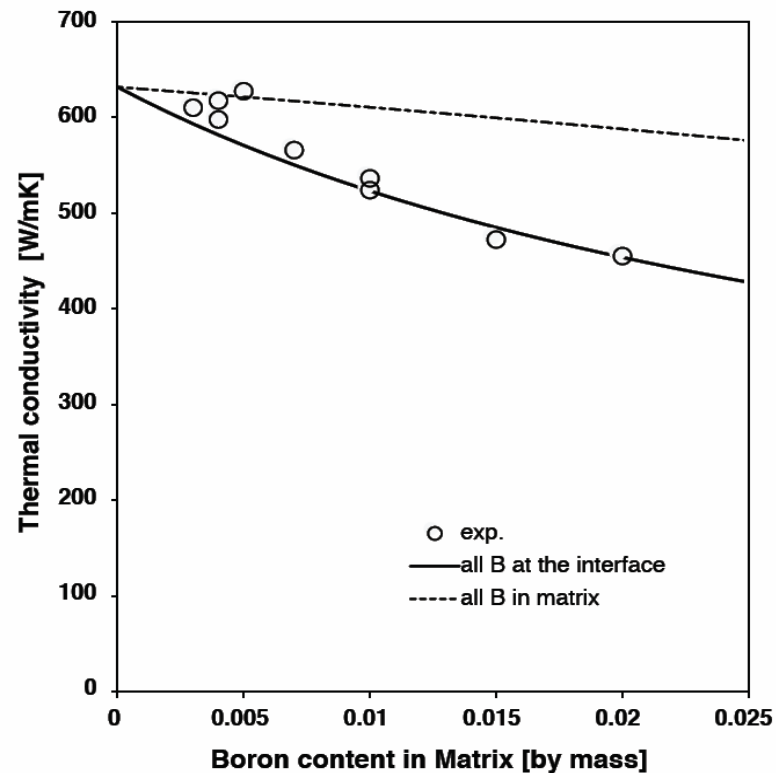
Thermal conductivity vs. copper matrix alloy



Influence of the Boron Content on the Thermal Conductivity / CTE



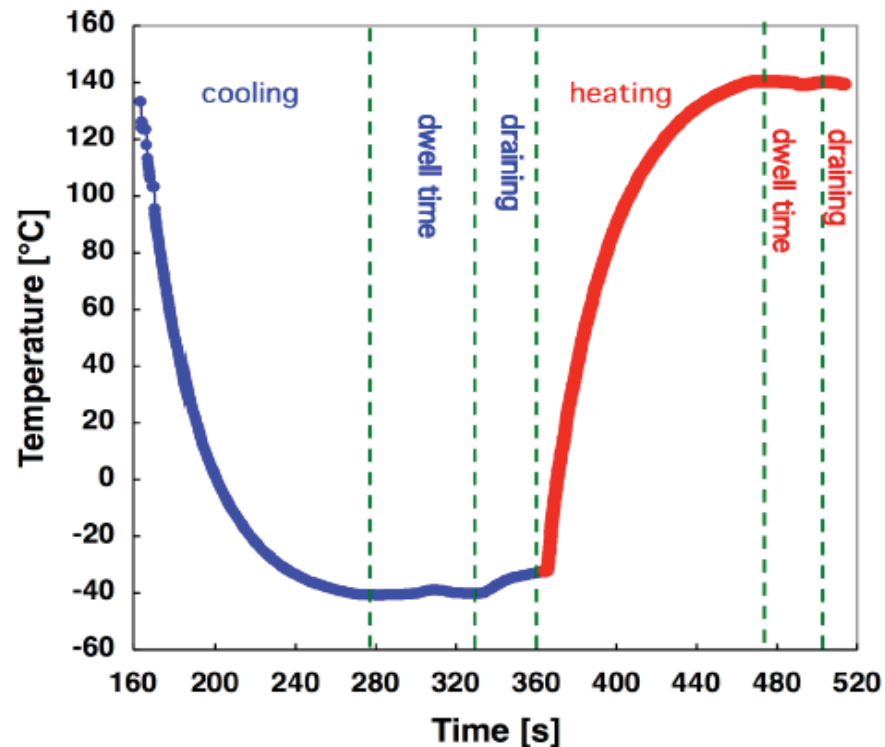
Thermal Properties vs. Boron Content – Modelling by EPFL



➤ a $\sim 1\mu\text{m}$ carbide layer (2 wt.% B) can reduce the interfacial thermal conductance of the composite
 from $3,0 \cdot 10^7 \text{ W/m}^2\text{K}$
 to about $1,7 \cdot 10^7 \text{ W/m}^2\text{K}$

➤ an increasing thickness of the boron carbide layer can cause the reduction of TC of the composites with the increasing boron content
 ??

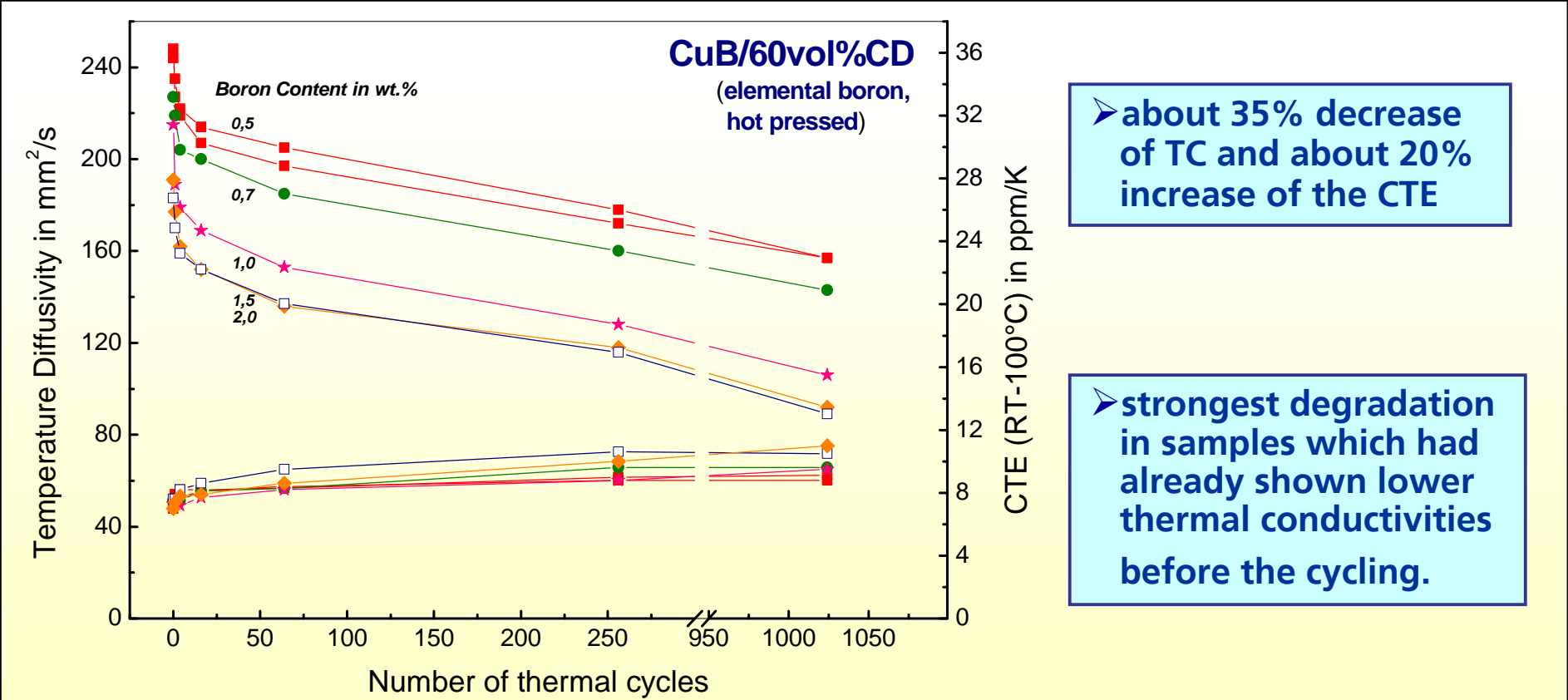
Environmental Testing at EPFL



➤ thermal fatigue testing for up to 1000 cycles between -50°C and 140°C

➤ One thermal cycle needs about 6 min.

Thermal Fatigue of the CuB Composites

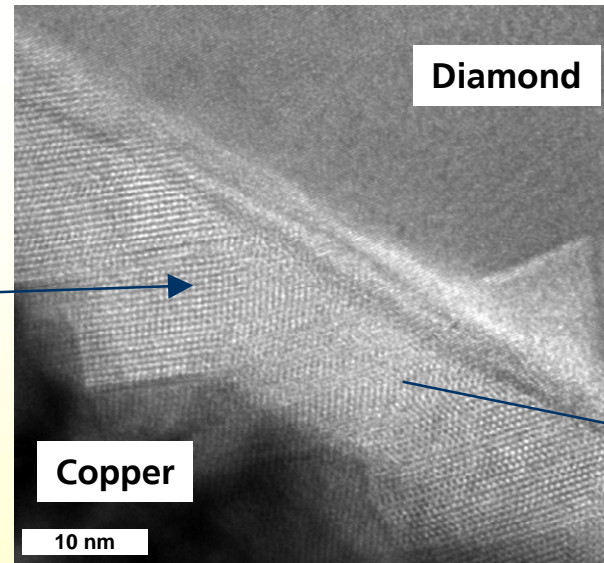
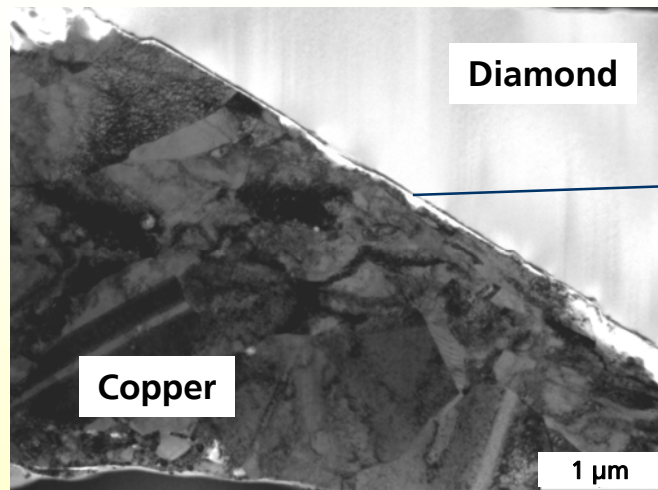


➤ about 35% decrease of TC and about 20% increase of the CTE

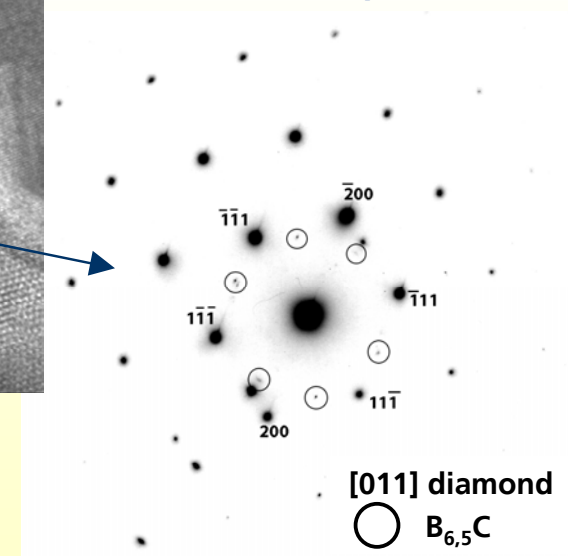
➤ strongest degradation in samples which had already shown lower thermal conductivities before the cycling.

Microstructures

TEM micrographs showing the Cu/diamond interface



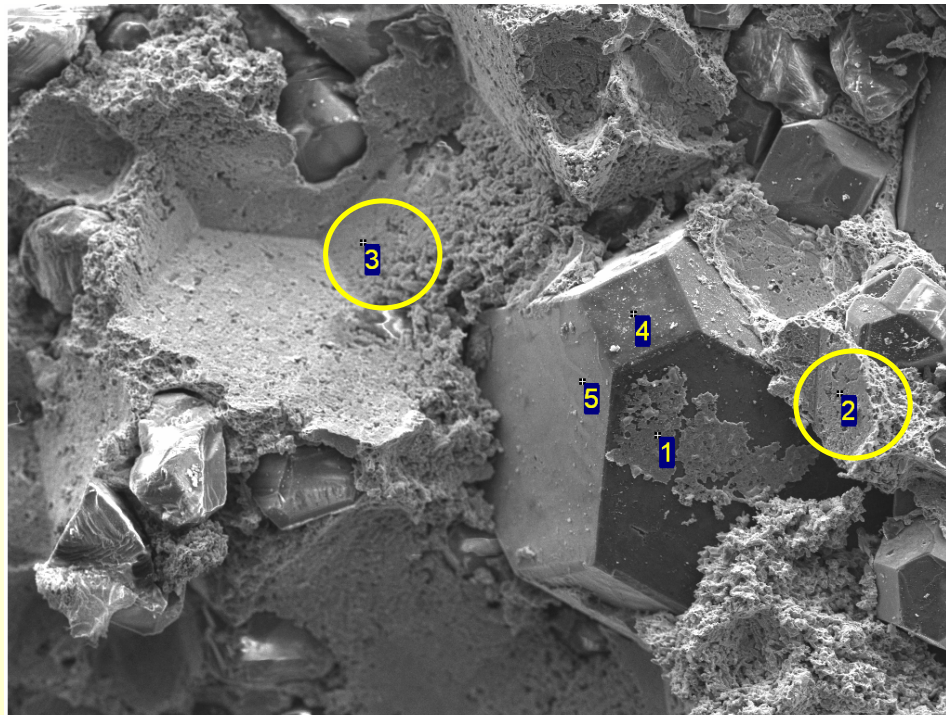
Diffraction pattern



- An interfacial phase of some 20 nm in thickness was revealed.
- Judging from the relative intensity of diffraction spots $B_{6.5}C$ is most probable (compared to B_4C).



Fracture Surface of the CuB Composites



100µm

Elektronenbild 1

Low interfacial bonding
between diamond and boron
carbide:

	Cu	C	B	in wt. %
1:	61	39		
2:	22	22	56	
3:	20	17	62	
4:		100		
5:		100		

Conclusions

- **P/M - fabrication of copper composites with high diamond loading up to 65 vol% by using bimodal particle mixtures.**
- **Optimisation of the boron content in CuB/60 diamond composites.**
- **Study of the thermal cycling behaviour revealed some weakness of the interfacial bonding, especially at the side of diamond/carbide.**



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