

Nano-crystalline and amorphous cores

Products and applications

ZVEI:

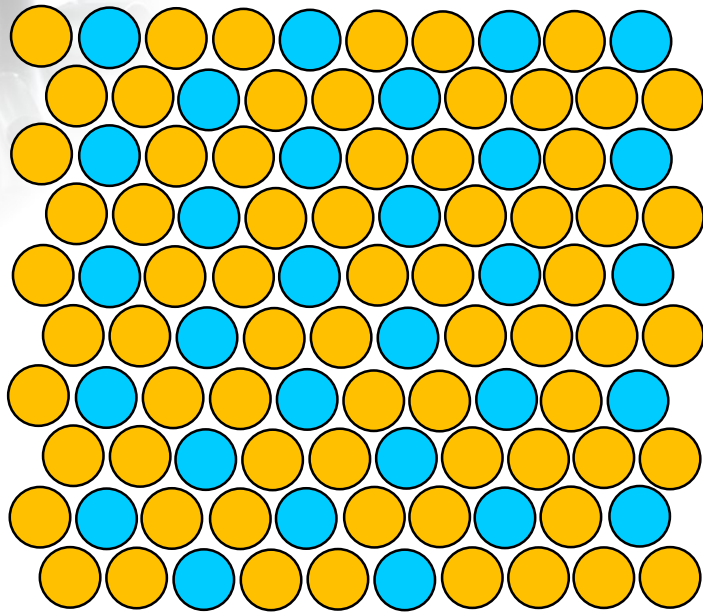
Casting issues and developments

ZVEI Workshop

Dr. Swen Graubner, SEKELS GmbH

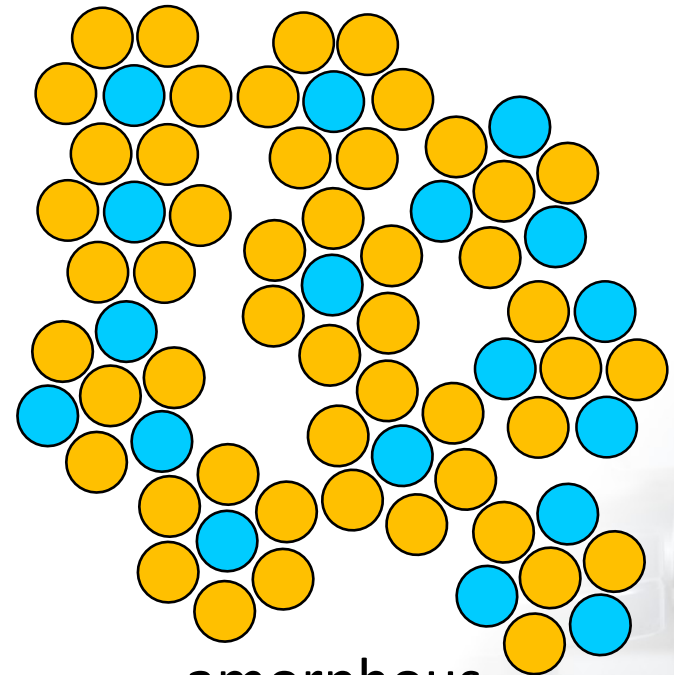
05.05.2015 Berlin

- Introduction to casting process
- Alloy-specific properties
- Some applications
- Summary



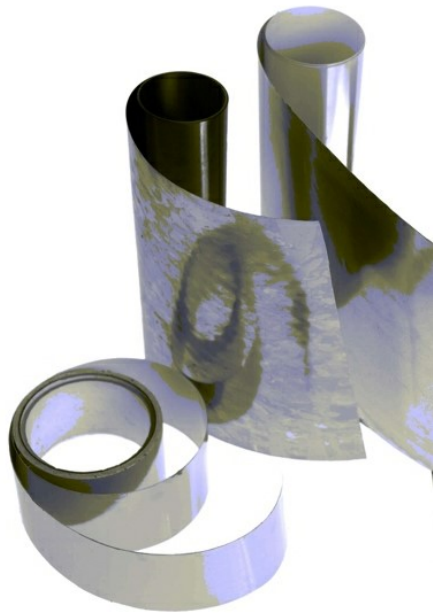
crystalline

- Ordered structure
- High density



amorphous

- Short range order
- No long-range order
- Some „crystalline effects“ do not occur



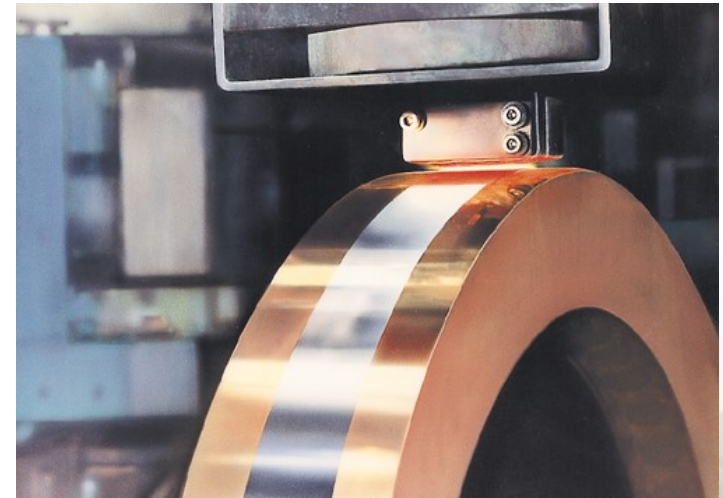
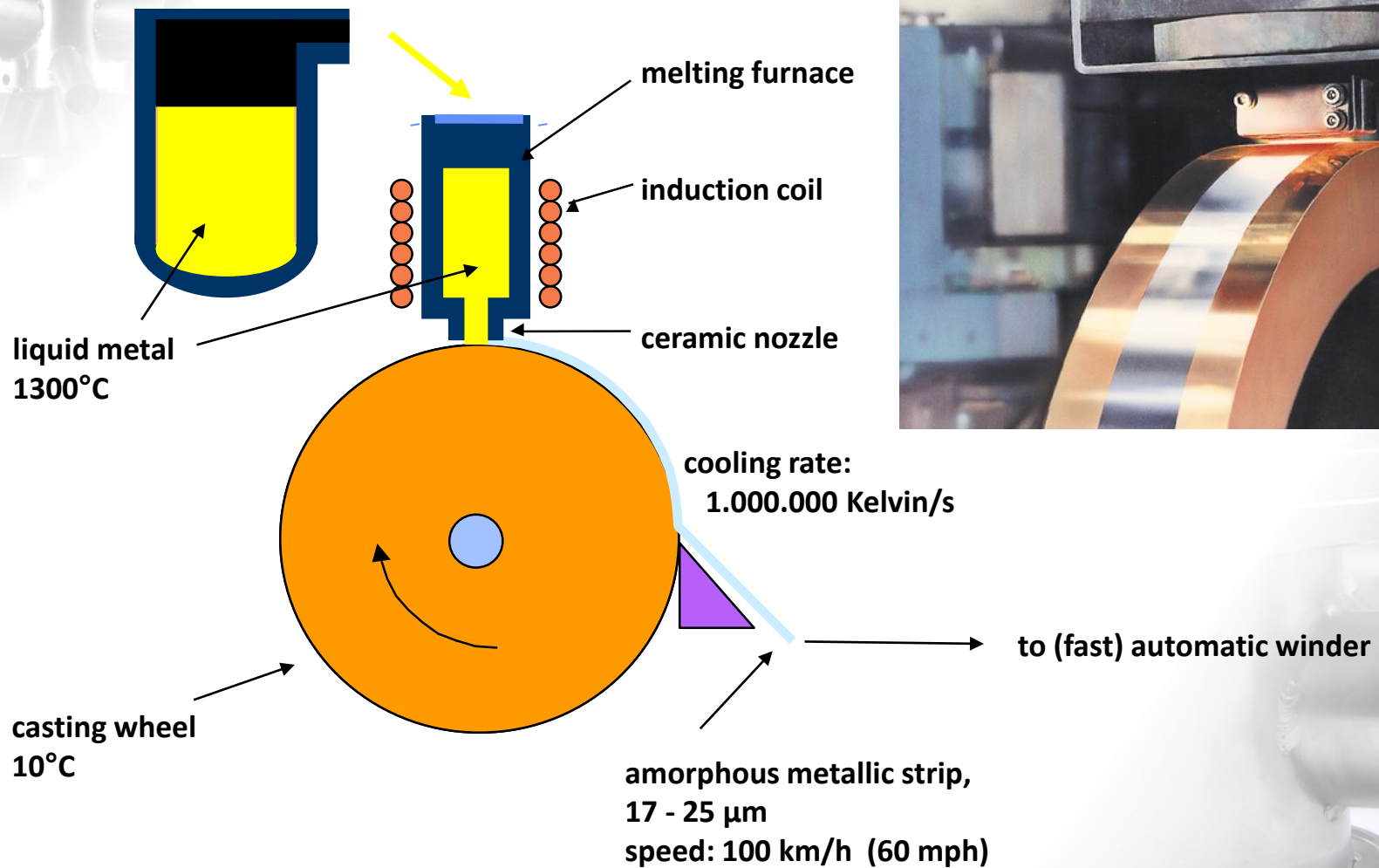
“metallic” glass



“real” glass

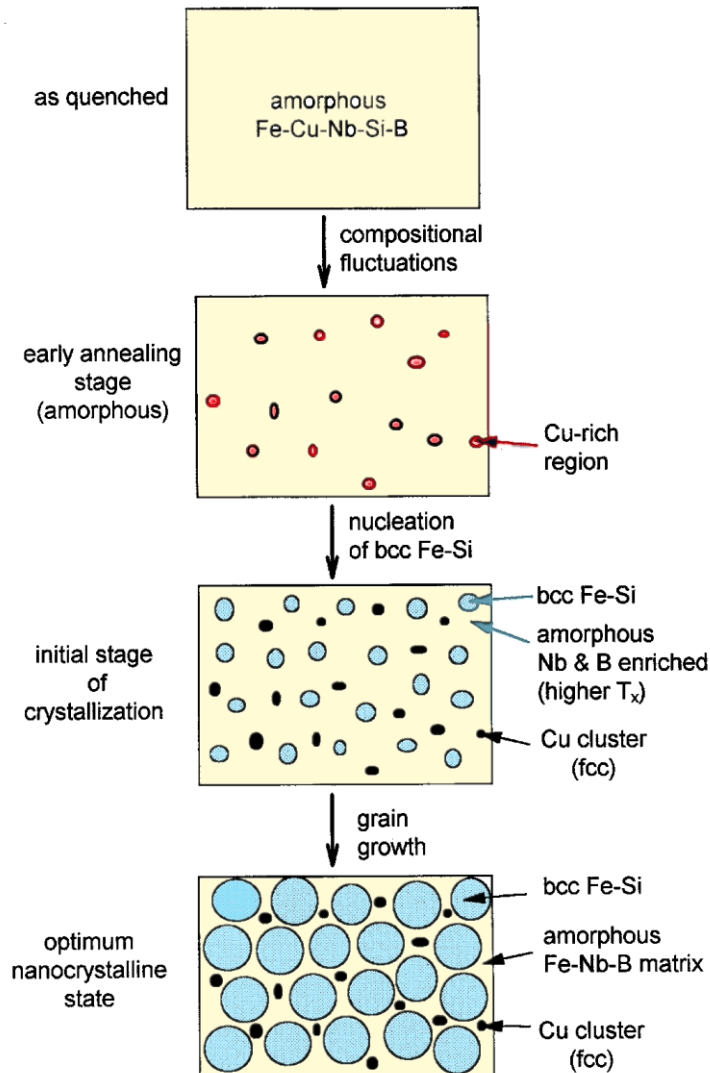
From: www.wikipedia.de

Production of amorphous strip



One process step from melt to final strip thickness

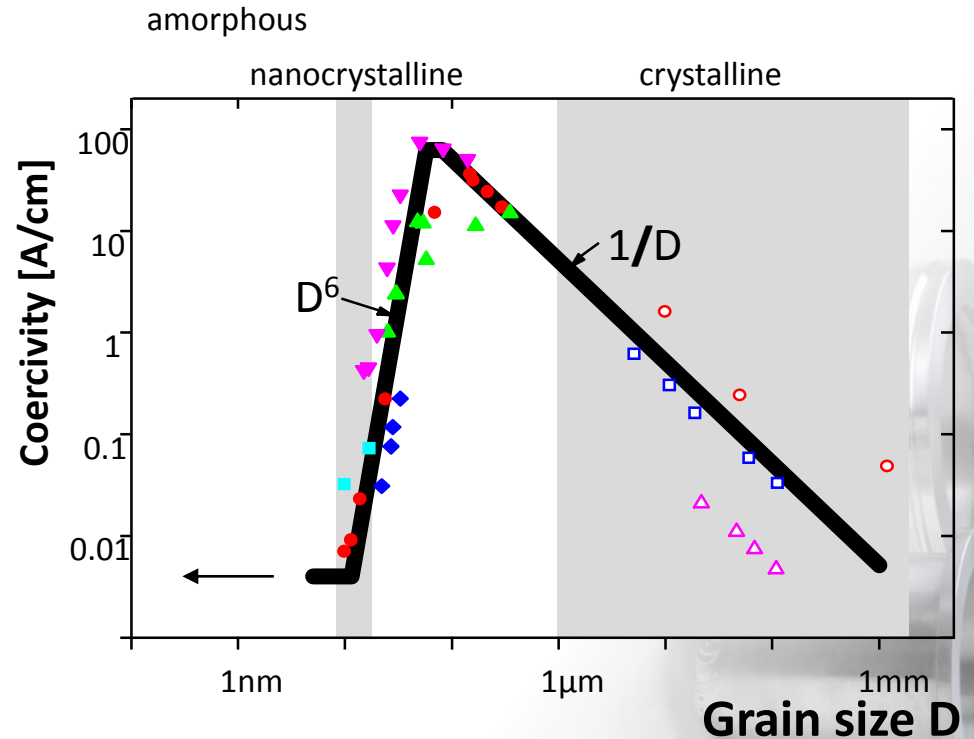
How to grow nano-crystals?



- Start with amorphous material
- Heat it up to 550-600°C
- Let many small crystals grow
- BUT stop them from getting too big and to merge!
- Grain size very important

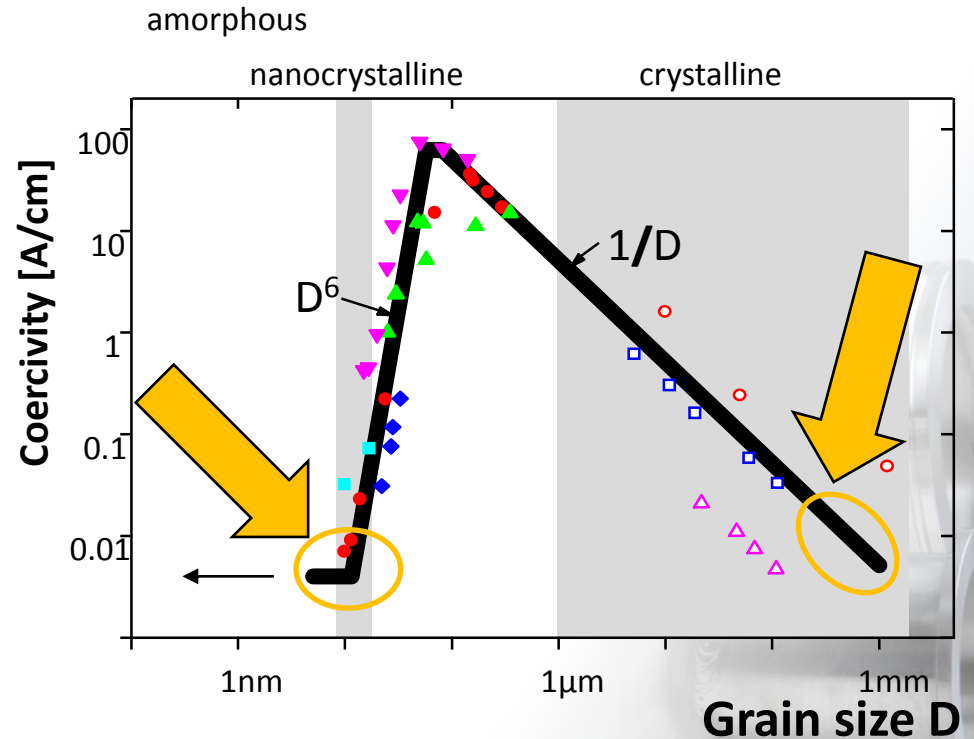
Why is nano-crystalline soft magnetic?

- Zero magnetostriction
- High Curie temperature
- Low temperature dependence
- No Nickel or Cobalt
- Low losses

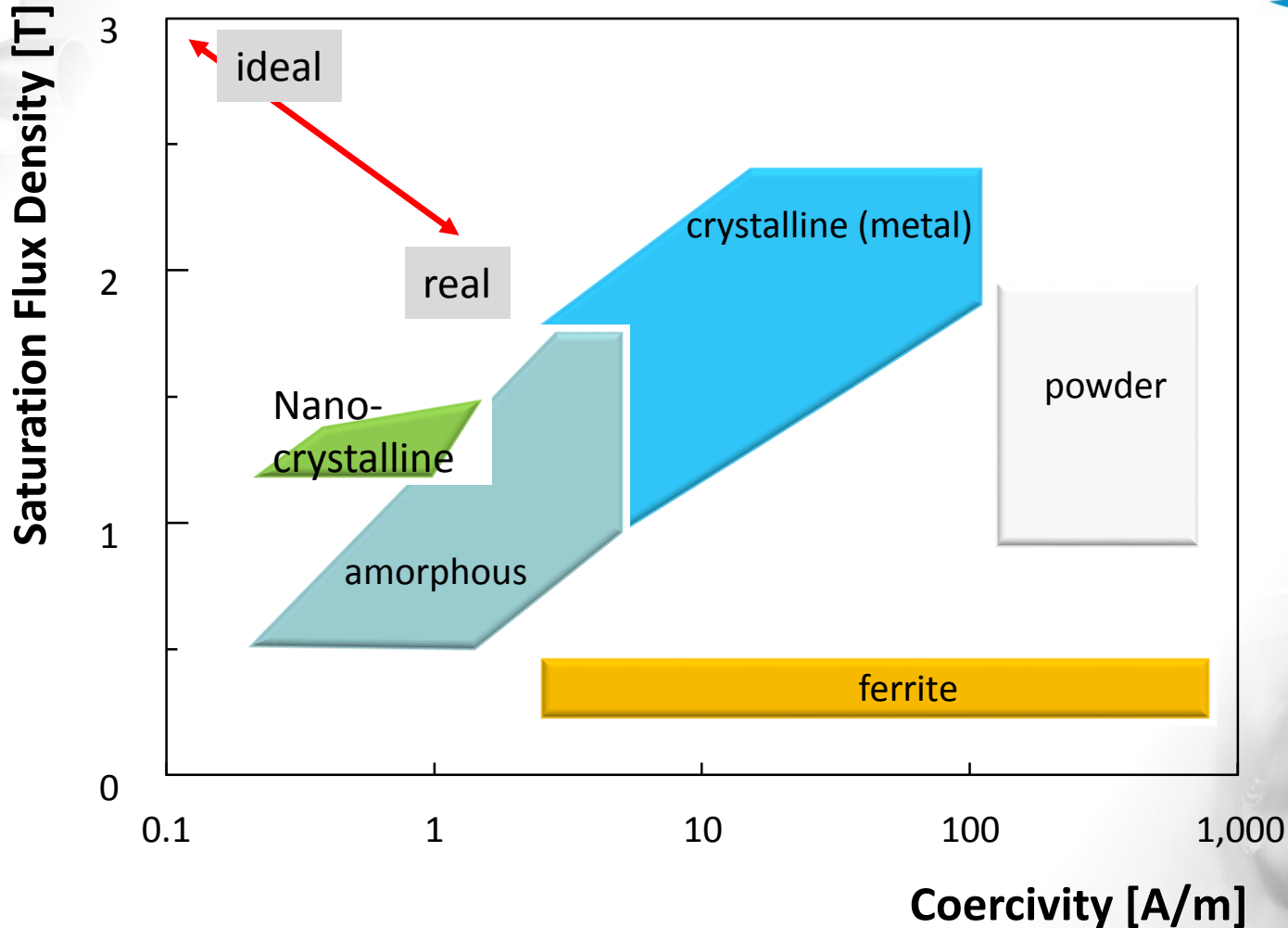


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Soft magnetic alloys for electrotechnical applications



Mother nature likes huge varieties (and busy engineers 😊)

- Power Chokes
- Common Mode Chokes
- Current Transformers
- Power Transformers
- Saturable Reactors



- **Power Chokes**
- Common Mode Chokes
- Current Transformers
- Power Transformers
- Saturable Reactors



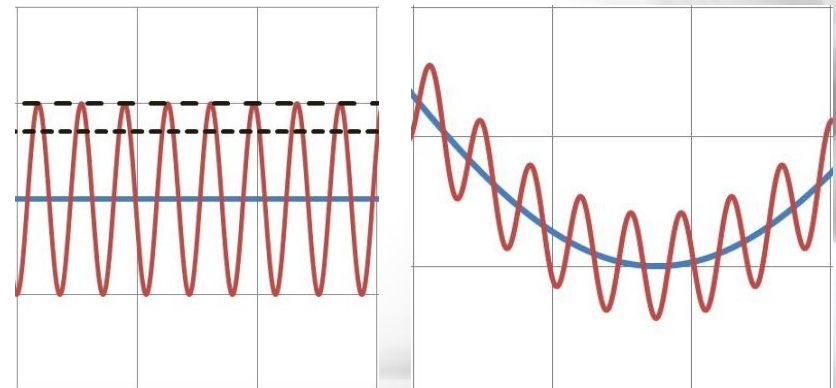


Power Choke

- „Linear“ choke
- Usually for higher currents
- Stores magnetic energy
- Smoothens current



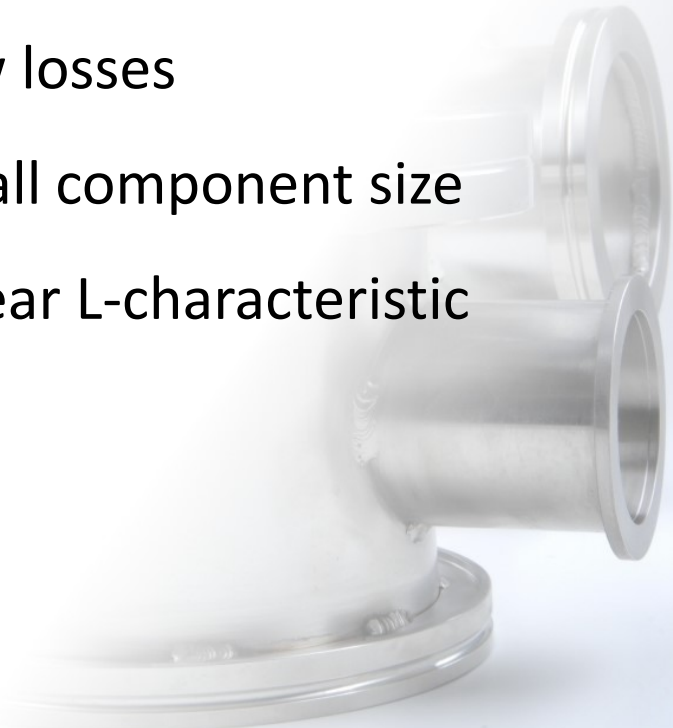
„Inductance with magnetic core“

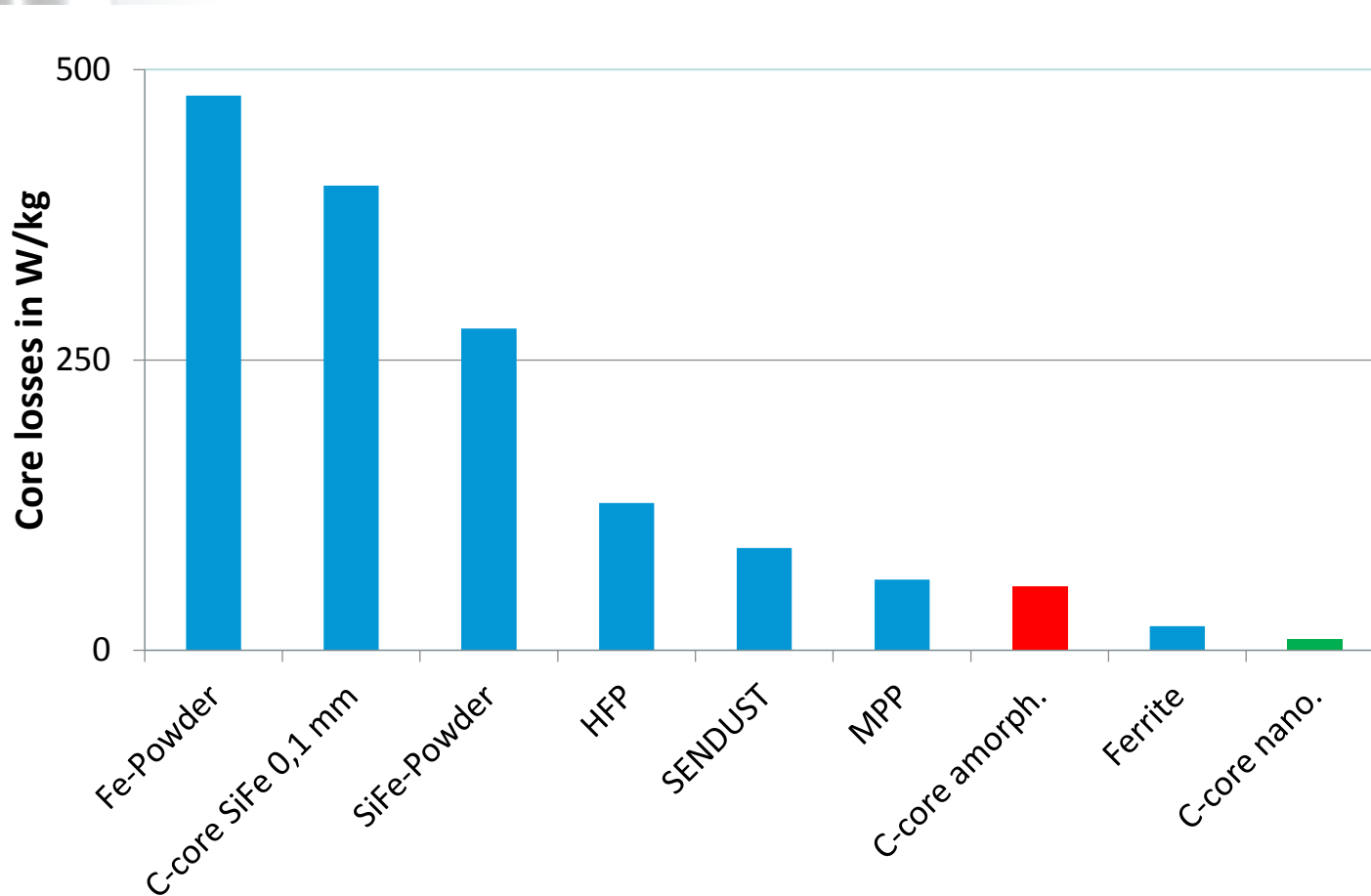




Important parameters:

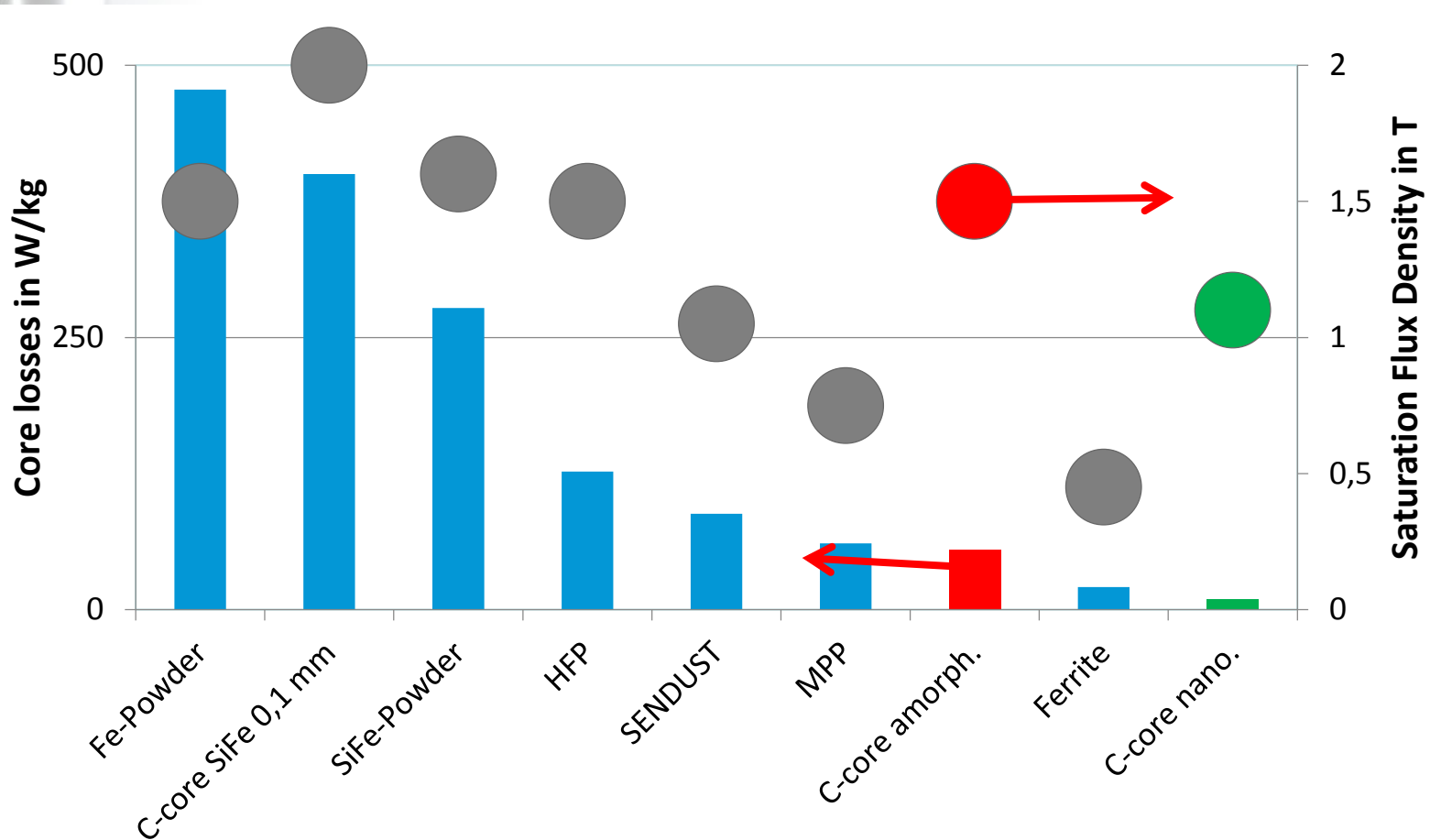
- + High flux density
- + Low losses
- + Small component size
- + Linear L-characteristic





Typical core losses (**columns**) in W/kg ($f = 25 \text{ kHz}$, $B_p = 0,2 \text{ T}$) and saturation flux density (**circles**) of choke materials (losses should be low, flux density high 😊)

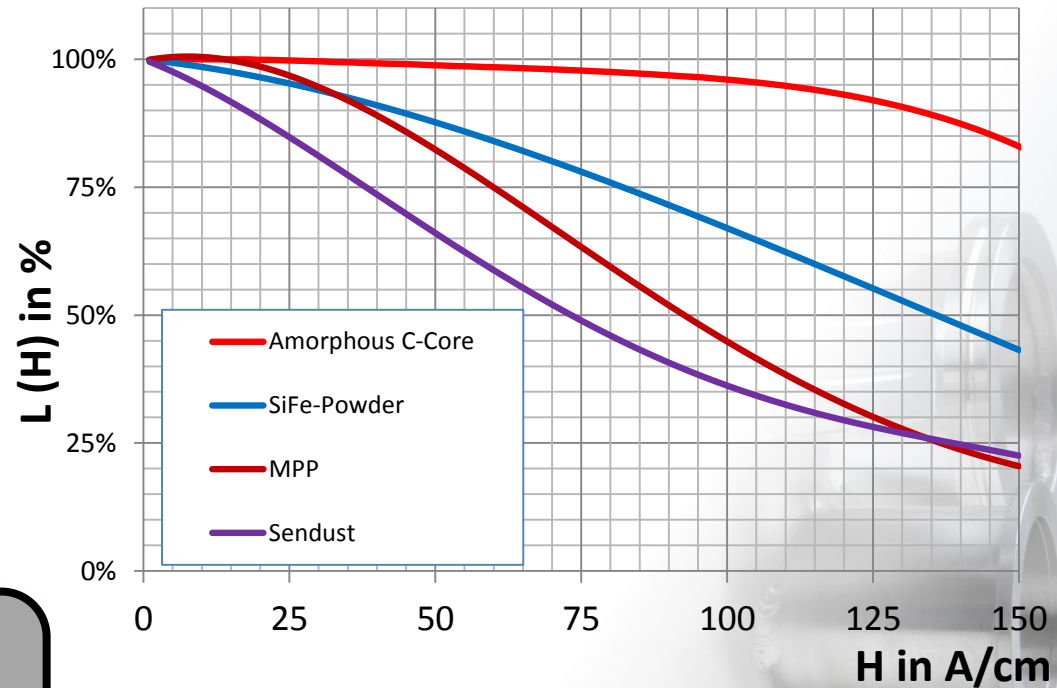
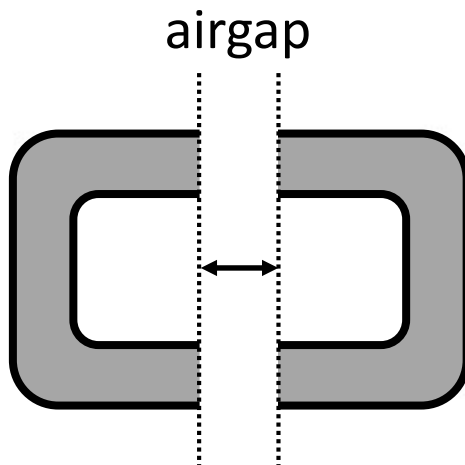
Alloys for power chokes



Typical core losses (**columns**) in W/kg ($f = 25 \text{ kHz}$, $B_p = 0,2 \text{ T}$) and saturation flux density (**circles**) of choke materials (losses should be low, flux density high 😊)

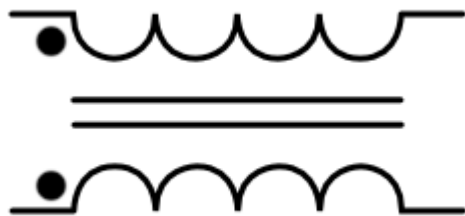
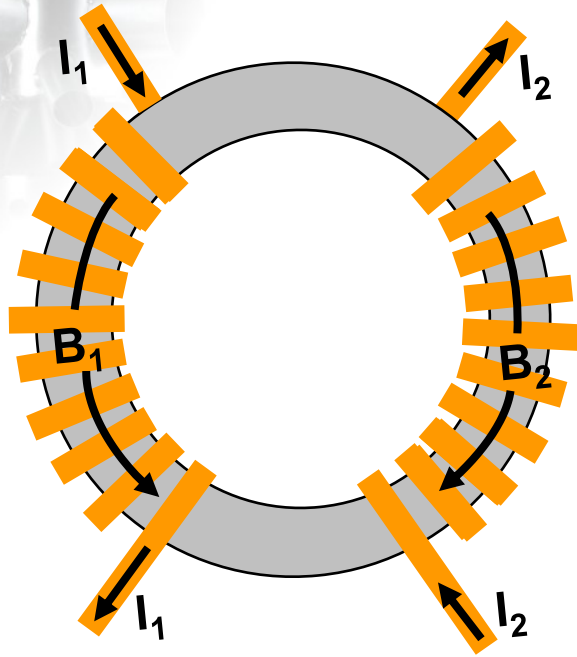
Inductance „stiffness“

- Air gap can be used to adjust inductance
- Good energy storage capability
- Linear L-characteristic („stiffness“)



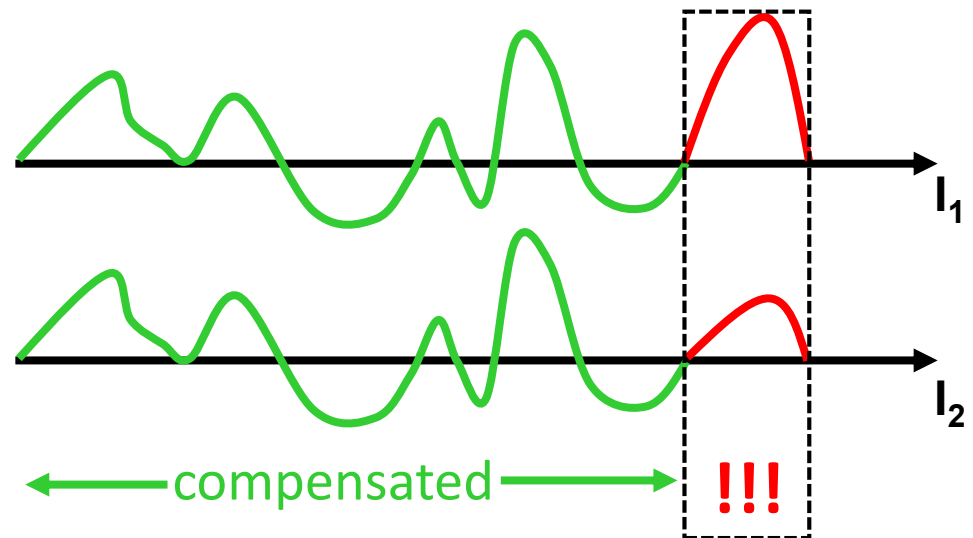
- Power Chokes
- **Common Mode Chokes**
- Current Transformers
- Power Transformers
- Saturable Reactors

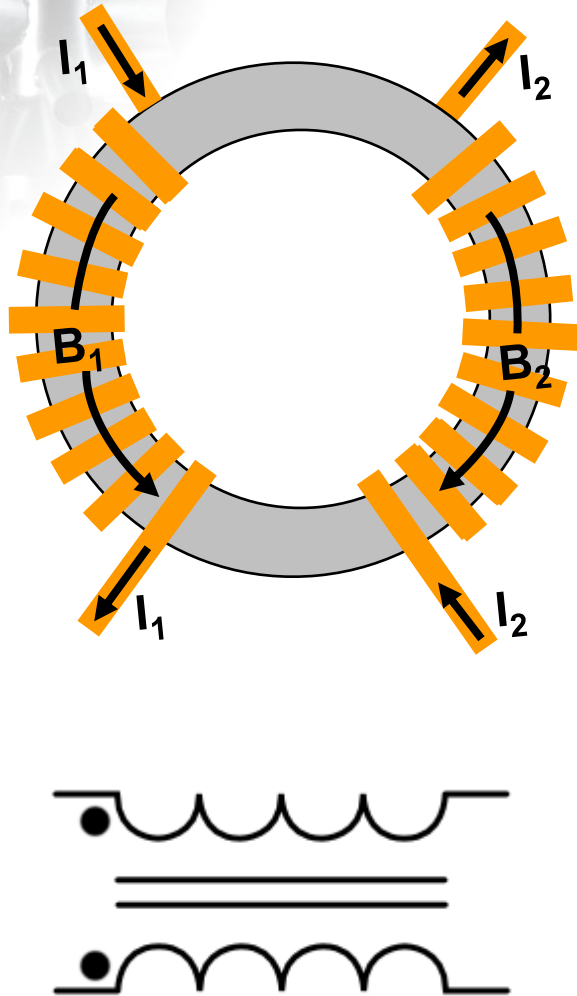




Common Mode Choke

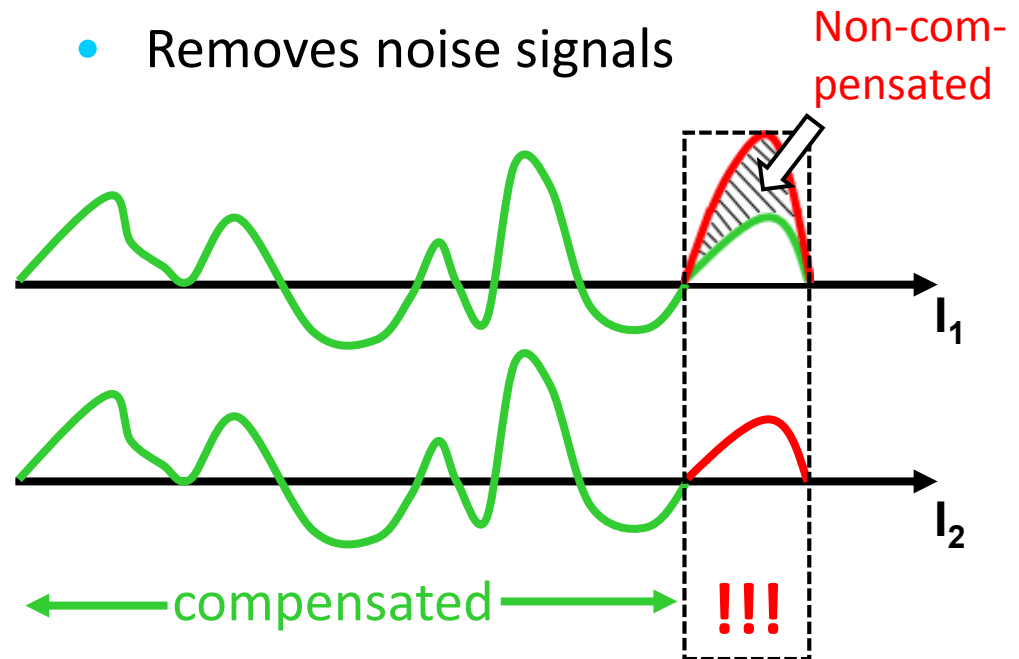
- Trick: compensating fields
- Small size possible
- No saturation by nominal current
- Removes noise signals





Common Mode Choke

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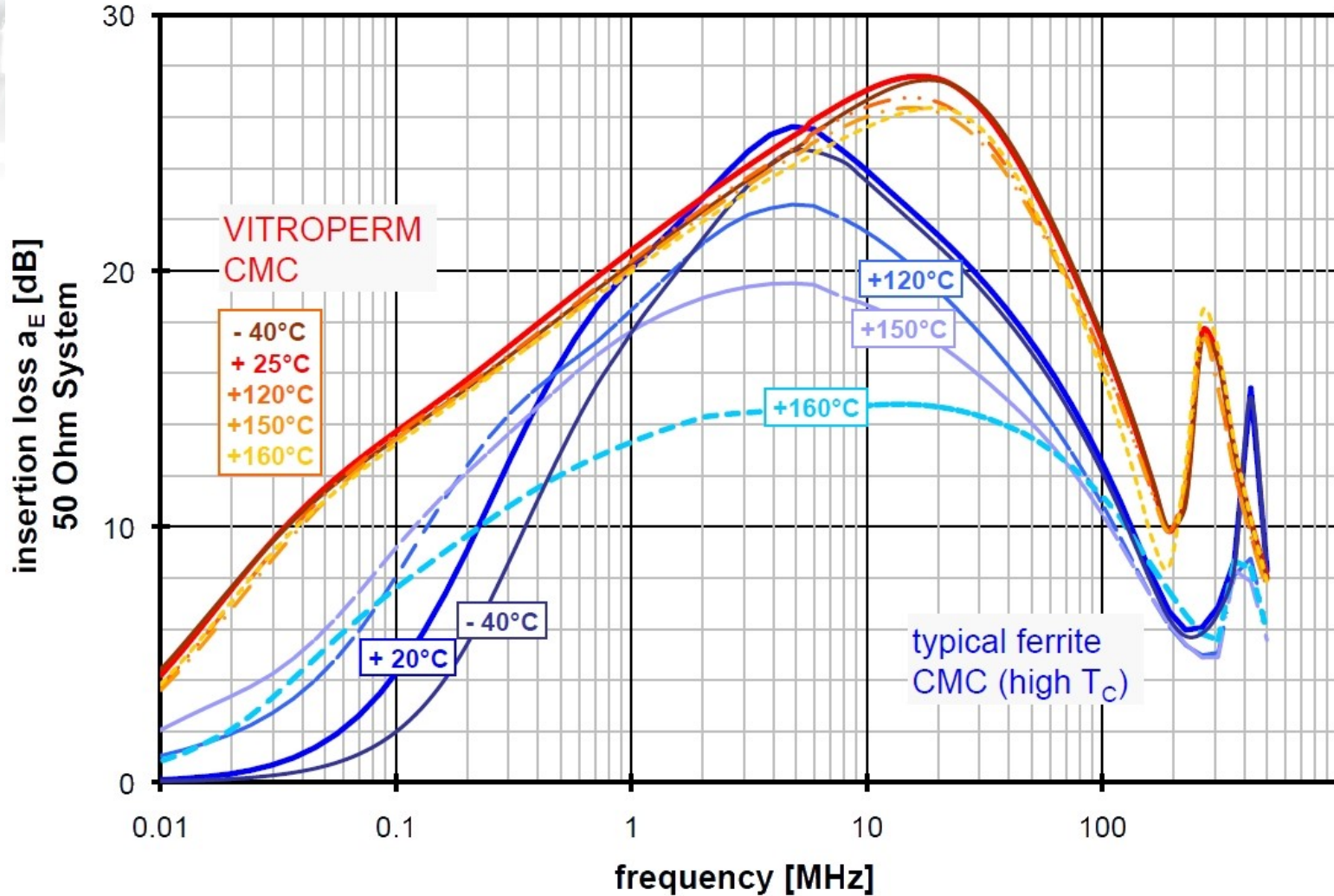


Important parameters:

- Damping behavior
 - Permeability
 - Frequency dependence
 - Saturation magnetization
- Size/weight
- Temperature stability
- Price



Common mode chokes with nanocrystalline cores



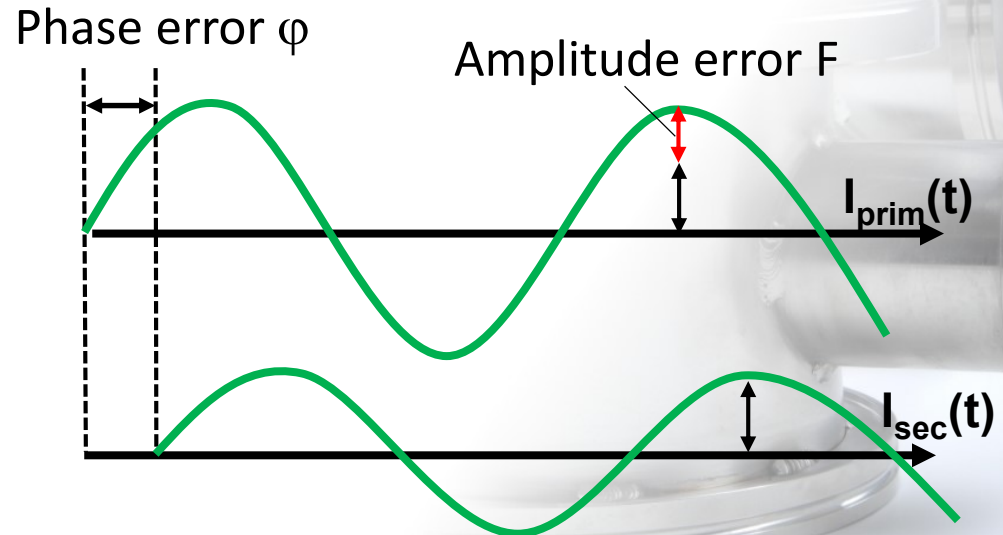
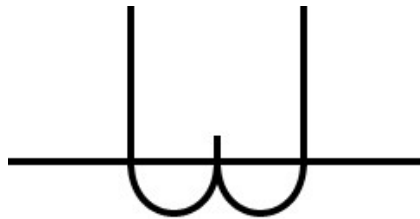
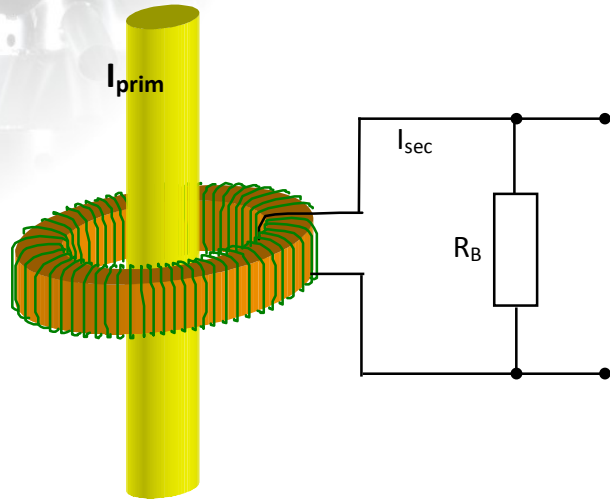
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- Power Chokes
- Common Mode Chokes
- **Current Transformers**
- Power Transformers
- Saturable Reactors



Current transformer

- Measuring device
- Measuring accuracy important
- Transformation of large primary current into low secondary current



Current transformer error sources

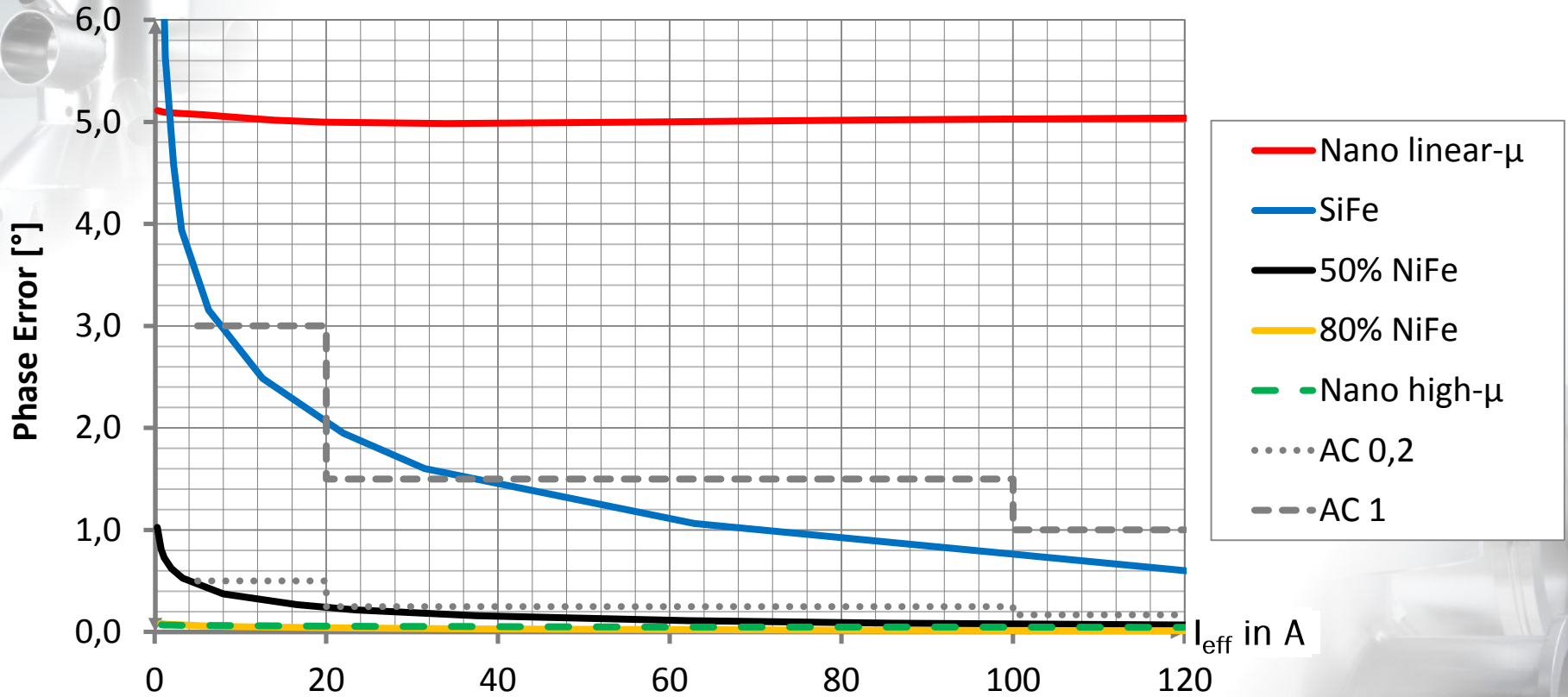
Phase Error

Permeability
 $\mu = \mu' + j \mu''$

Losses
(layer thickness)

Amplitude Error

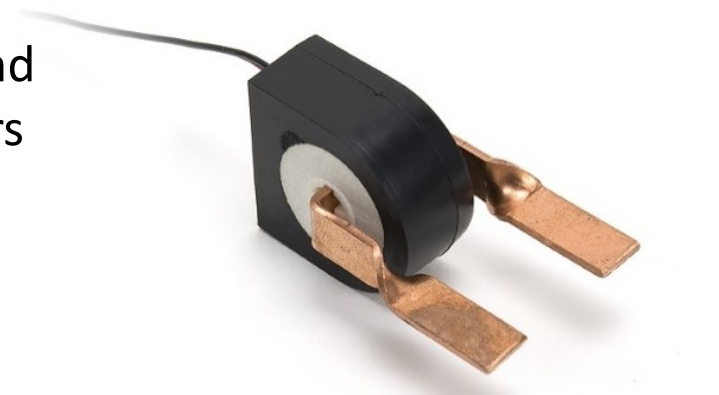
Advantages of nanocrystalline cores for CTs



- + Cost-effective replacement of NiFe cores with improved frequency response
- + Cost effective replacement of amorphous Co-based cores for „DC-immune“ energy meters

State of the art:

- Nano-crystalline or high-permeability Nickel-Iron (MUMETALL[®], VACOPERM[®])
- Clear tendency to nano-crystalline alloys
- Established in RCCB in households and precision CTs in electronic wattmeters



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- There are no really “good” or “bad” materials
- Amorphous and nano-crystalline alloys are an interesting option for several applications
- Choose the right tool for your problem



From: www.pc-games.de



From: www.wikipedia.de



- There are no really “good” or “bad” materials
- Amorphous and nano-crystalline alloys are an interesting option for several applications
- Choose the right tool for your problem
- Be open for new solutions 😊



From: www.pc-games.de



From: www.wikipedia.de



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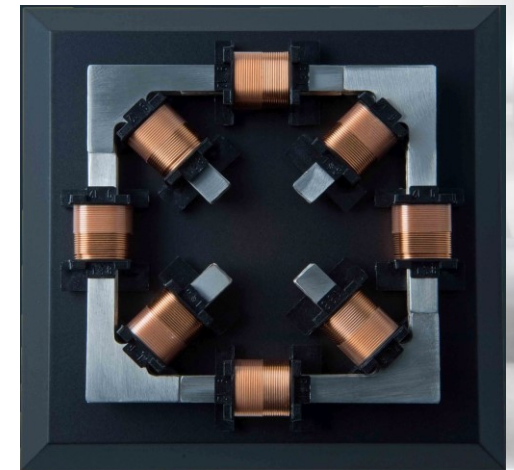


Special inductive components

VAC[®]
VACUUMSCHMELZE



Standard cores and components



Magnetic applications

Thank you for your attention!!

Any questions??

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