

NF Wire Forum

Aurubis
Metals for Progress

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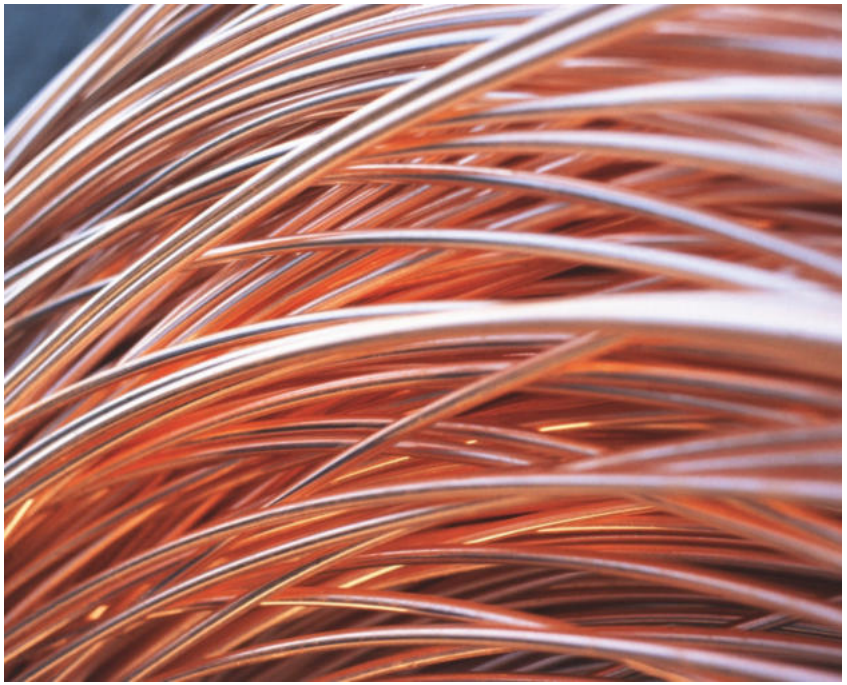
Latest copper developments for E-Mobility and sustainability efforts at Aurubis

NF Wire Forum

Dr. Cornel Abratis – Technical Marketing Copper Products

NF Wire Forum 2025

Prague, October 28th, 2025



Agenda

NF Wire Forum

1 Aurubis Group

2 Sustainability efforts at Aurubis – Tomorrow Metals

3 Latest copper developments for E-Mobility

Aurubis: We are experts for metals.

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Successful in
20 countries on
3 continents

> 7,000 x
passion and
engagement

159 years
of experience in the production of non-ferrous metals

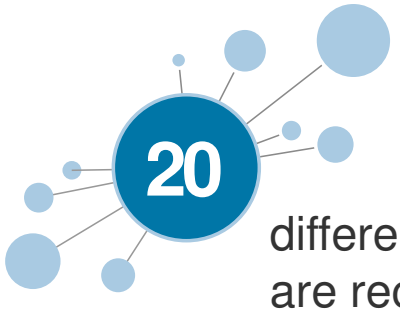


One of the
worldwide leading
companies in
copper recycling

about **1 million t**



of recycling materials
are processed by Aurubis
on a yearly basis



different **metals**
are recovered by
Aurubis

Aurubis production sites

Headquarters Primary Copper Recycling/Precious Metals
Copper Products





















Aurubis sites – production of primary and secondary copper

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Production of Cathodes and Rod



- Aurubis operates a closely linked network of 6 key plants in Europe with a focus on smelting and refining primary and recycling raw materials
- Furthermore, Aurubis operates a network of 9 plants in Copper Products

	FY 2023/24
Concentrate throughoput	2,266,000 t
Copper scrap / blister copper throughput	494,000 t
Other recycling materials	545,000 t
Cathode output	1,092,000 t
Rod production	880,000 t
Oxygen-free rod production	~33.000 t

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Shaping tomorrow, today.

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At Aurubis, *Tomorrow Metals* is our promise: By sourcing our metals, customers choose best-in-class sustainability — today and tomorrow. Our approach is structured into four action fields:



Responsibility	Environmental Impact	Decarbonization	Circularity
Everything we do focuses on a balance of economy, environment and people.	We are committed to delivering more value with less environmental footprint.	We ensure transparent & measurable progress in our emission reductions towards net zero.	We expand multimetal recycling to conserve natural resources and strengthen the circular economy.

Our LCA results confirm **our leadership in low-carbon products**

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Carbon footprint of Aurubis products in 2024 compared to global average

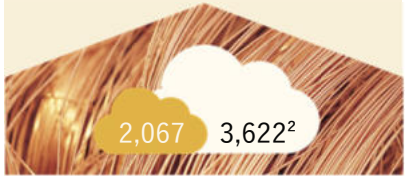
Aurubis Copper Cathode
in kg CO_2 equivalents per t of copper cathode



Aurubis SHAPES
in kg CO_2 equivalents per t of shapes



Aurubis ROD | RheinROD
in kg CO_2 equivalents per t of wire rod



Aurubis FOXROD
in kg CO_2 equivalents per t of oxygen-free rod



Aurubis BARS + PROFILES
in kg CO_2 equivalents per t of product



Aurubis Silver
in kg CO_2 equivalents per kg of silver



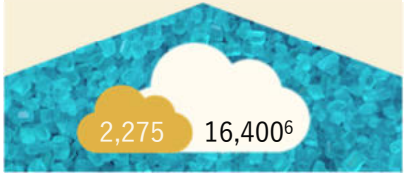
Aurubis Gold
in kg CO_2 equivalents per kg of gold



Aurubis Tin
in kg CO_2 equivalents per t of tin



Aurubis Nickel Sulfate
in kg CO_2 equivalents per t of Ni content



Aurubis Selenium
in kg CO_2 equivalents per kg Se in selenium products



Sources: Aurubis LCAs // [1] ICA 2019, [2] ICA 2019, [3] Ecoinvent 2021, [4] World Gold Council 2019, [5] ITA 2020 (Please note that the ITA data is reported using the CML impact assessment method, which is only comparable to a limited extent), [6] Nickel Institute 2023.

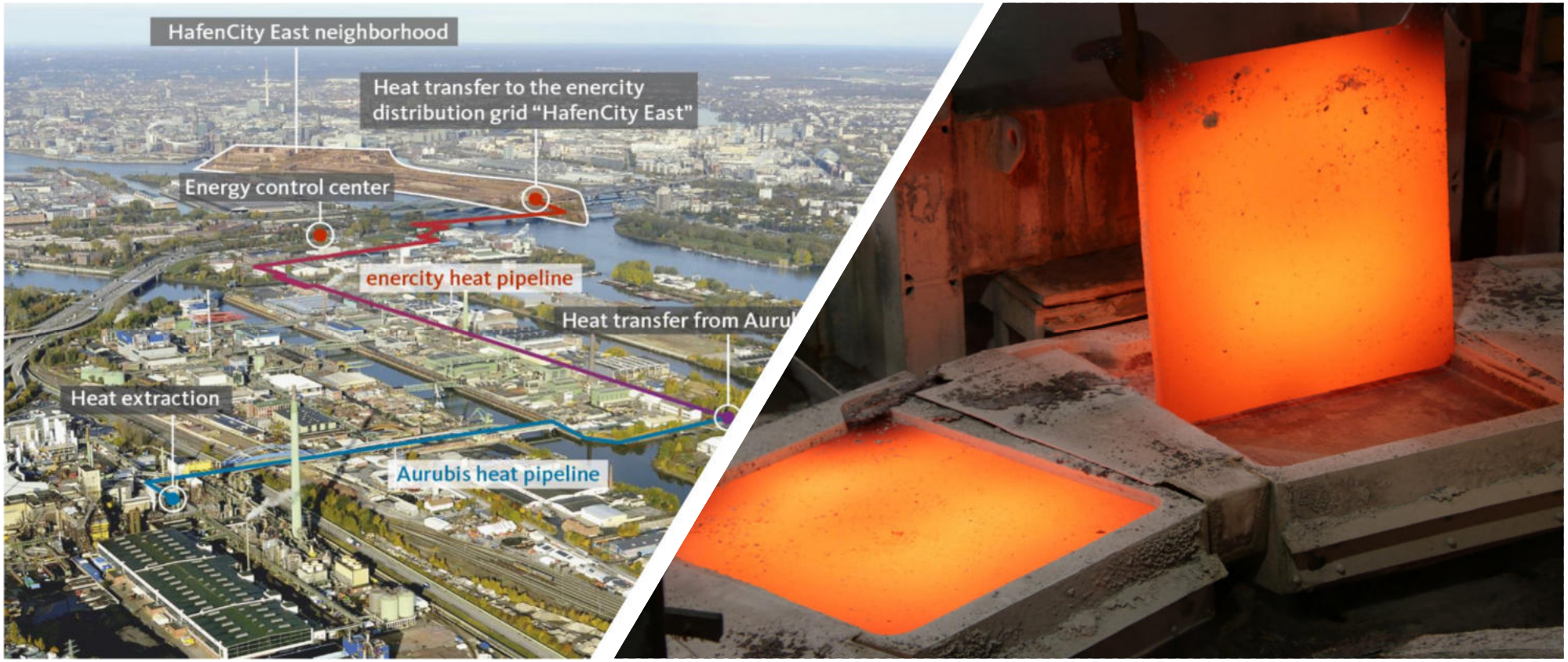
Bleed treatment Olen Beerse (BOB) - Olen Advanced Sludge Processing by Aurubis (ASPA) - Beerse

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Aurubis expands Germany's largest industrial heat system and makes anode furnaces H2-ready

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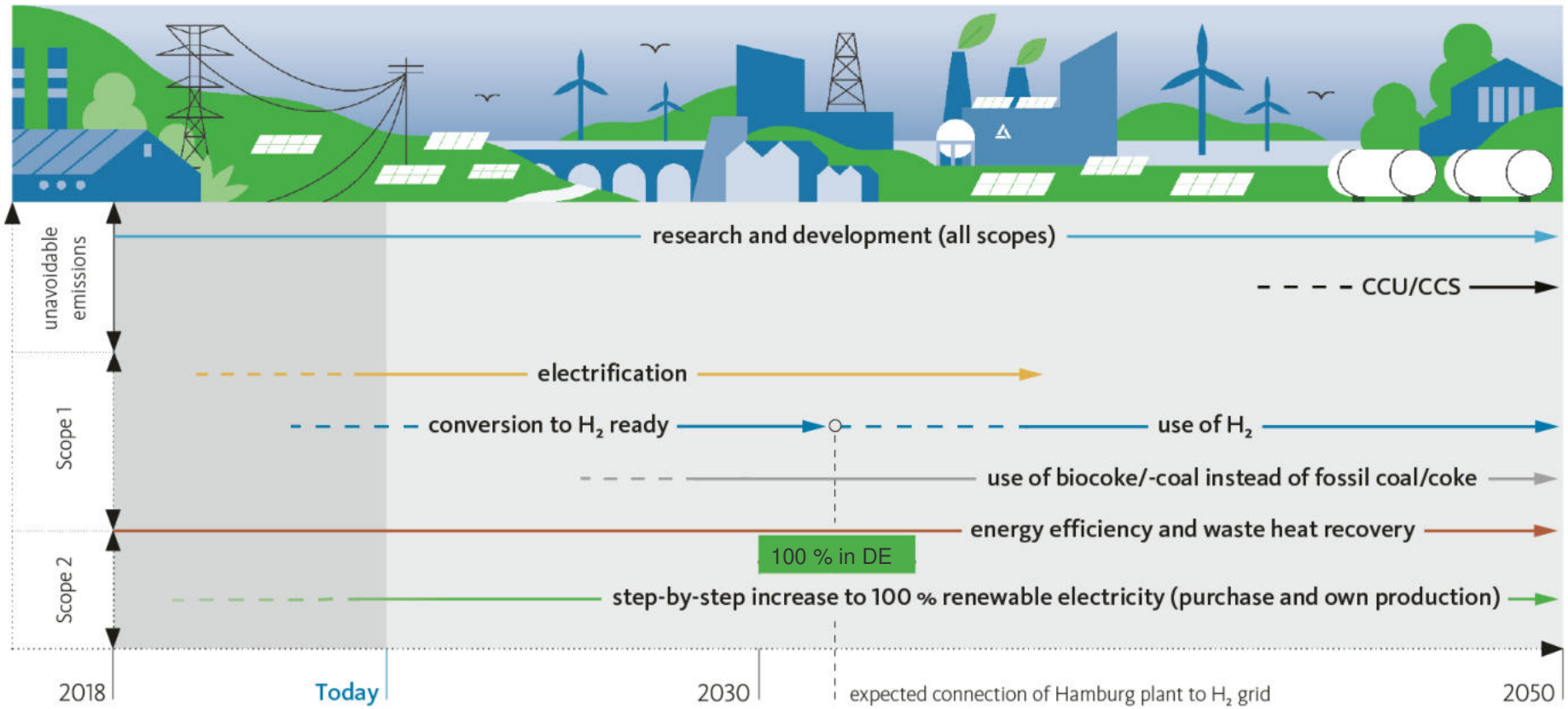


Aurubis Richmond – first Multi-Metal recycling smelter in the US started opertions in September 2025

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Decarb Roadmap at a glance: **Key technologies**



The powerful duo – By sourcing primary and secondary materials responsibly, we ensure a low carbon footprint across our portfolio

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e.g. Copper



Aurubis Metals for Progress · BALLOFFET · BECHEM LUBRICATION TECHNOLOGY · kupfer_ · NIEHOFF GRUPPE

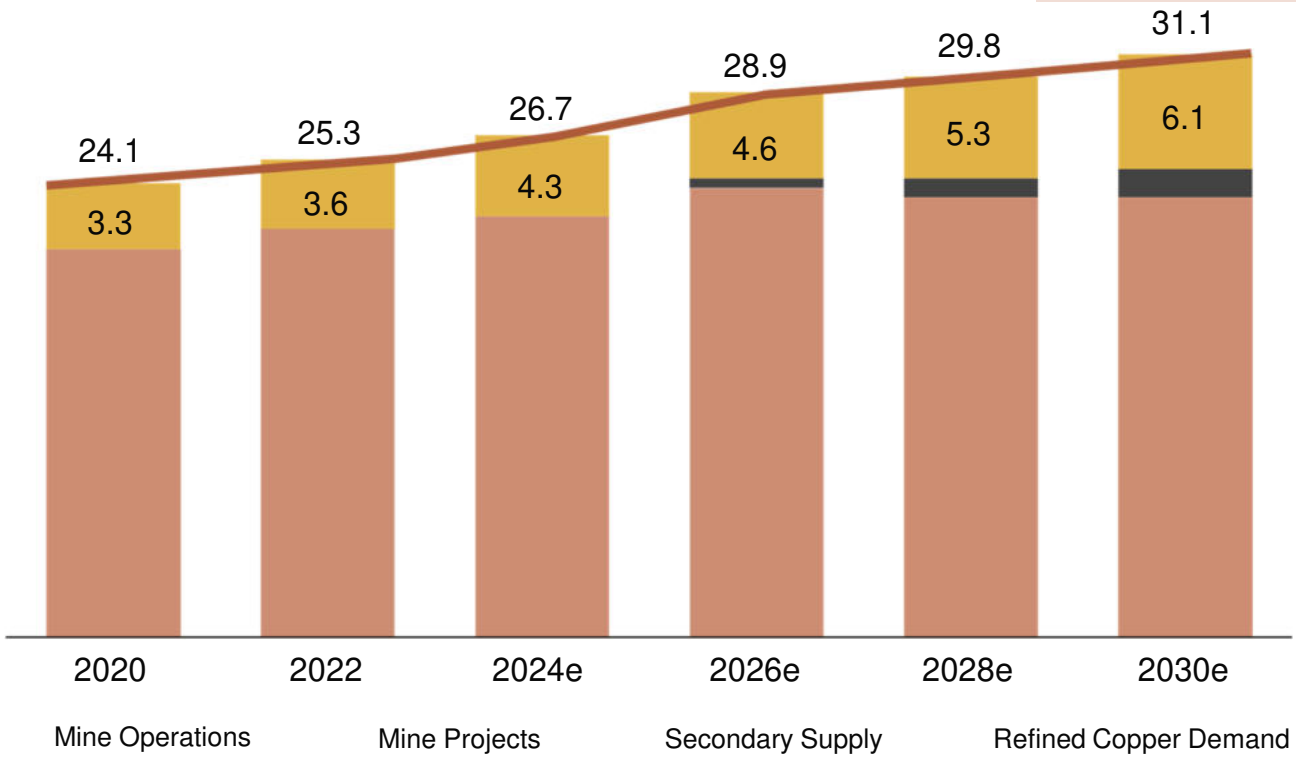
Global copper demand continues to outpace supply

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Copper only

A holistic approach: Future copper demand requires both **recycled and primary copper.**

Refined copper supply development by source (in Mt)



Source: Wood Mackenzie Global Copper Investment Horizon Outlook - Q4 2023

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Bending and welding behavior with different copper grades in the hairpin stator process chain

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Aurubis

The powerful duo – Secondary and Primary supply forms the foundation of our business.



SHWIRE

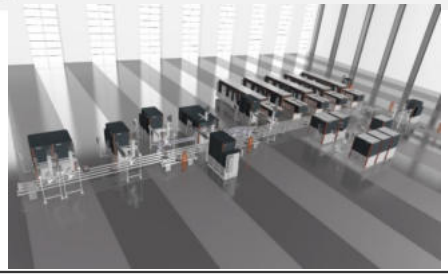
Europe's largest and most modern single location for enamelled wire

60.000t Annual capacity

175k km Wire length produced daily

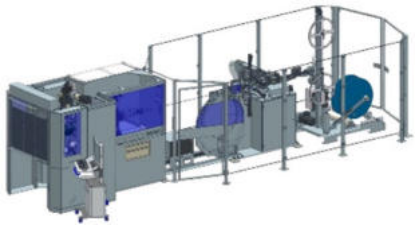
Gehring

Machines and system solutions for sample and scalable mass production

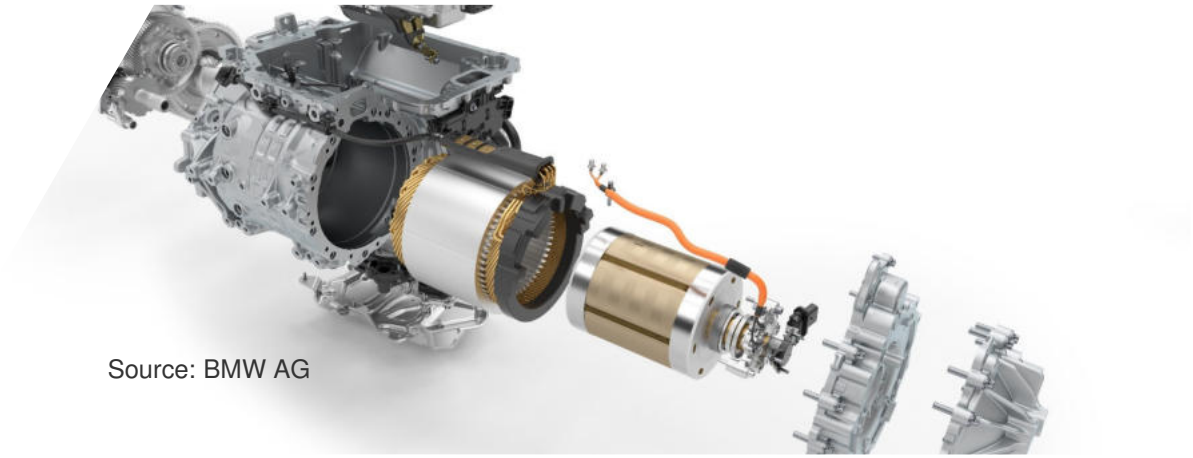


WAFIOS

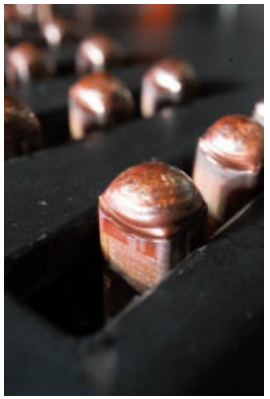
World leader in wire processing machinery since 132 years



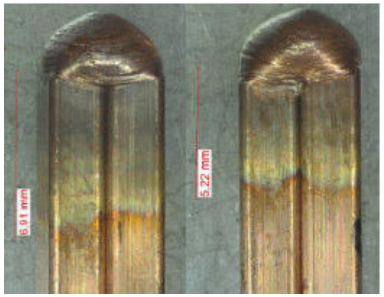
Laser beam welding of EV wires for stators in e-traction motors



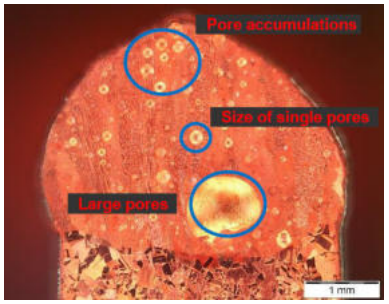
Source: BMW AG



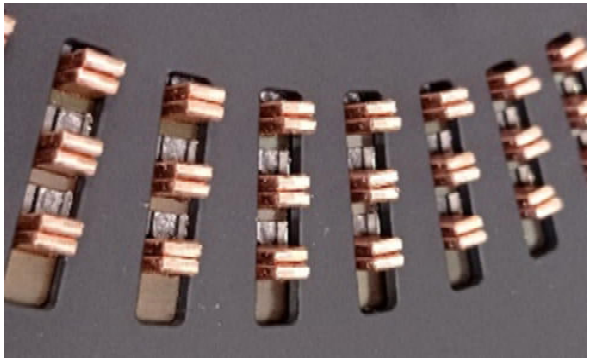
Source: Gehring Technologies



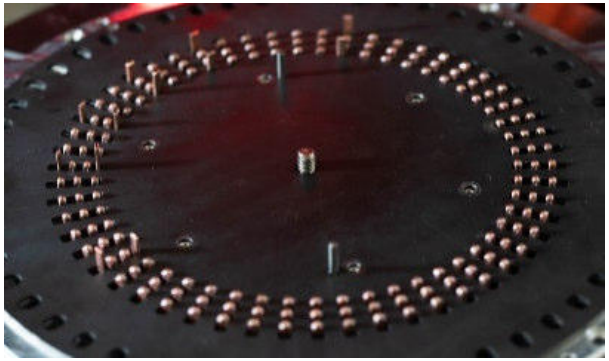
Source: TRUMPF



Source: TRUMPF



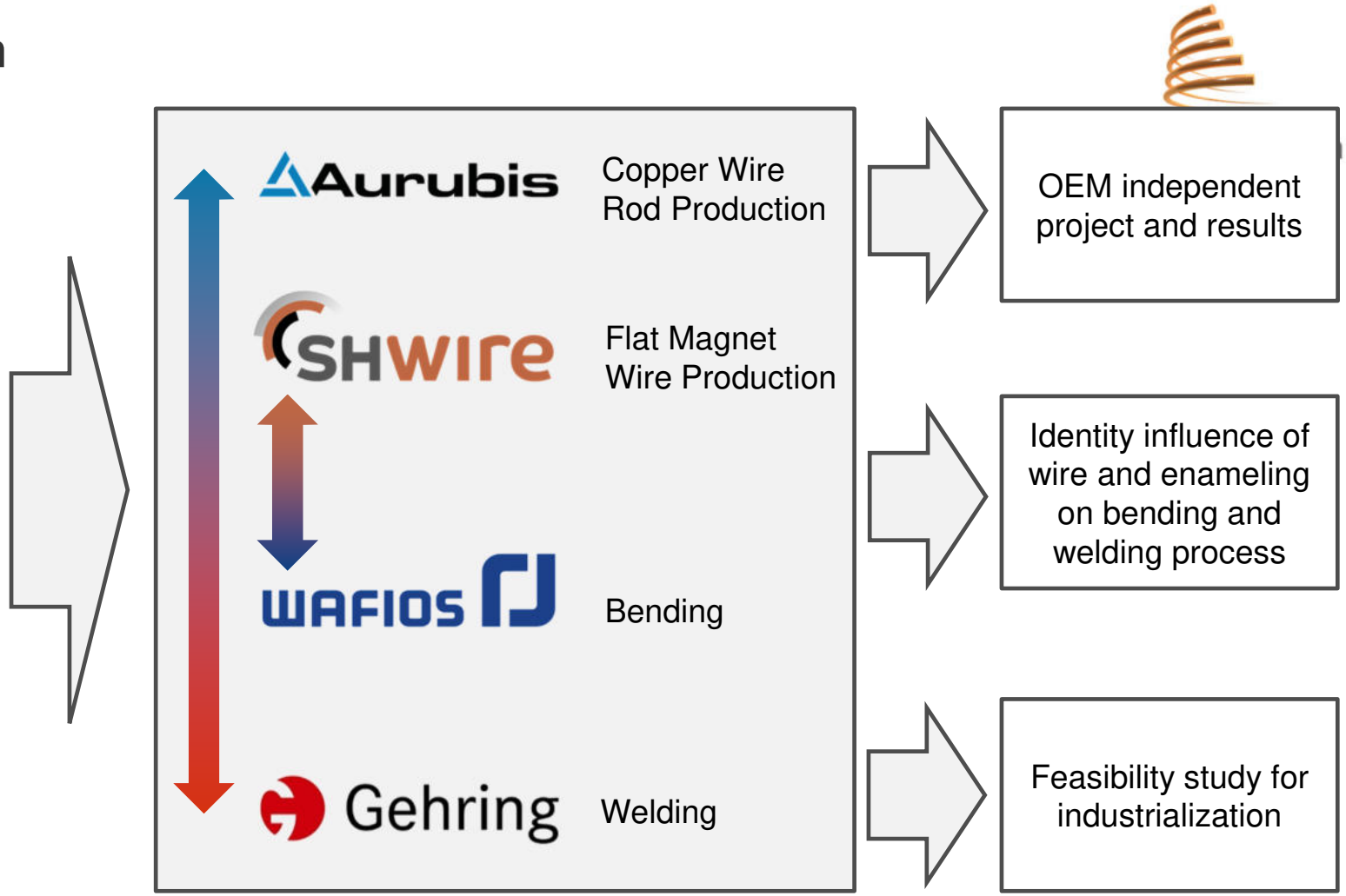
Source: Gehring Technologies



Source: Gehring Technologies

Project initialization

- The production of **hairpins** involves **numerous process** steps across company borders
- The used materials have to apply to **different requirements** (e. g. **bending** and **welding**)
- Beside the technical properties the **availability** and the **costs** of the materials have to be taken into account
- The **hairpins** have to withstand **operation** in the final application



Aurubis copper products portfolio

Copper Products:

Continuous Cast Rod

- Aurubis ROD | RheinROD
- Aurubis FOXROD

Shapes

Bars & Profiles

Flat Rolled Products

High conductivity copper and copper alloys

Material grades	Aurubis ROD, dg-RheinROD & Aurubis FOXROD							
	Copper wire rod		Cu-HCP	Cu-DXP	CuAg		CuSn	
Type	Cu-ETP1	Cu-OFE	Cu-OFE	Cu-OFE	ETP1	OFE	ETP1	OFE
Diameter	8 – 23.5 mm	8 – 25 mm	8 – 21 mm	8 – 21 mm	8 – 23.5 mm	8 – 25 mm	8 mm	8 – 25 mm
Chemical elements	100 – 400 ppm oxygen	< 4 ppm oxygen	0.001 – 0.007 wt % P	0.04 – 0.06 wt % P	0.005 – 0.12 wt % Ag	0.005 – 0.5 wt % Ag	0.005 – 0.3 wt % Sn	0.005 – 0.5 wt % Sn
Conductivity in % IACS	> 101	> 101	> 101 – 97.4	> 76.4 – 67.8	> 100	> 100	100 – 78	100 – 66
Cu content	Min 99.99 %	Min 99.99 %	Min 99.95 %	Min 99.9 %	Rest	Rest	Rest	Rest

In accordance with standards DIN EN 1977 & ASTM B 49 (where applicable).

Flat Rolled Products

Alloyed brass			
ISO	UNS	EN	JIS
CuZn11.5Sn1	C42200		
CuZn9.5Sn2	C42500		C4250
CuZn14Fe0.8Sn0.8	C66430		
Phosphor-bronze alloys			
ISO	UNS	EN	JIS
CuSn2Fe0.1P0.03	C50715		
CuSn2Zn2.2Fe0.1P0.03	C50725		
CuSn1			
CuSn2			
CuSn4	C51100	CW450K	C5111
CuSn5	C51000	CW451K	C5102
CuSn6	C51900	CW452K	C5191
CuSn8	C52100	CW453K	
CuSn10	C52400		
CuSn12			
Special bronze			
ISO	UNS	EN	JIS
CuAl5Zn5Sn1			
CuNi10Fe1Mn	C70600	CW352H	
High performance alloys			
ISO	UNS	EN	JIS
CuCrZr	C18150		
CuZr0.1	C15100		
CuMg0.1	C15500		
CuNi1.5Si	C19010		
CuNi1.5Sn	C19005		
CuFe2P	C19400	CW107C	C1940
CuFe2PMg	C19400		
CuFe0.7MgP	C19700		
CuSn1.2Ni0.8P0.07	C19040		
CuNi0.5Sn0.5	C19022		
CuNi1.8Si0.4Zn1.1SnMg	C64760		
CuNi3SiMg	C70250		
CuNi2Si0.4	C70260	CW111C	

Aurubis also supplies slightly modified alloys with special properties, e.g. in accordance wit
* available in US

A wide range of Aurubis Copper Products are used in automotive and in other applications

Copper Wire Rod – Cu-ETP1 and Cu-OFE

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Copper Products:

Continuous Cast Rod

- Aurubis ROD | RheinROD

- Aurubis FOXROD

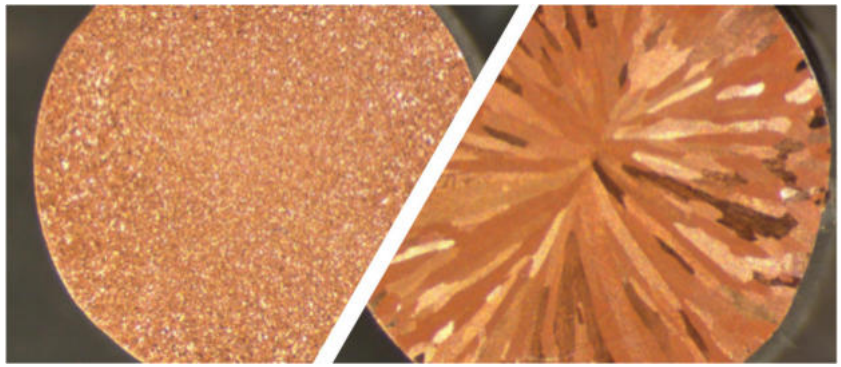
Shapes

Bars & Profiles

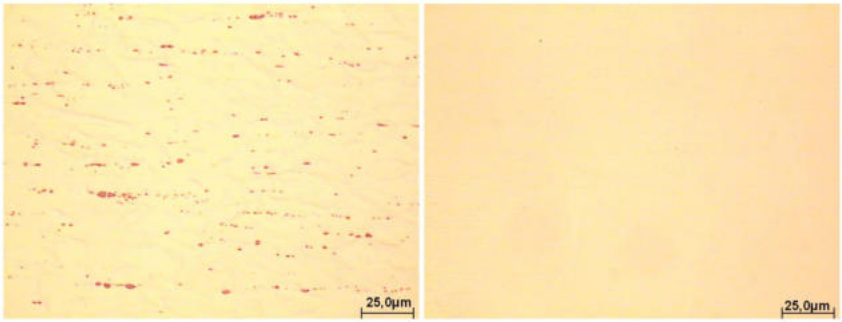
Flat Rolled Products

	Copper wire rod	
Type	Cu-ETP1	Cu-OFE
Diameter	8 – 23.5 mm	8 – 25 mm
Chemical elements	100 – 400 ppm oxygen	< 4 ppm oxygen
Conductivity in % IACS	> 101	> 101
Cu content	Min 99.99 %	Min 99.99 %

Table 2: Comparison of Cu-ETP1 (C11040) vs. Cu-OFE (Oxygen-Free, C10100)



Grain structure of hot-rolled Cu-ETP1 and Cu-OFE



Microstructure of Cu-ETP1 (Cu_2O precipitation) and Cu-OFE

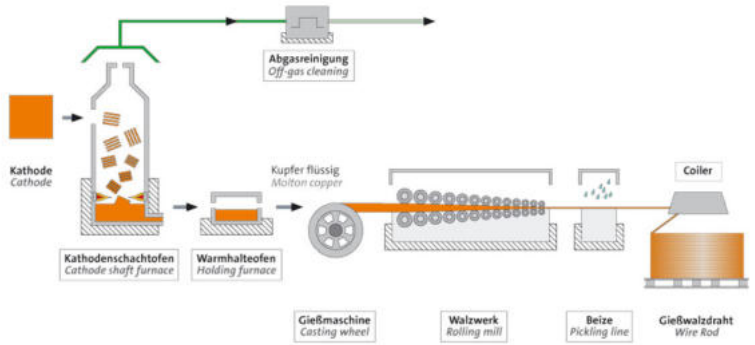
2 different copper grades with high purity and high conductivity but different microstructure

Main differences between Cu-ETP1 and Cu-OFE

Cu-ETP1

Oxygen content: 100 - 400 ppm

Oxygen content is controlled during melting and melt transfer.



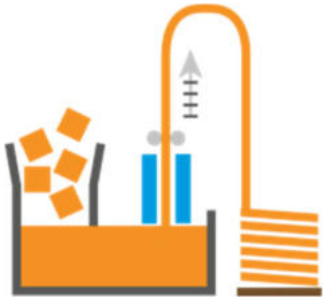
Production lines:

- high productivity (Contirod®, Southwire®, Properzi®)
- Output of **25 - 55 t/h** with a production capacity of **120.000 – 250.000 t/a**

Cu-OFE

Oxygen content: < 4 ppm

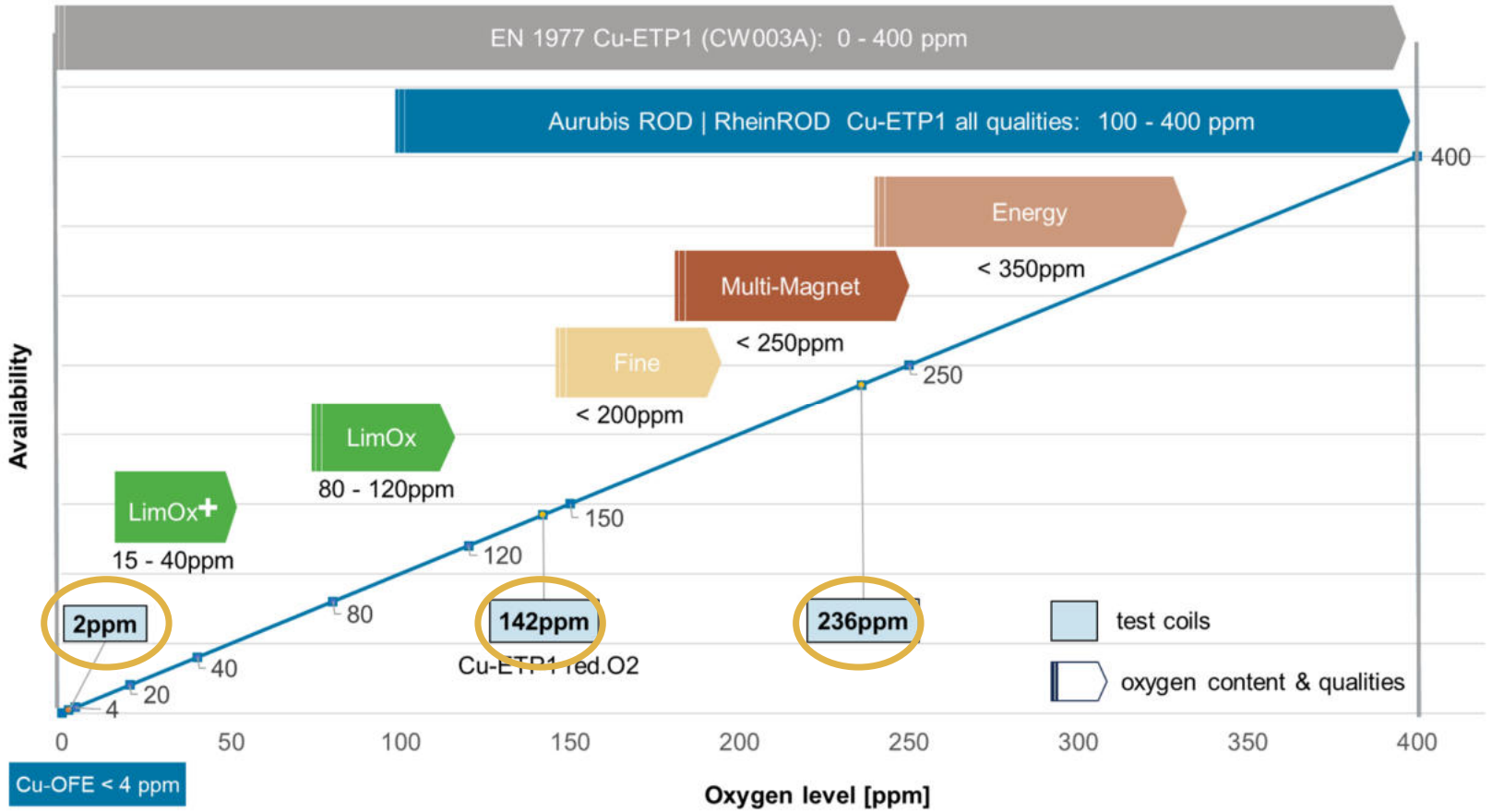
Oxygen content below 4 ppm is mandatory, if the material is exposed to hydrogen at high temperatures (>> 500° C).



Production lines:

- lower productivity (Upcast®, Rautomead®, Dipforming®). This is caused by efforts to achieve a low oxygen level in the copper melt.
- Output of up to **1 t/h** with a production capacity of up to max. **25.000t/a** (exception Dipforming® up to **60.000t/a**)

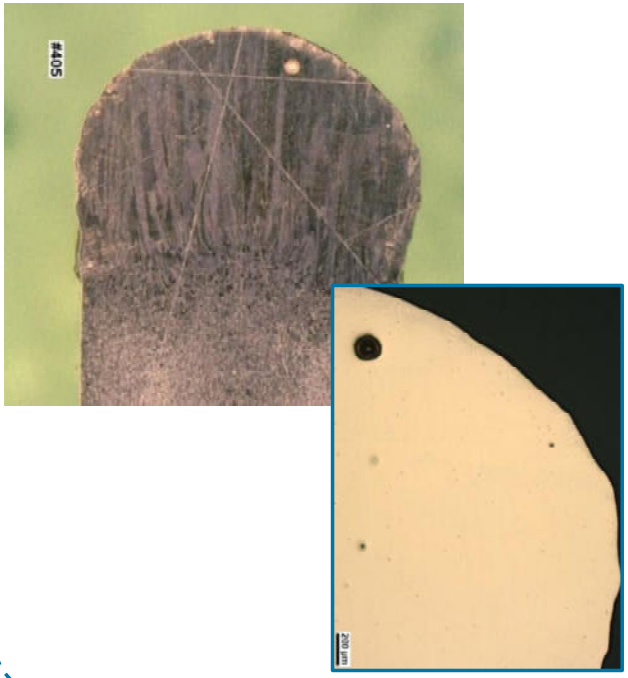
Oxygen content of test material for EV wire welding



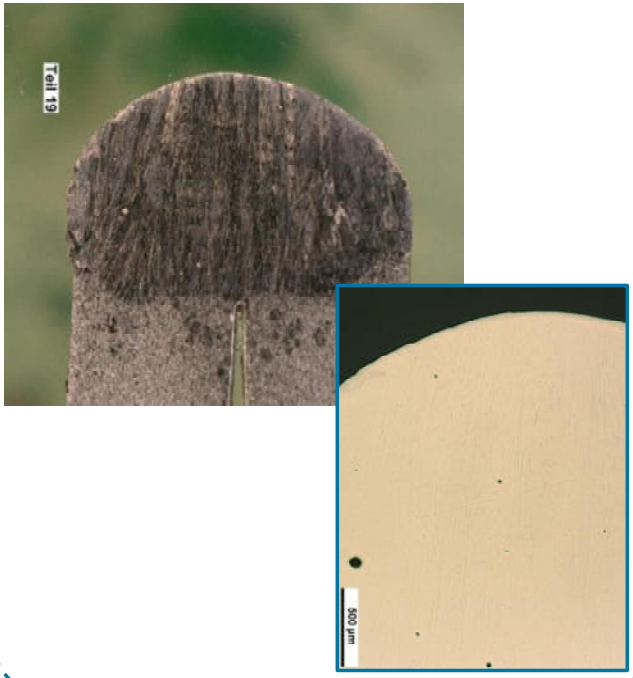
» In this hairpin stator project 3 different oxygen contents have been applied

Cross-sections

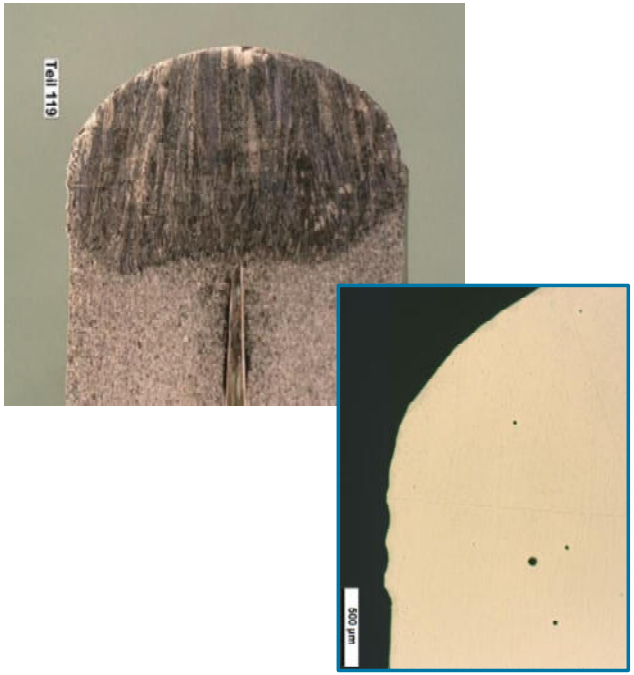
Cu-OFE



Cu-ETP1 red. O_2

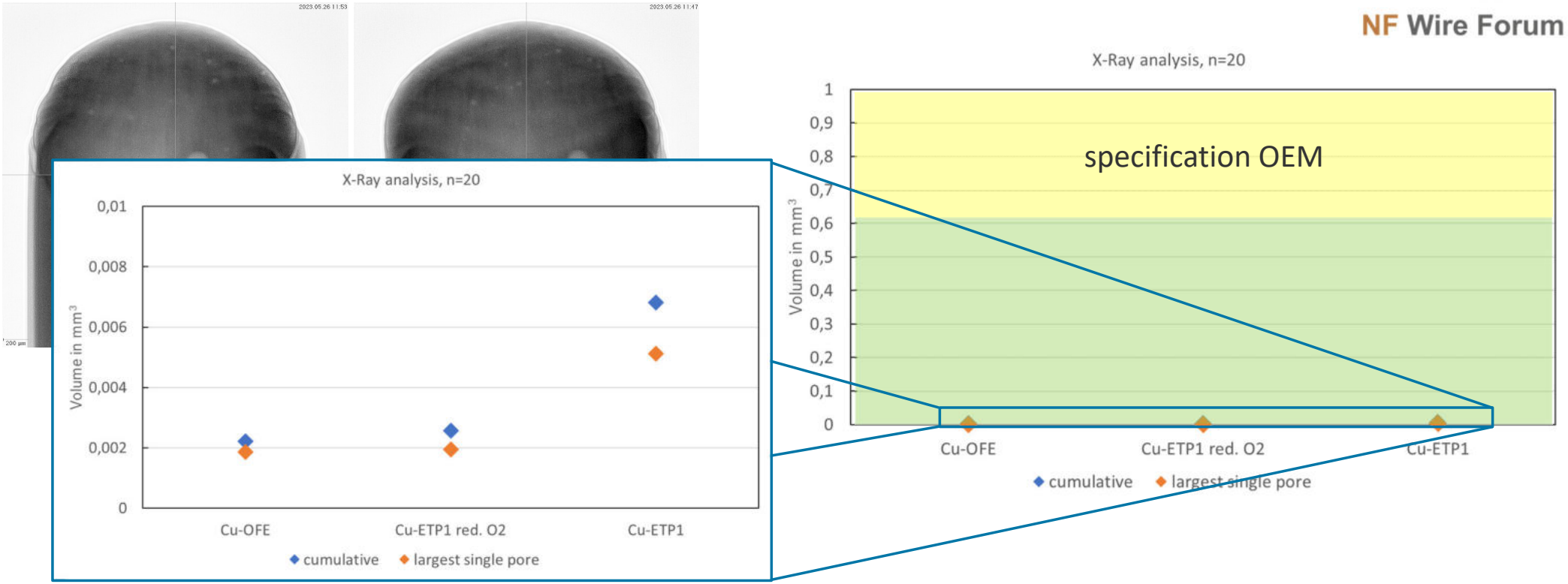


Cu-ETP1



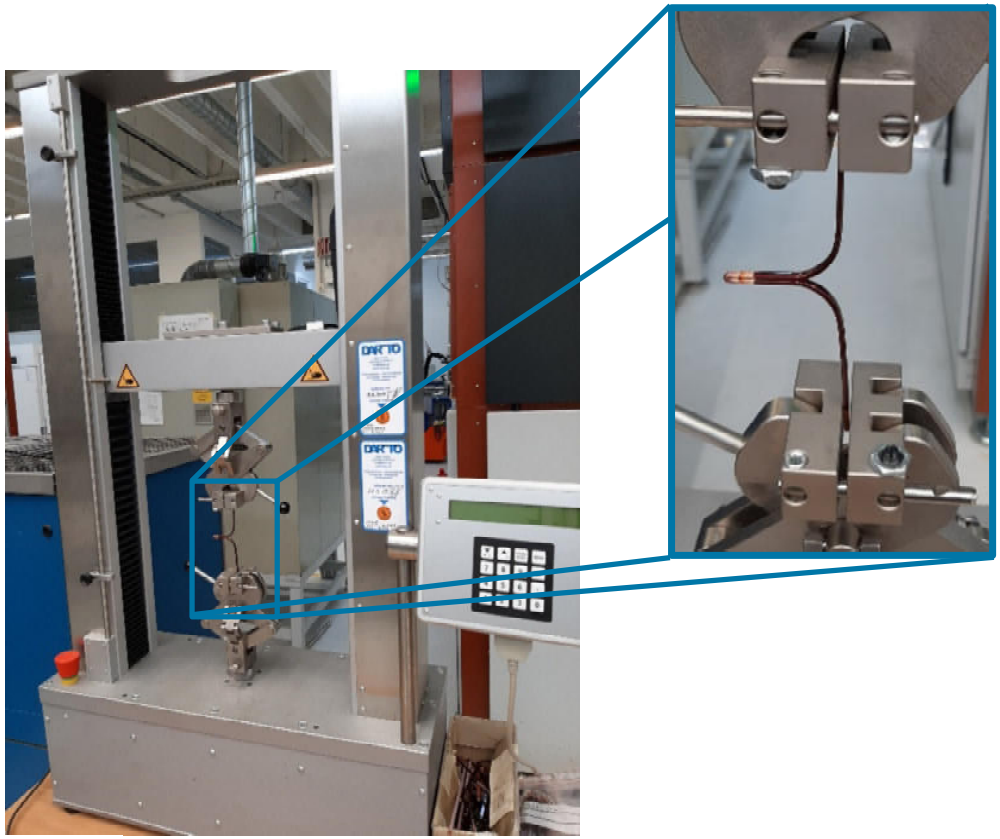
→ All copper grades contain small micro pores.
→ No recognizable differences in the microstructure @ different copper grades.

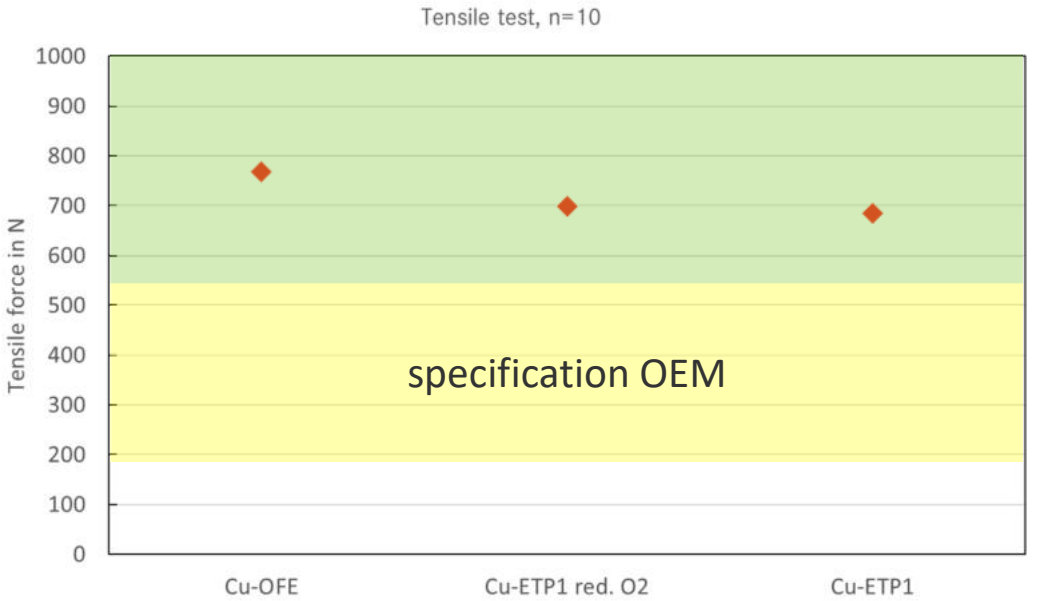
X-Ray analysis



→ Slight increase in pore volume with increasing oxygen content.
→ All copper grades exceed OEM specification.

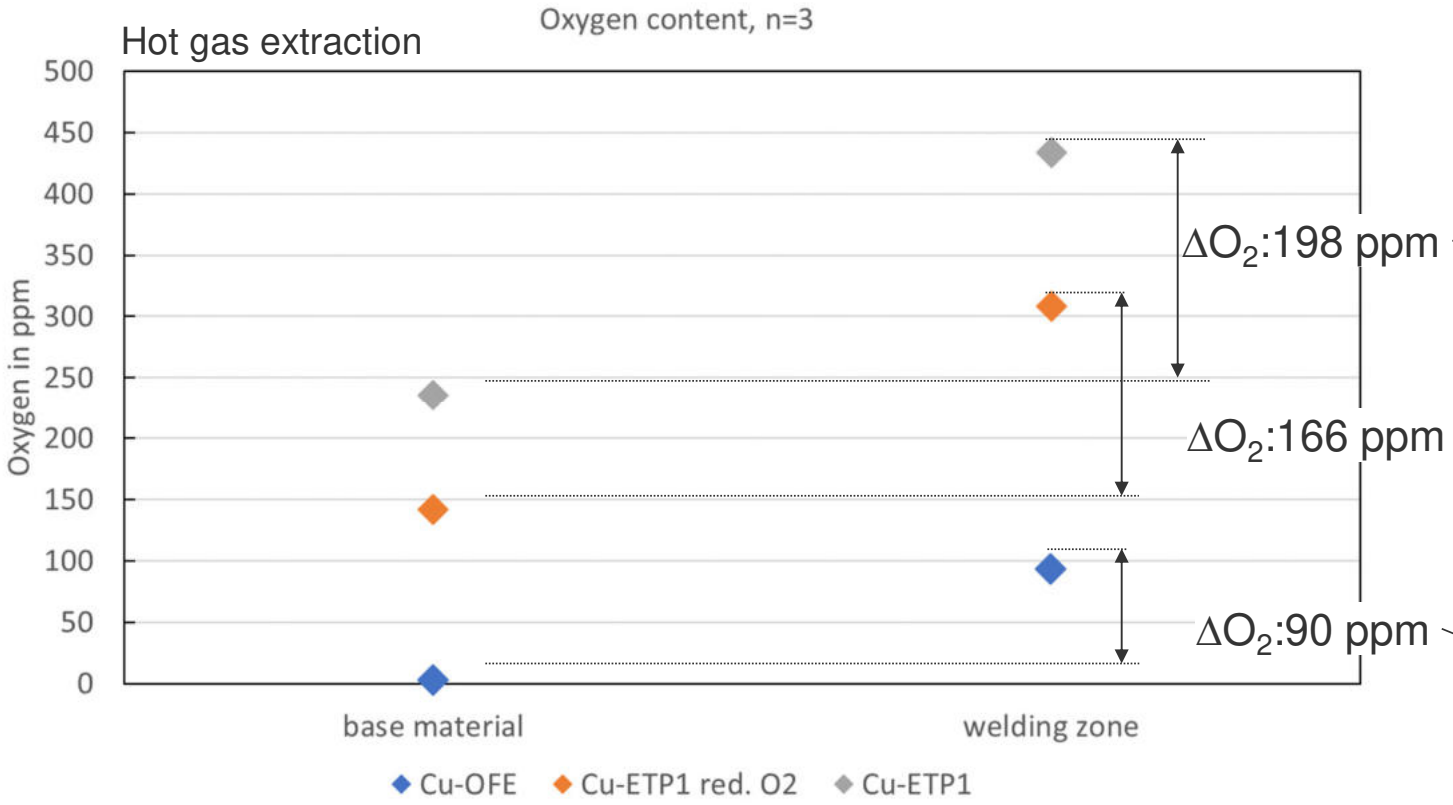
Tensile test results

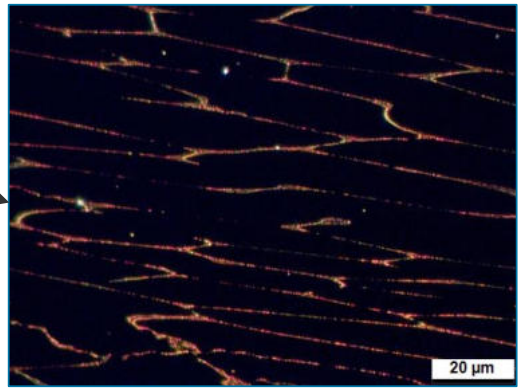


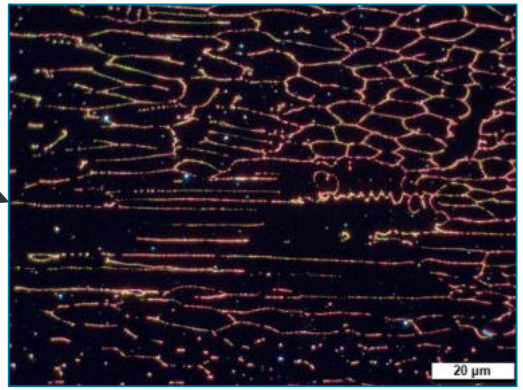


→ Minor differences in the mechanical strength @ different copper grades.
→ All copper grades exceed OEM specification.

Oxygen content of the welding zone



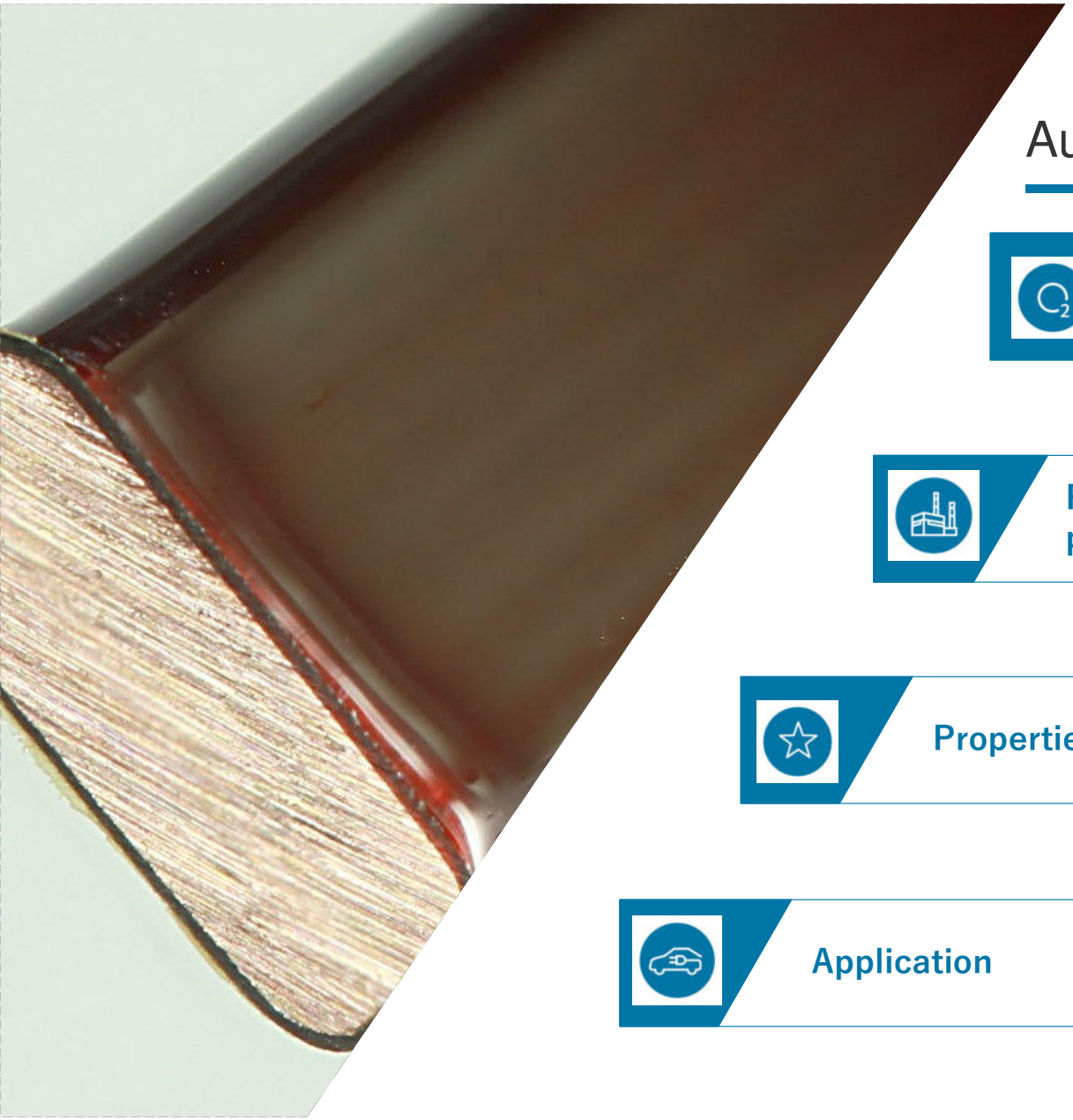




Cuprous precipitation Cu_2O seen in dark field illumination



→ Oxygen enters into the copper @ welding zone.
→ „Cu-OFE transformes into Cu-ETP1“ during welding.



Aurubis ROD | RheinROD **LimOx**

Oxygen content

- Limited to max. **120 ppm**
- LimOx**+**: max. **40 ppm** (first tests accomplished)

Production provisions

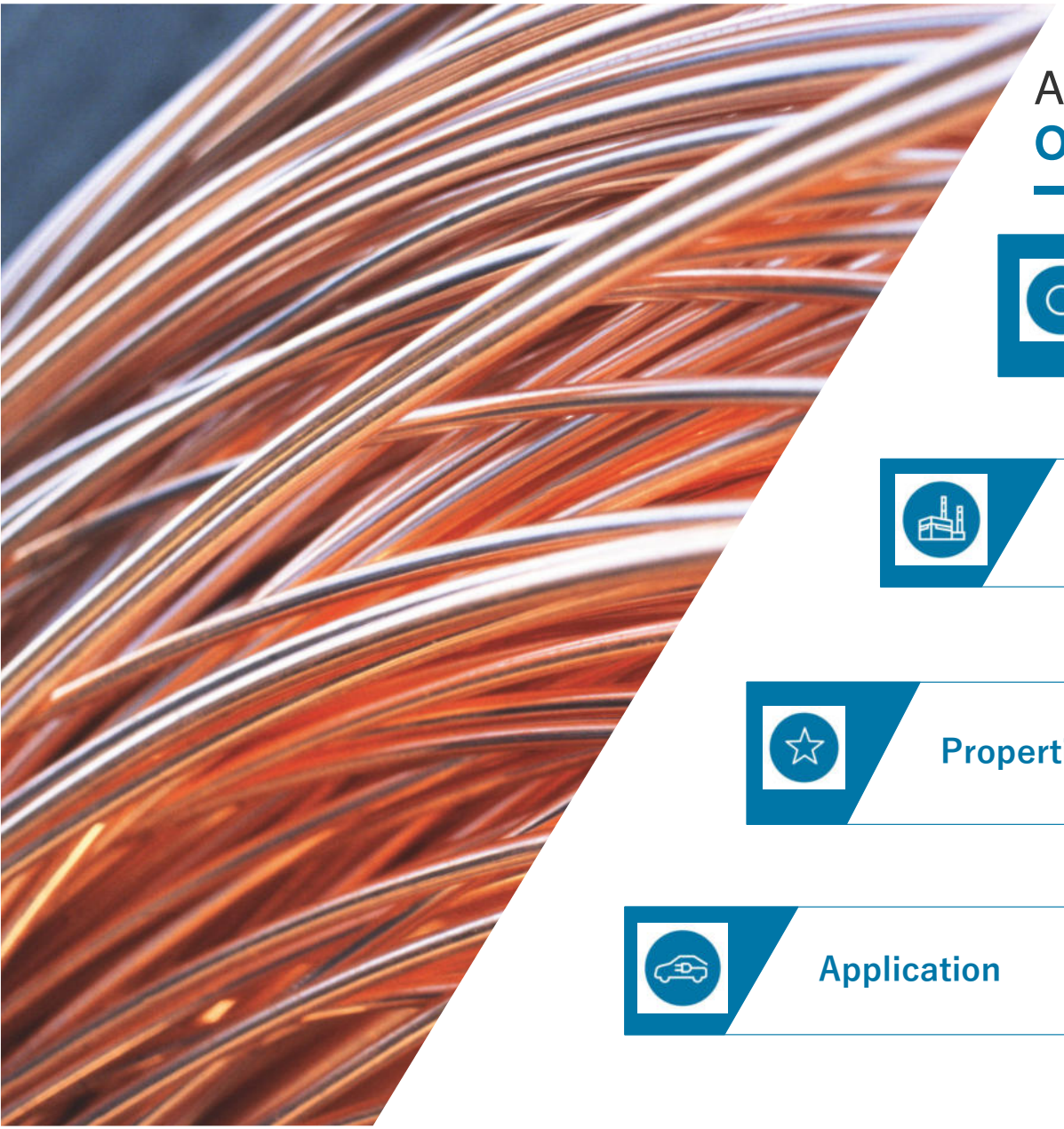
- **Limited** access of **oxygen** in all copper melt areas

Properties

- **Product** and **processing properties** on the **same level** of standard **Cu-ETP1**
- **Excellent** surface quality for **magnet wire**

Application

- Hairpin / EV wire for **laser beam welding** at atmosphere in e-motor stators



Aurubis FOXROD
Optimized Surface

Product Limitations

- Limited to **4 ppm oxygen**
- Diameter **12.5mm**
- Coarse grain structure

Production provisions

- Casting process **optimized**
- Production **capacity** in focus

Properties

- **„Bamboo free“** surface quality for flat rectangular **magnet wires**
- Surface groove deepth < 10µm

Application

- Hairpin / EV wire for **laser beam welding** at atmosphere in e-motor stators

Summary

Aurubis has a smelter network with **4 tankhouses** and **4 rod lines** in Europe with over **900,000 t/a** production capacity

Cu-ETP1 grade with a **limited oxygen level** has a **very good laser beam weldability** for EV wires

2 new grades with very low in oxygen levels available
(from continuous casting rod lines)
- **LimOx** with max. **120 ppm**
- **LimOx+** with max. **40 ppm**

1 new grade in OF with **optimized surface** in **12.5 mm** Aurubis **FOXROD OS**

Tomorrow Metals
The Aurubis Sustainability Promise

