Impact of alloy selection on technological properties & reliability of base plates for power modules

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Major aim

» Copper base plates are widely used for power module applications due to copper's mechanical reliability & outstanding thermal conductivity. Progressive miniaturization & demanding design requirements pose a challenge for copper base plates. Thus, this investigation reveals that the selection of copper alloys is crucial in order to design base plates for different conditions & applications.

Approach

» Six different copper alloys were selected for this comprehensive examination.
» High-performance alloys (HPAs), such as C151 & C184, were compared with standard pure copper alloys.
» Base plates were produced from 3 mm strips.
» Stamping, bowing & stress-relief annealing (simulation of brazing) operations were subsequently carried out.
» Base plate materials were characterized & compared regarding mechanical & microstructural properties, as well as softening & relaxation resistance.

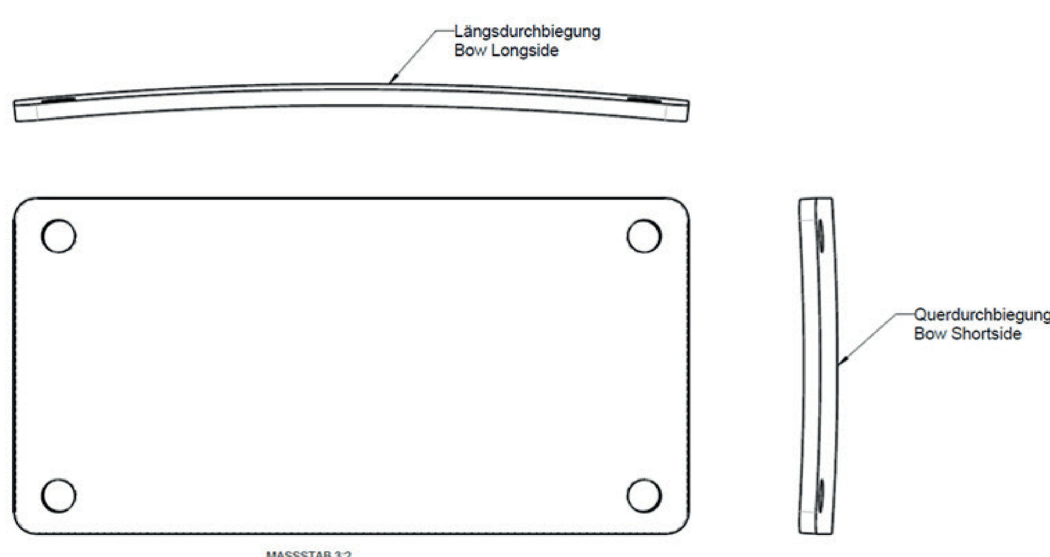

Fig. 1: Sketch of base plate geometry & warpage

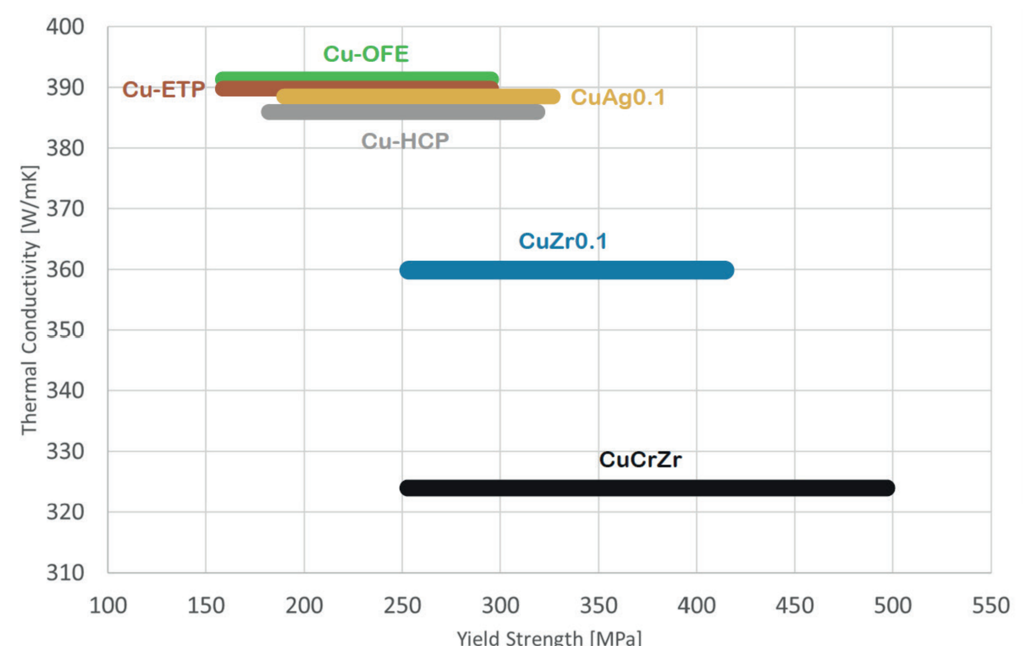

Fig. 2: Thermal conductivity & strength of selected alloys

Results

» Pure copper exhibits the highest remaining ductility but lower strength.

UNS	ISO	Aurubis	Tensile strength	Yield strength	Elongation	Thermal conductivity
			R_m [N/mm²]	$R_{p0.2}$ [N/mm²]	A_{50} [%]	[W/mK]
C101	Cu-OFE	PNA 203	264	230	34	394
C103	Cu-HCP	PNA 210	265	235	35	385
C107	CuAg0.1	PNA 217	330	311	14	388
C110	Cu-ETP	PNA 211	260	235	30	390
C151	CuZr0.1	PNA 296	349	336	11	360
C184	CuCrZr	PNA 372	501	470	11	325

» The HPAs C151 & C187 show the highest resistance against softening, which is synonymous for a loss of mechanical stability.
» Furthermore, lower relaxation leads to reliable contact forces & stable heat dissipation.
» Pure copper tends to have an inhomogeneous microstructure, with the risk of anisotropic behavior.

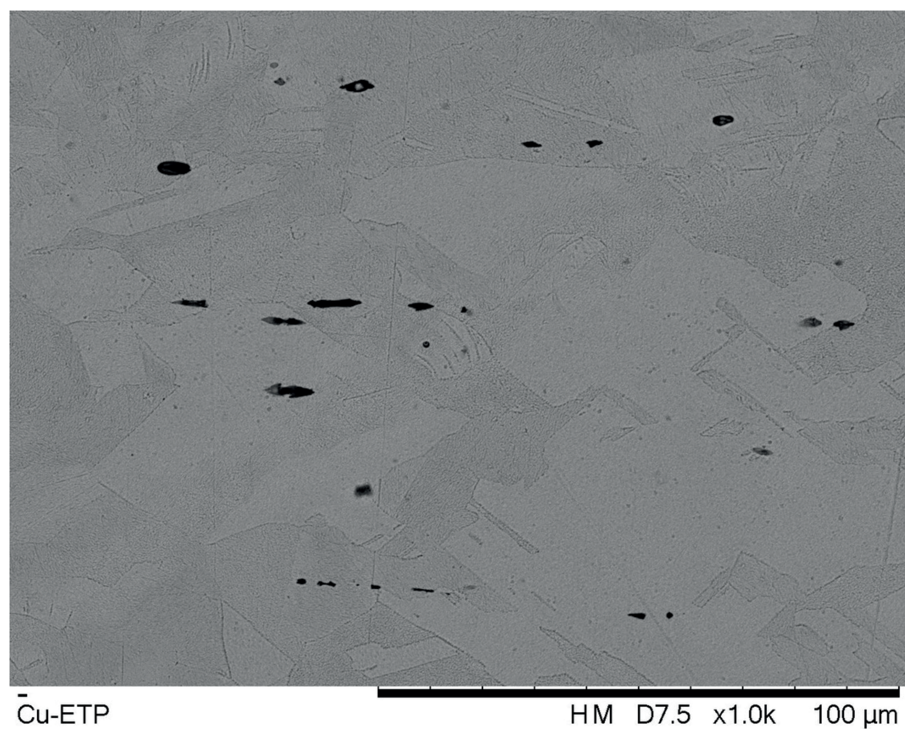

Fig. 3: Microstructure of Cu-ETP

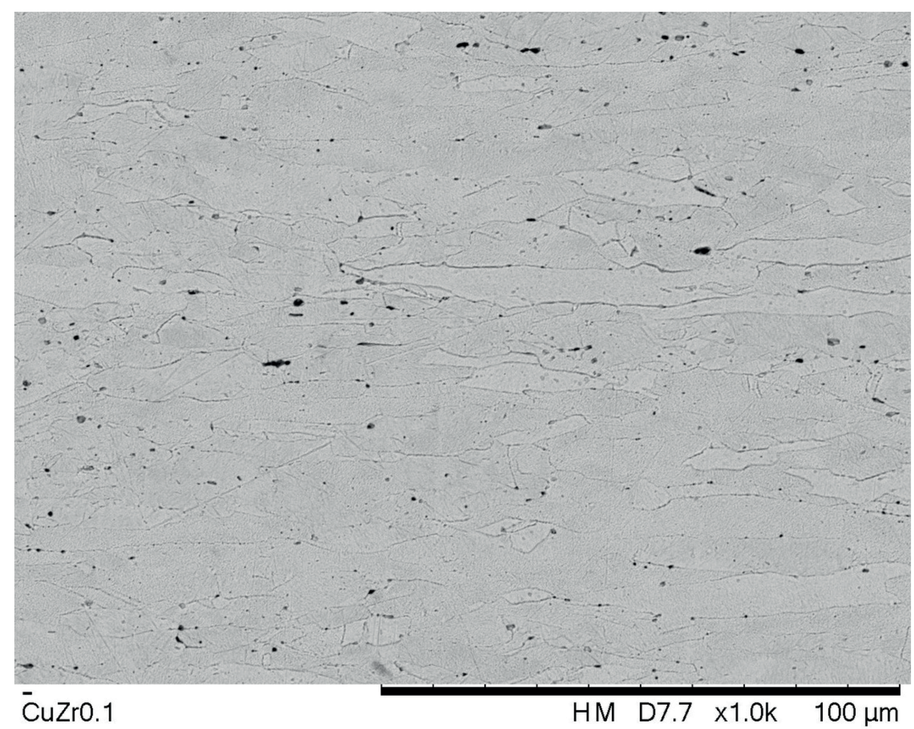

Fig. 4: Microstructure of CuZr0.1

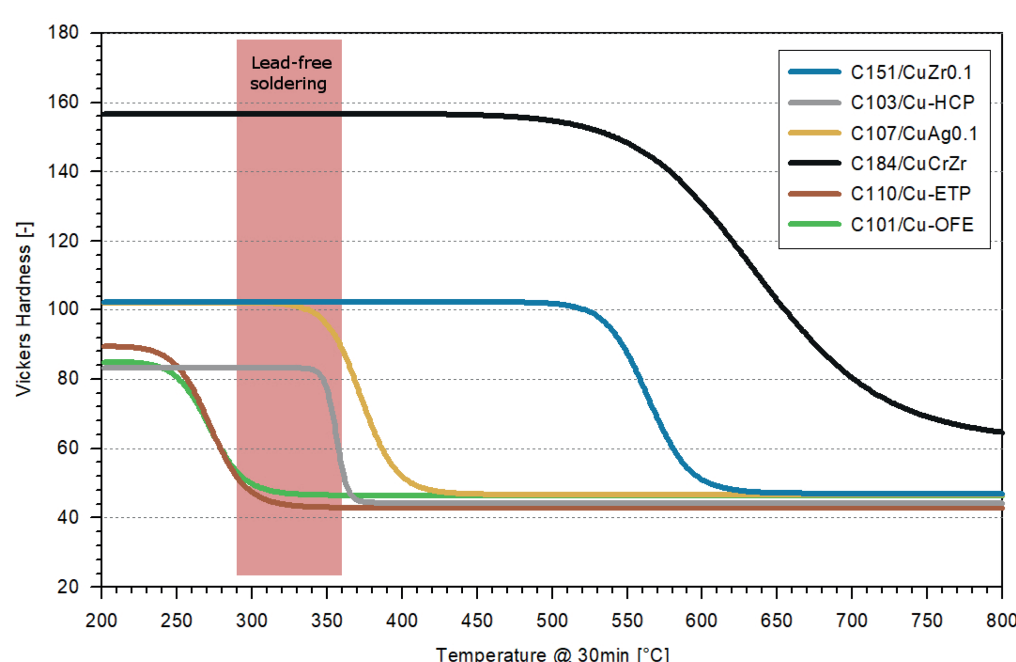

Fig. 5: Softening resistance of selected alloys

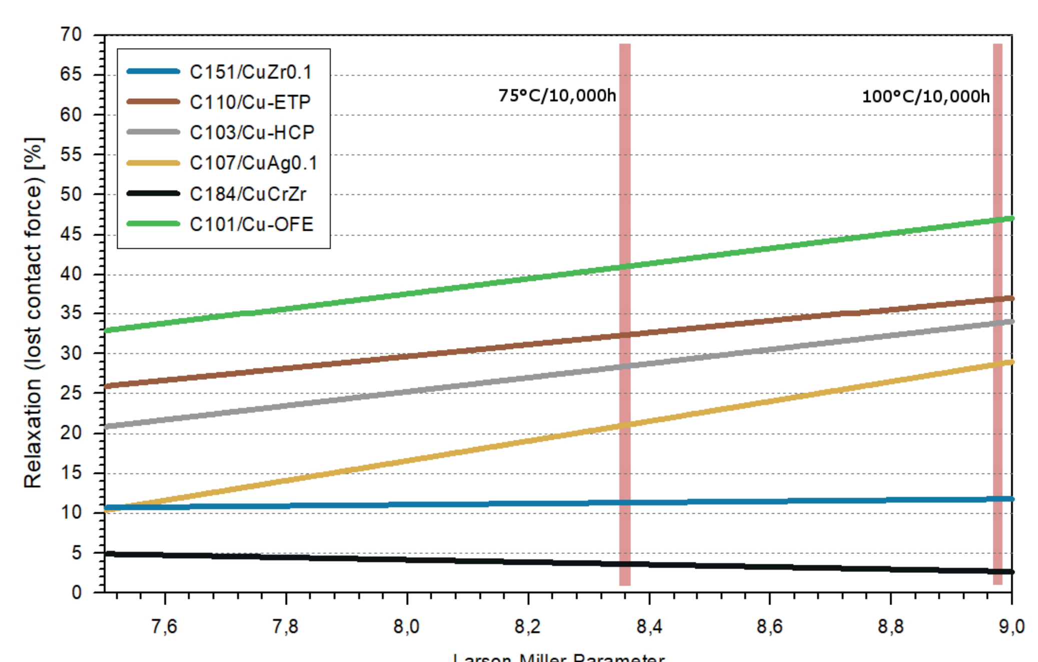

Fig. 6: Relaxation behavior of base plate materials

Conclusion

» Careful selection of alloys for base plate application is necessary, considering material properties.
» A comparison of eligible alloys & their properties is found in the following table.

UNS Number	Material	Aurubis trade name	Thermal conductivity	Tensile strength	Reliability	Softening resistance	Homogeneity of properties	Isotropy of properties
C101	Cu-OFE	PNA 203	++	o	--	-	-	o
C103	Cu-HCP	PNA 210	++	o	o	o	+	+
C107	CuAg0.1	PNA 217	++	o	+	+	o	o
C110	Cu-ETP	PNA 211	++	o	-	-	--	--
C151	CuZr0.1	PNA 296	+	+	++	++	+	+
C184	CuCrZr	PNA 372	+	++	++	++	+	+

» The advantage of HPAs over standard base plate materials is the suitability for demanding requirements, e.g. higher soldering temperatures.
» Alloys such as C151 & C184 should be considered, in particular for larger high-power IGBT modules.

Acknowledgement

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Rudi Göbel GmbH & Co. KG

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