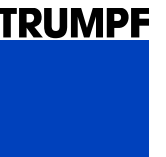


TRUMPF Additive Manufacturing

Philipp Wagenblast, Michael Thielmann | TRUMPF Additive Manufacturing

5. May 2022



Agenda

01 TRUMPF Additive Manufacturing

02 Applications and Materials

03 Cu Additive Manufacturing

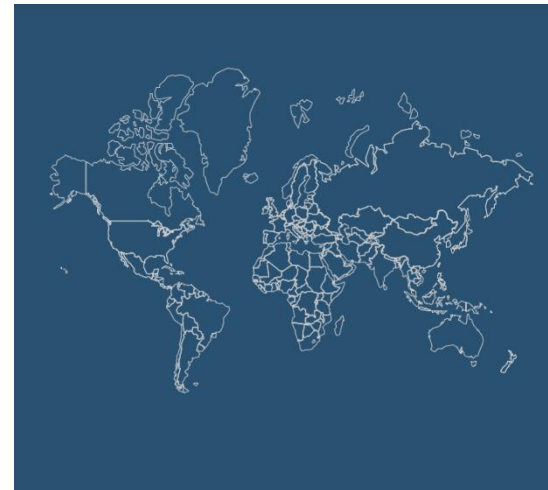
TRUMPF is...



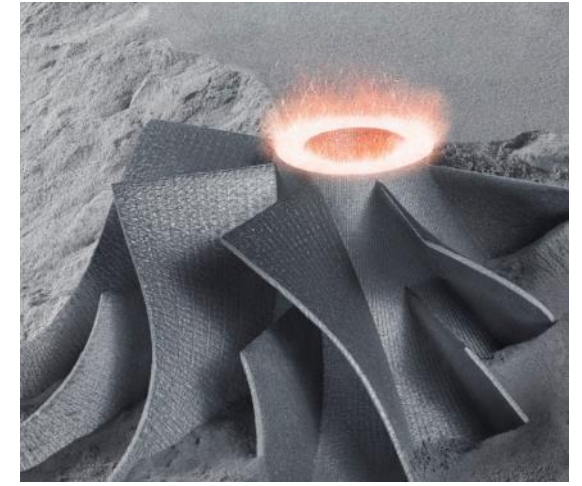
Family business



Technology leader



Close to the customer



Innovation guarantor

At a glance

Further key corporate figures 2020/21

Sales revenues 2020/21 (in bn. €)

3,505

R+D costs (in mio. €)

382 +1.4 %

Order intake 2020/21 (in bn. €)

3,925

Earnings before taxes and interest (EBIT) (in mio. €)

370 +19.5 %

R+D quota

10.9 %

Employees on June 30,2021 (Quantity)

14,767

EBIT margin

10.5 %

Investments (in mio. €)

145 -25.2 %

Machine Tools business division

Machines for laser cutting



Machines for punching and punch laser processing



Machines for bending



Machines for laser welding



Machines for tube processing

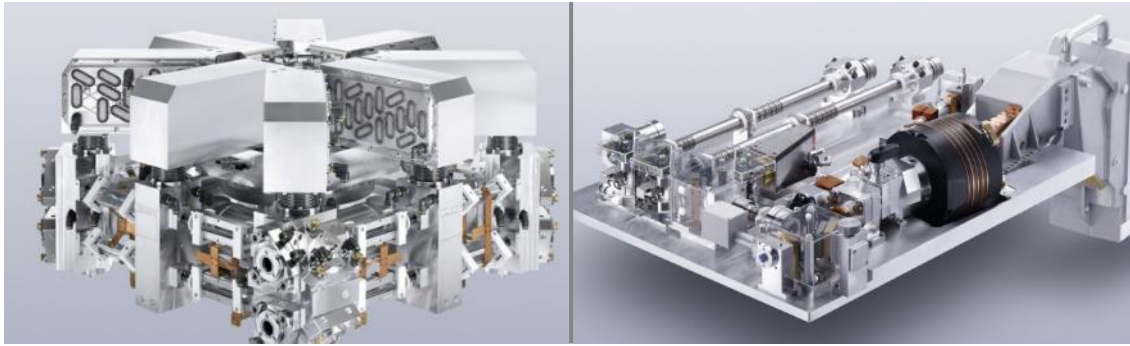


Solutions for a networked production



Laser Technology business division

CO₂ and solid state lasers



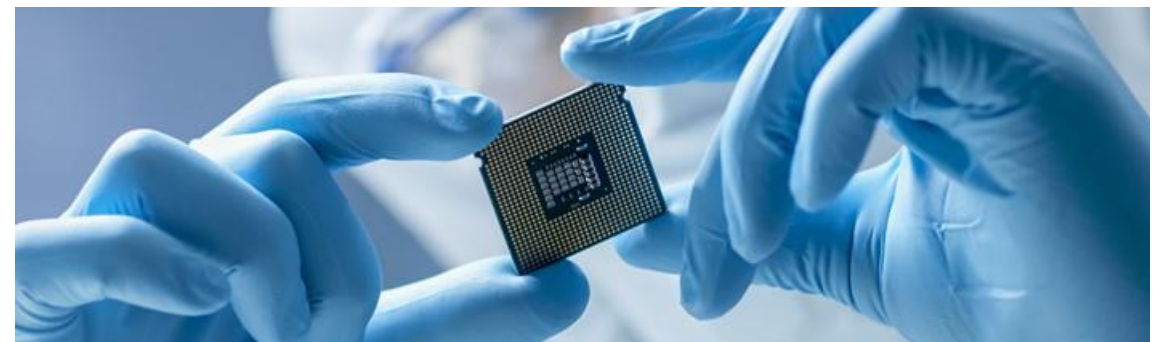
Laser systems



Laser marking systems



RF generators for industrial applications



Business fields

High-power laser systems for EUV lithography

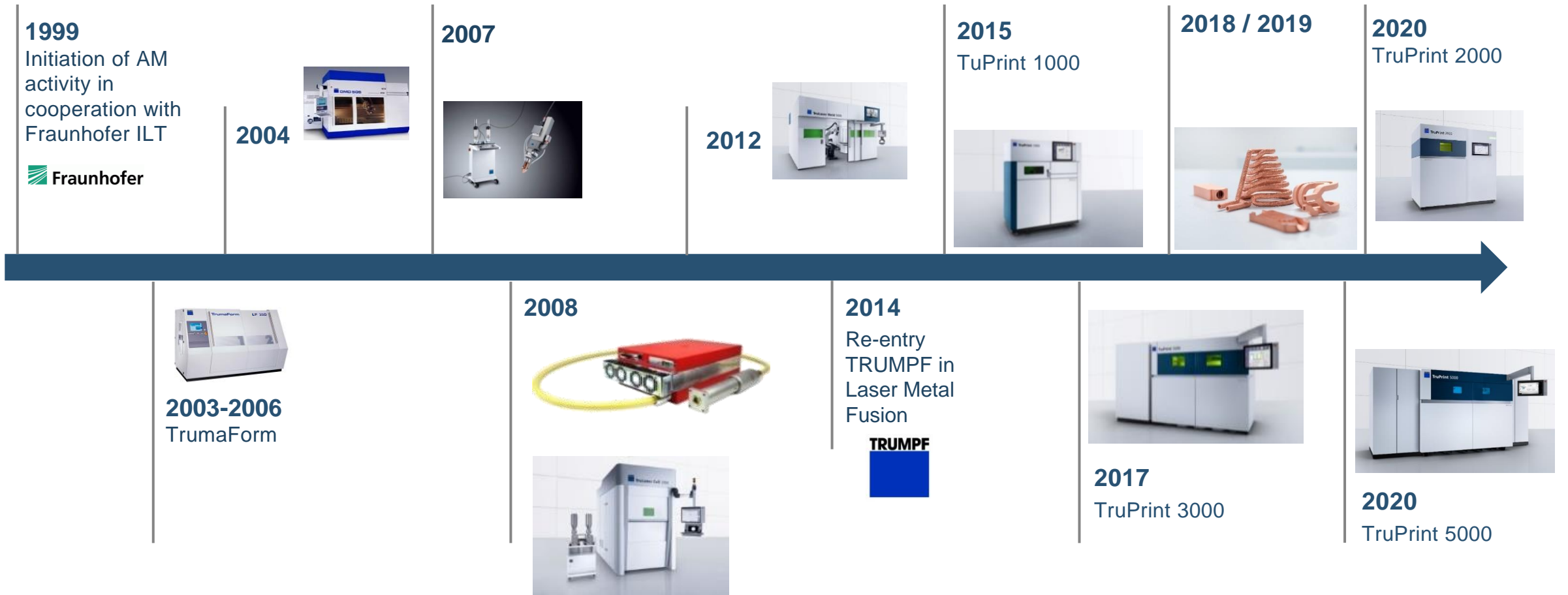


Additive Manufacturing



TRUMPF Additive Manufacturing

More than two decades of experience in AM



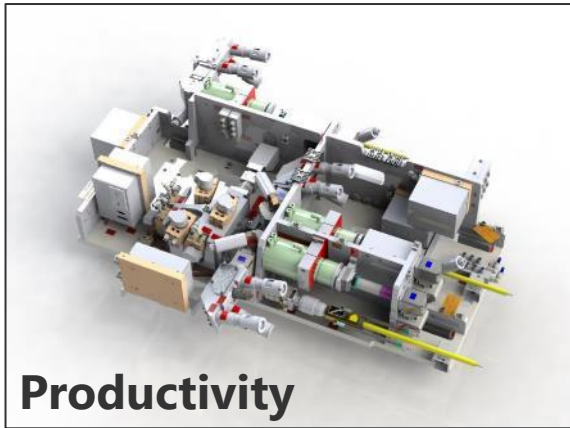
Agenda

01 TRUMPF Additive Manufacturing

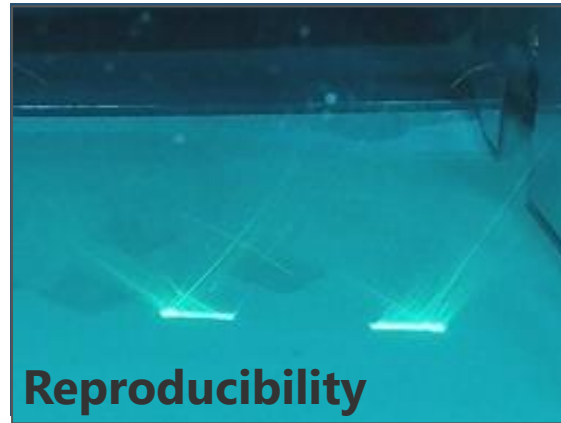
02 Applications and Materials

03 Cu Additive Manufacturing

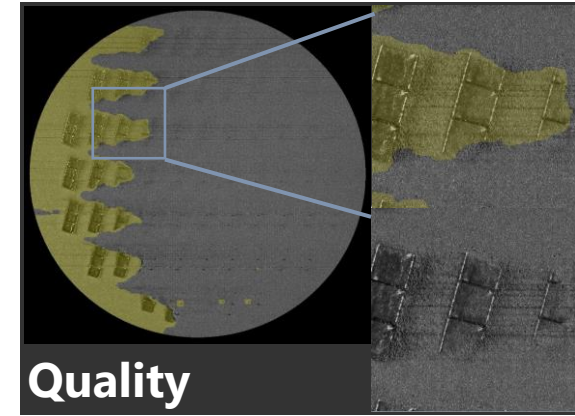
TruPrint machines offer advanced functionality



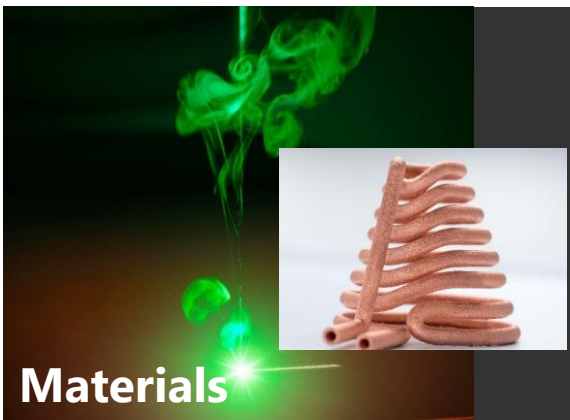
State-of-the-art multi-scanner systems



Highly effective gas flux



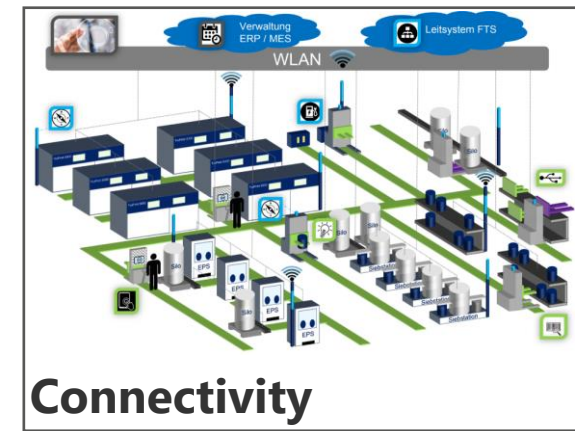
Powder bed and melt pool monitoring



515nm copper processing



TruTops Print build processor

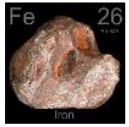


OPC-UA and factory automation

Materials for powder bed fusion



Co-Cr Alloys



Stainless Steel



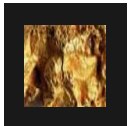
Tool Steel



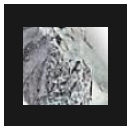
Nickel-based Alloys



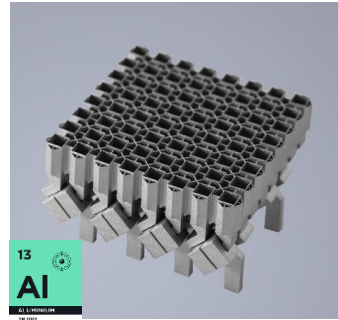
Titanium Alloys



Precious Metals



Amorphous Metals



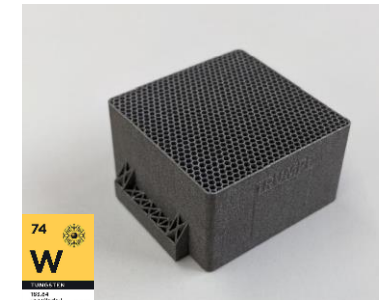
Aluminium Alloys

AlSi10Mg RF Antenna
for spacecom



Refractory Metals

Niobium Satellite
thruster



Refractory Metals

Tungsten x-ray
collimator grid



Copper Alloys

Copper RF Quadrupole
S. Gruber and CERN from:
CERN-ACC-NOTE-2021-0024

Symbols from: fineartamerica.com

Agenda

01 TRUMPF Additive Manufacturing

02 Applications and Materials

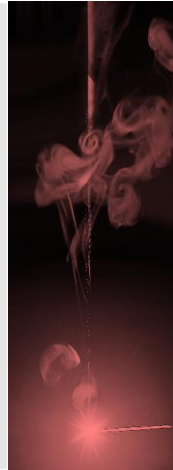
03 Cu Additive Manufacturing

Processing of Pure Copper

Challenge and Comparison: two different Wavelengths

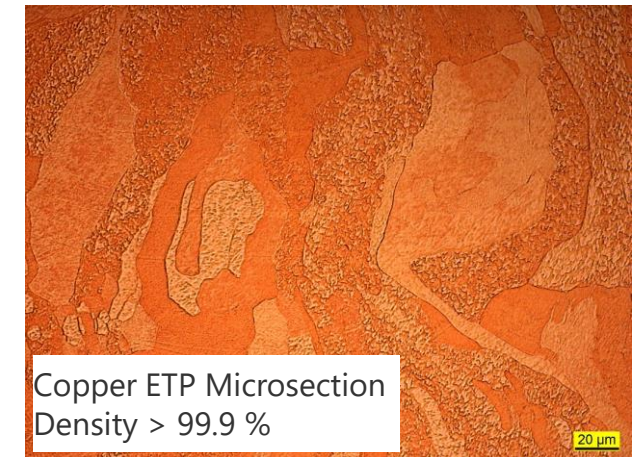
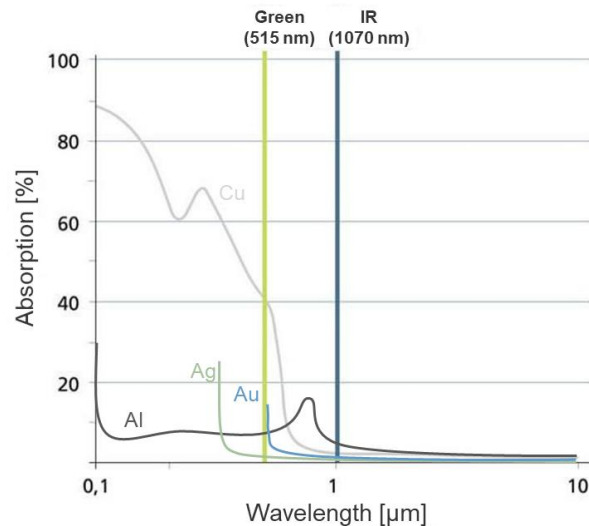
Status Quo with IR laser ($\lambda = 1070 \text{ nm}$)

- Pure copper difficult to process - limited efficiency and productivity
- Copper alloys as a workaround
- Electric and thermal conductivity limited
- Small process windows
- Limited quality and low process robustness



Possibilities with Green Laser ($\lambda = 515 \text{ nm}$)

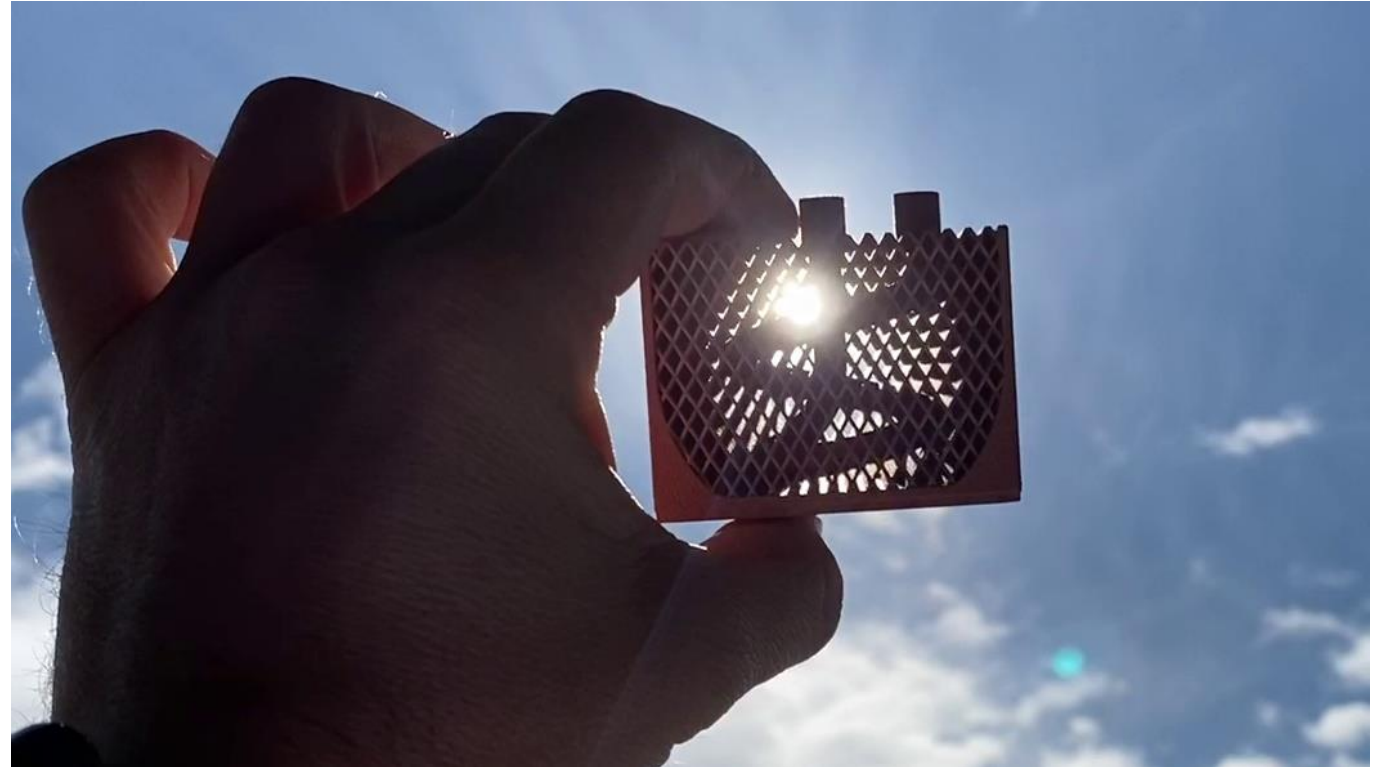
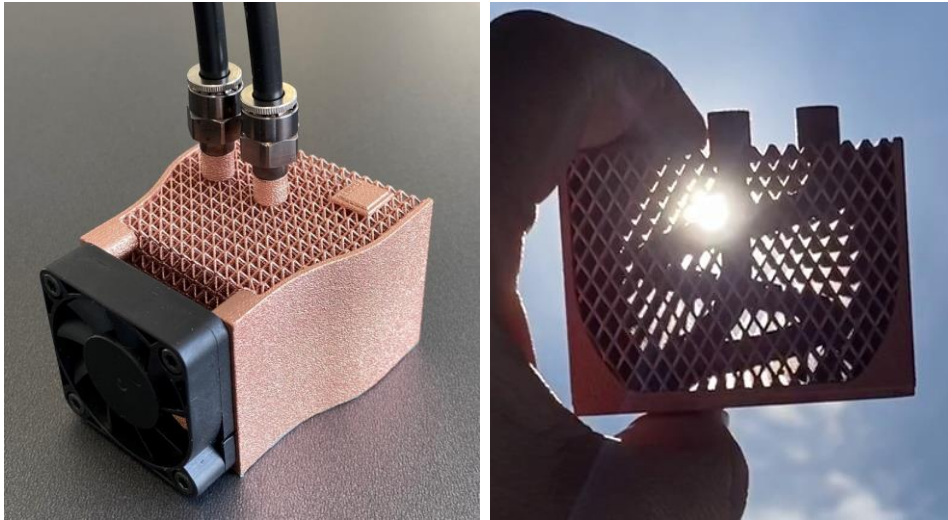
- Stable process – high absorptivity
- Considerably higher productivity
- Pure copper, precious metals and non-ferrous materials processable with high reproducibility
- High material density and properties



Processing on the Green Side of Light

High density for high performance parts

- Demonstrator for a water-air heat exchanger with internal cooling pipe
- Design for mass reduction
- Finest structures with 0,5 mm for a good surface/weight ratio
- High density shown with polished surface



Cu ETP - Conductivity

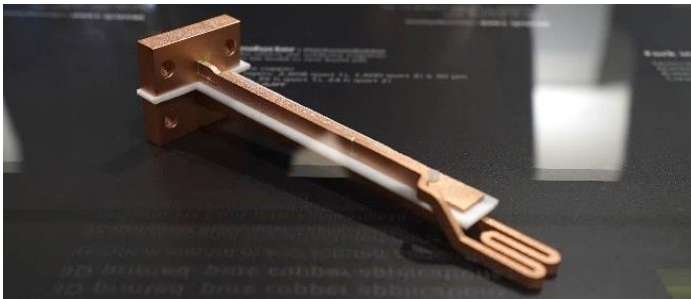
High density ensures high conductivity

Electrical conductivity

- Electrical conductivities are comparable to conventional copper
- Part induction performance are the same compared to conventional produced copper inductors
- Less manual work for small parts
- Heat-resistant up to ca. 300°C
- Holding pressures up to 10 bar

Thermal conductivity

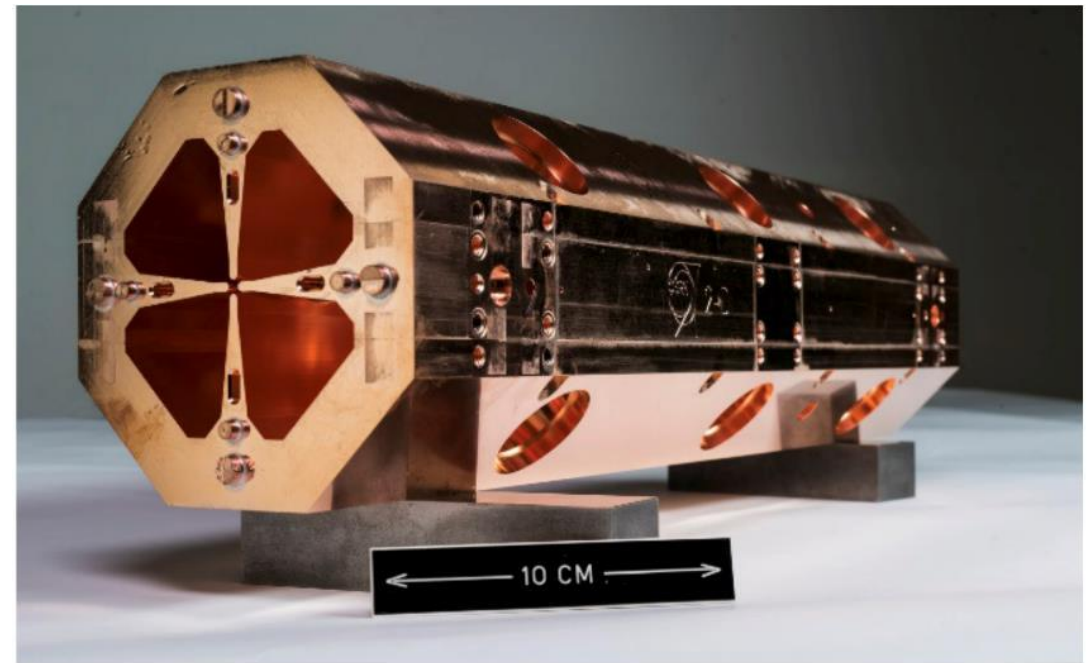
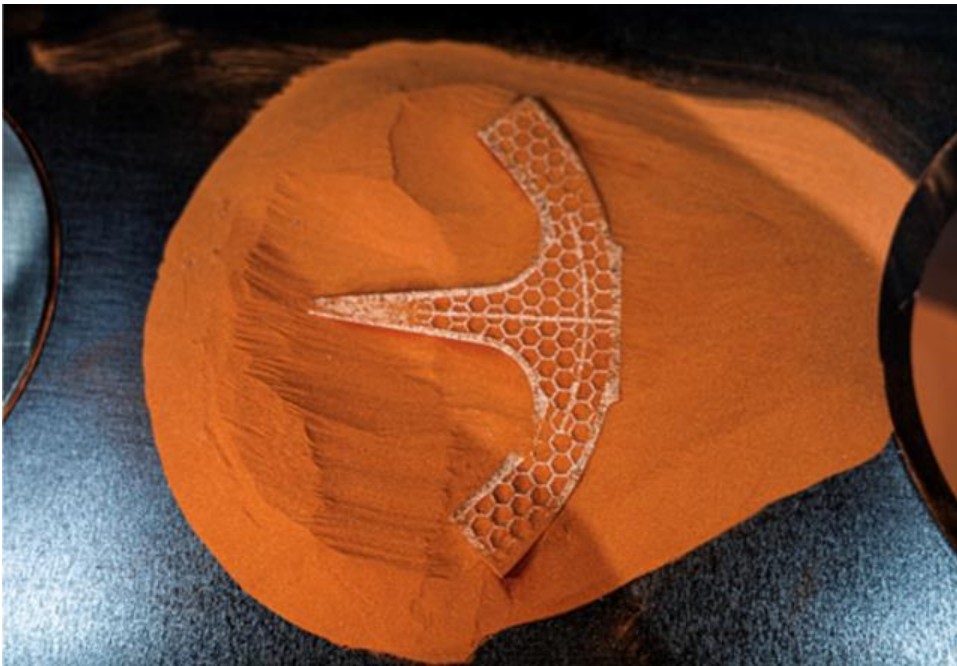
- Thermal conductivity is comparable to conventional copper
- Redesigned geometry increases the cooling performance
- New possibilities of mounting the cooler directly on the heat source due to the redesign
- Redesign with contour near and local cooling
- Cooling and transistor efficiency improvement



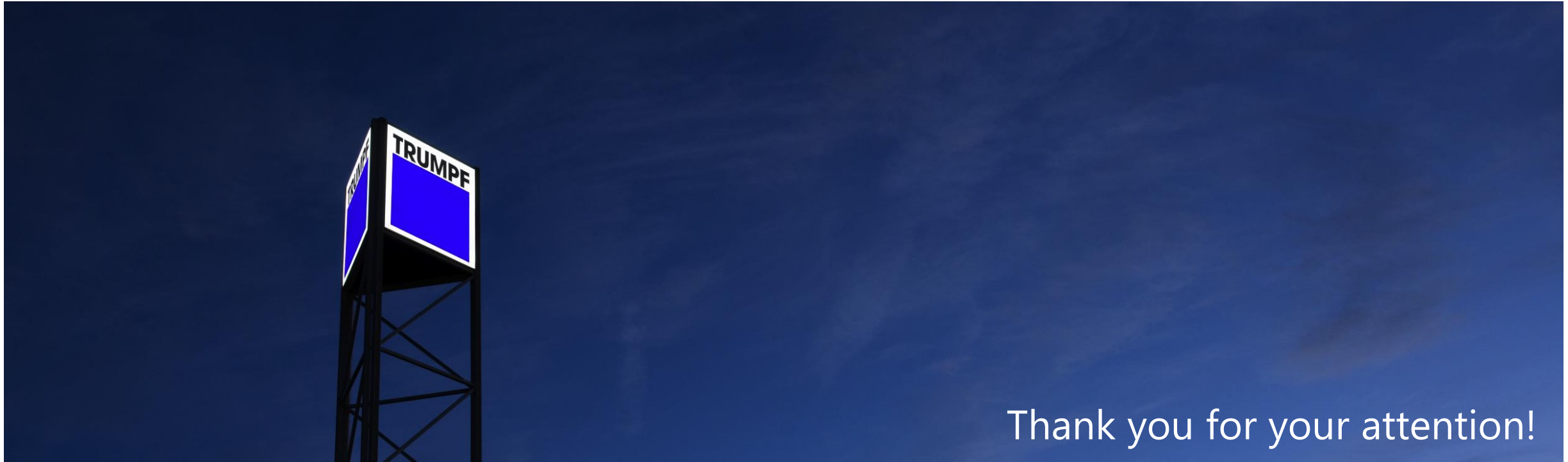
Accelerator RF Quadrupole

Capabilities of Cu Additive Manufacturing

Resolution Surface quality Thermo-mechanical properties Build volume \varnothing 300mm x 400 mm



S. Gruber, and CERN from: CERN-ACC-NOTE-2021-0024



Thank you for your attention!

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