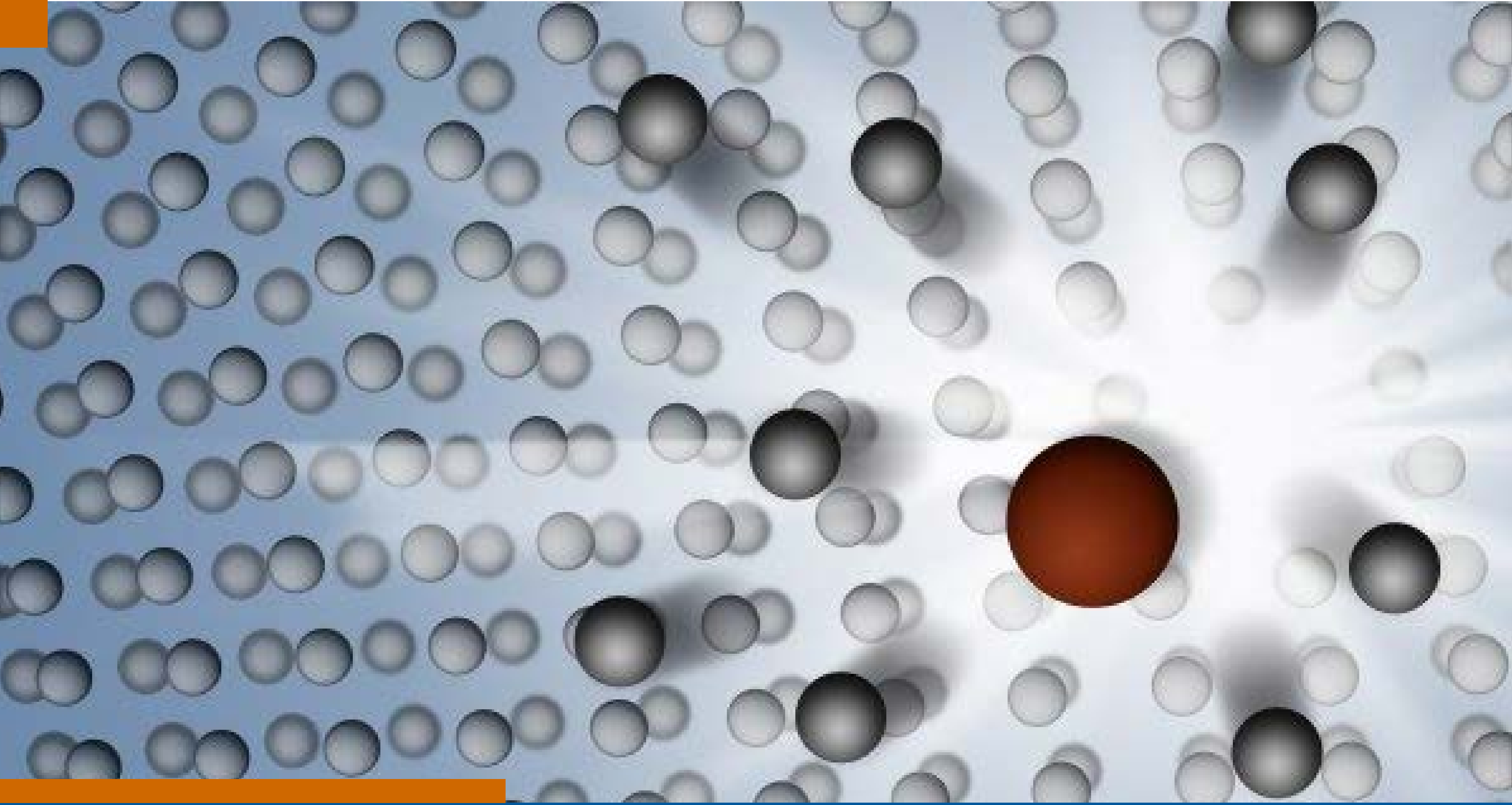


The Iron-Rhodium System

Modification of the Magnetic Phase

HZDR
HELMHOLTZ
ZENTRUM DRESDEN
ROSSENDORF

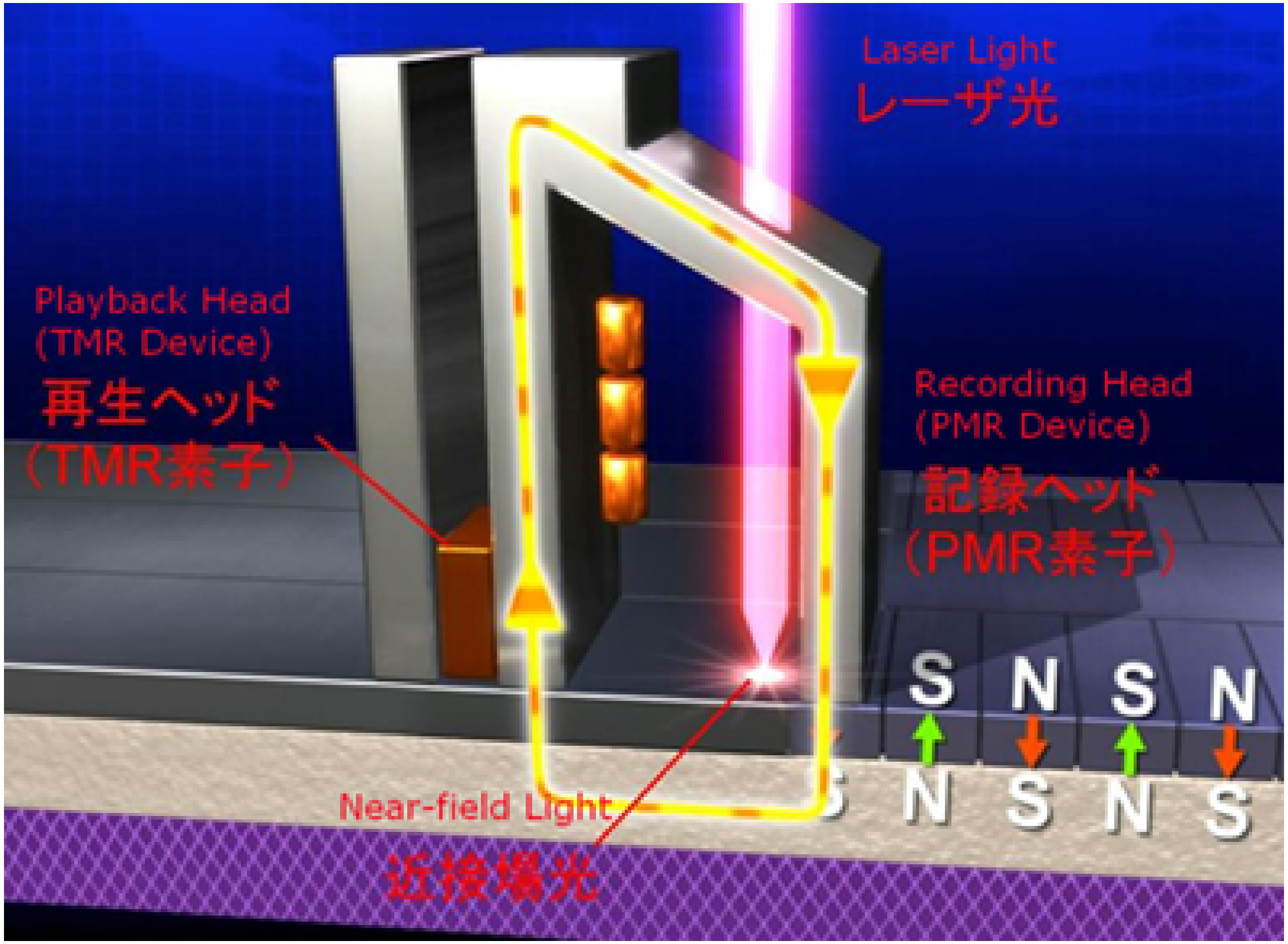
Member of the Helmholtz Association

Outline

1. Motivation - The FeRh binary alloy
2. Introduction
3. The new measurement system
4. Outlook

Motivation: Heat assisted magnetic recording (HAMR)

***Higher storage Density**
***Lower writing speed**

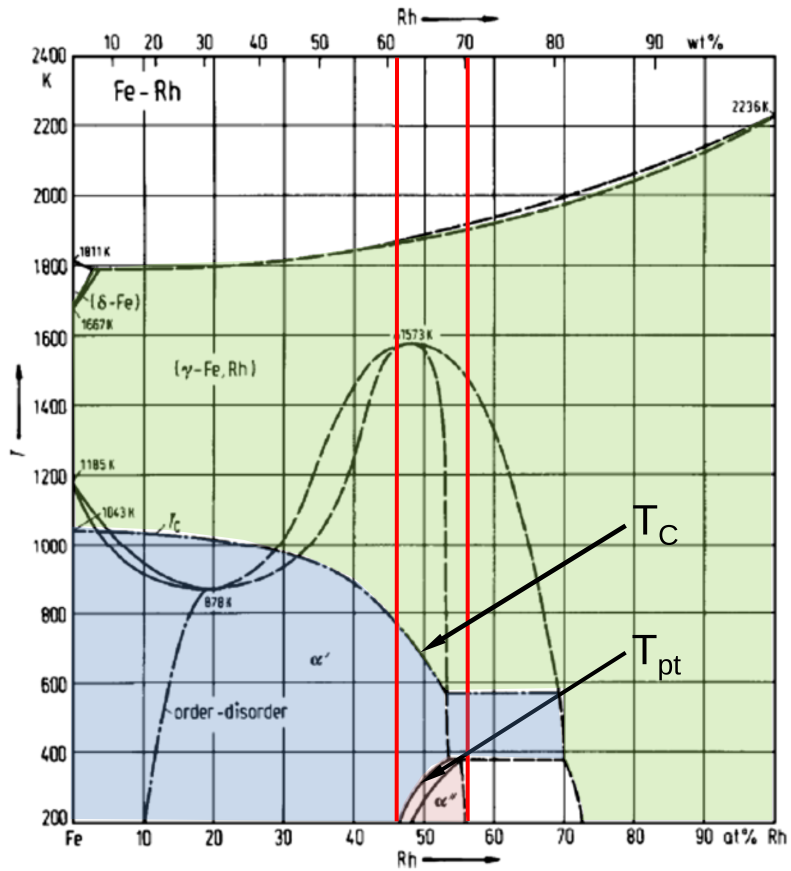


Source Seagate: Whoever said disk drive technology and supply was settling into boredom? No way, Jose!

Outline

1. Motivation
2. Introduction
3. The new measurement system
4. Outlook

Introduction: The Iron-Rhodium System



Phasediagram of the FeRh-Alloy.

Swartzenhuber, L.J., Bulletin of Alloy Phase Diagrams, 1984

Near equiatomic composition:

- B2-structure (bcc based, AFM, FM)
- A1-structure (fcc based, PM)
- Thermally induced phase transition

AFM
α‘‘-Phase
B2

→ T_{pt} →

FM
α‘-Phase
B2

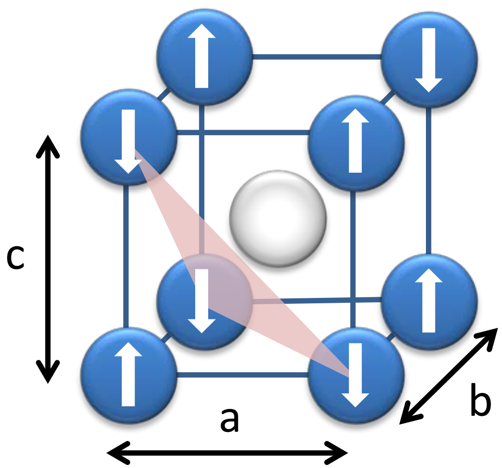
FM
α‘-Phase
B2

→ T_C →

PM
γ -Phase
A1

Introduction - The Iron-Rhodium system

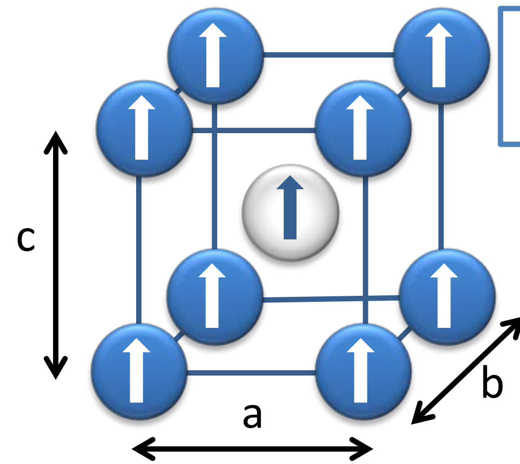
AFM ground state



a= b = 2,98 Å
c = 3,004 Å

- α‘‘-phase (B2)
- G-typ AFM order (magnetic monolayers along 111 plane → GMR)
- Fe ≈ 3,3 μ_B
- Rh = 0 μ_B

FM high temperature state



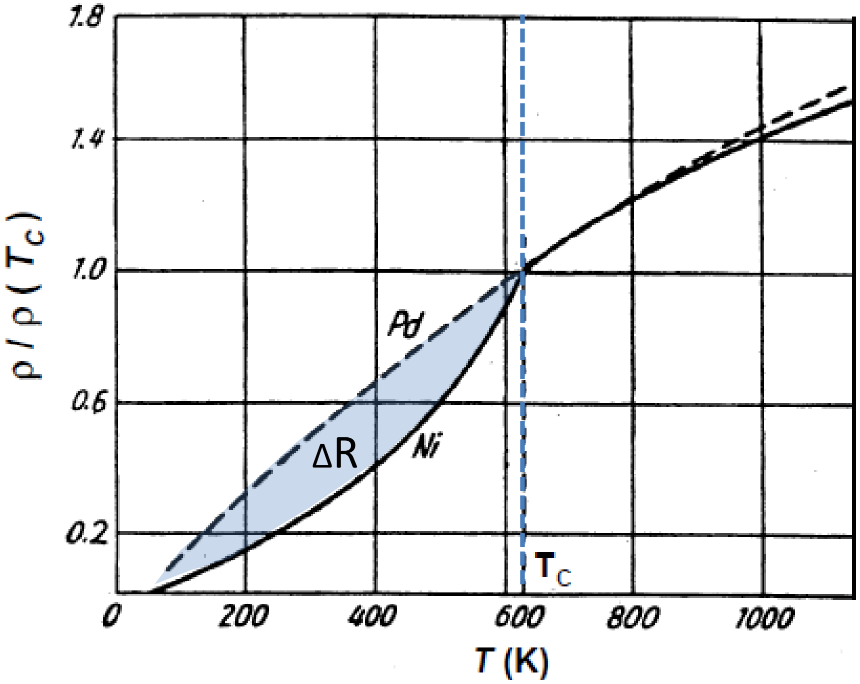
a= b = 2,98 Å
c = 3,028 Å

- α‘-phase (B2)
- FM order
- Fe ≈ 3,2 μ_B
- Rh = 0,9 μ_B

Introduction - Basics for the measurement

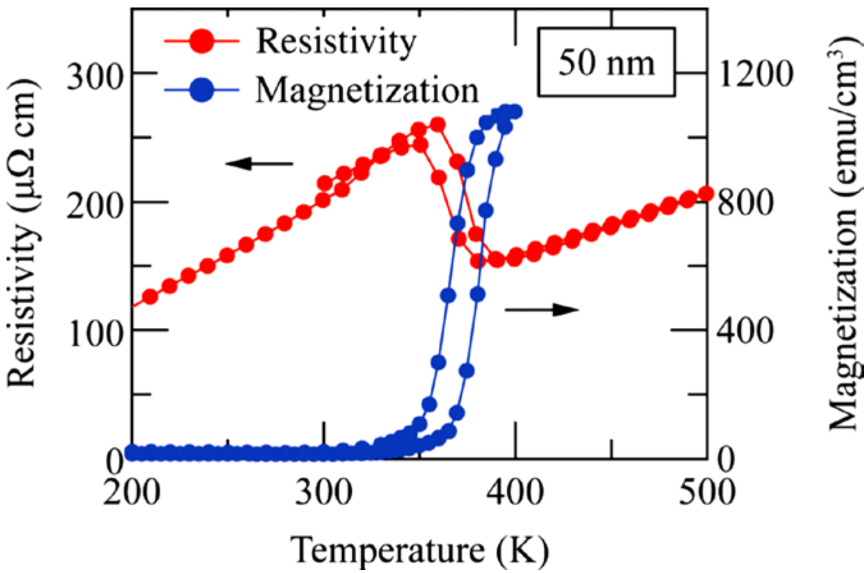
Resistance change at Curie point

- Occurs in ferromagnets
- Electrical resistance below Curie-temperature smaller then in non-ferromagnets
- Above the Curie-Temperature ferromagnets become paramagnetic and behave like normal conductors



Comparision of the electrical resitance of the non-ferromagnetic Pd and the ferromagnetic Ni.
(R.Gross, WMI Lecture Spintronics , 2005)

Introduction - Basics for the measurement



Magnetic phasetransition and negative magnetoresistive effect of a 50 nm thick FeRh-Layer .

Suzuki, I., et al., Journal of Applied Physics, 2011

AFM-FM phase transition

- around 350 K

Phase transition detection

- Resistance
- Magnetization
- Giant Magnetoresistance

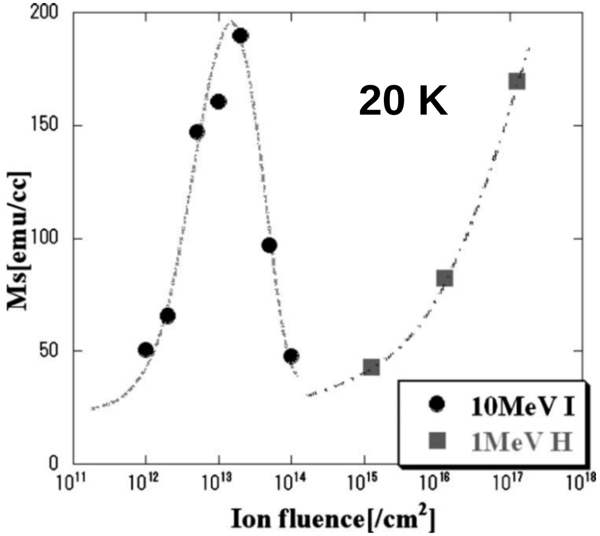
Between adjanced Fe layers

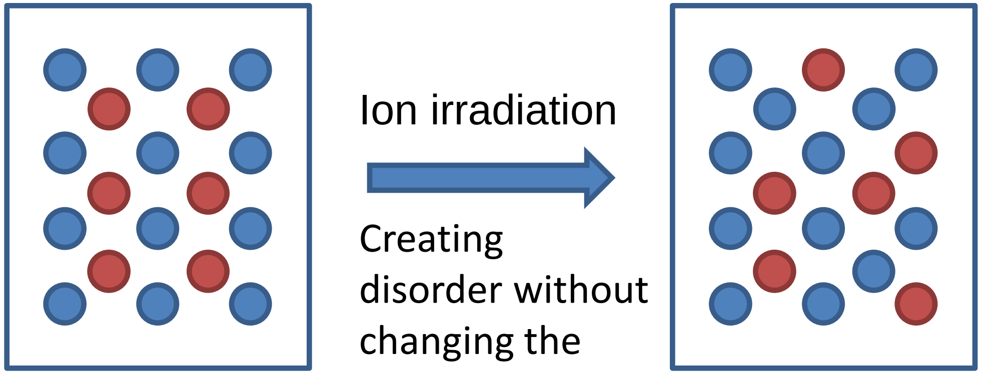
Fe↑-Rh-Fe↓ - R ↑

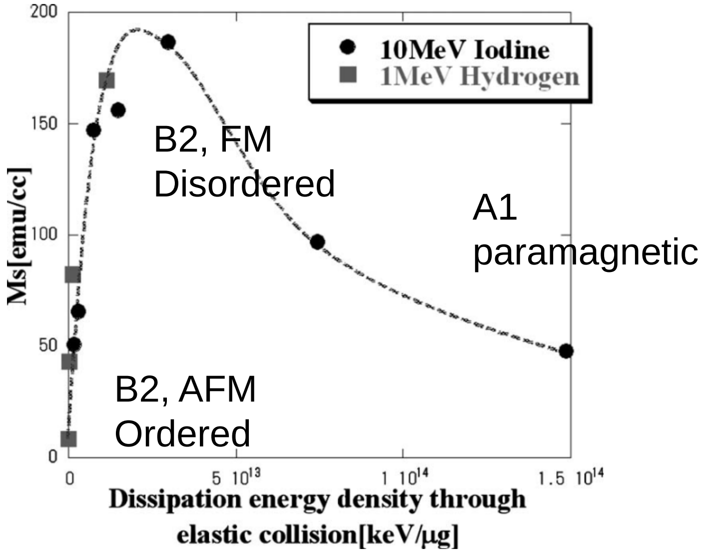
Fe↑-Rh-Fe ↑ - R ↓

Introduction - Ion beam induced magnetization changes

Ion irradiation of 80 nm B2 FeRh films







N. Fujita, Journal of Applied Physics, 2010

Ion irradiation

- Change in magnetization as a function of fluence
- Critical value of fluence exists
- Above critical value change of lattice structure

  from B2 to A1

Outline

The New Measurement System

How ?!?

FeRh properties

- AFM-FM transition due to temperature at 350 K
- AFM-FM transition due to ion irradiation
- Detection by resistance change with temperature
- Detection by Giant Magnetoresistance measured as function of external field at T > 350K

In-situ system with

- Temperature variation
- Resistance measurement
- GMR measurement (external field required)
- Ion irradiation and measurement of the fluence

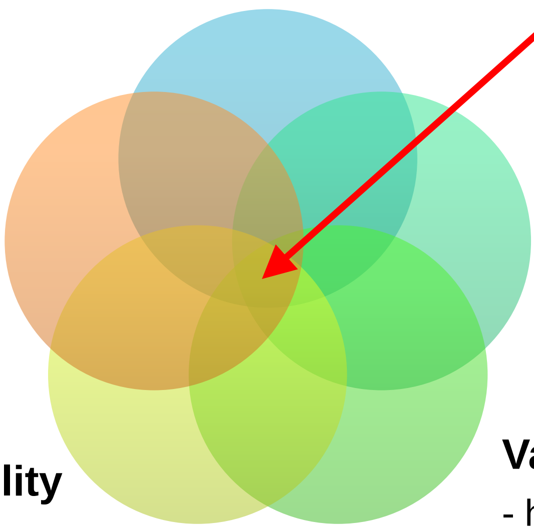
The New Measurement System

Material Selection

Strongly limited variety

Magnetic Properties
- diamagnetics
- paramagnetics

Electrical Properties
- conductors
- insulators



Maschinability
- small geometries
- cost efficency

Sputtering Stability
- low sputter yield

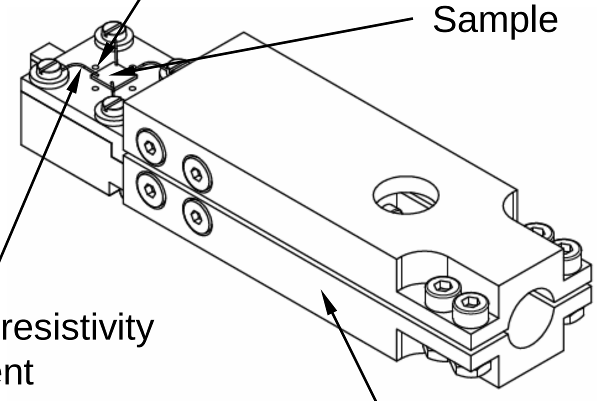
Vacuum Stability
- high melting point
- highperformance polymers

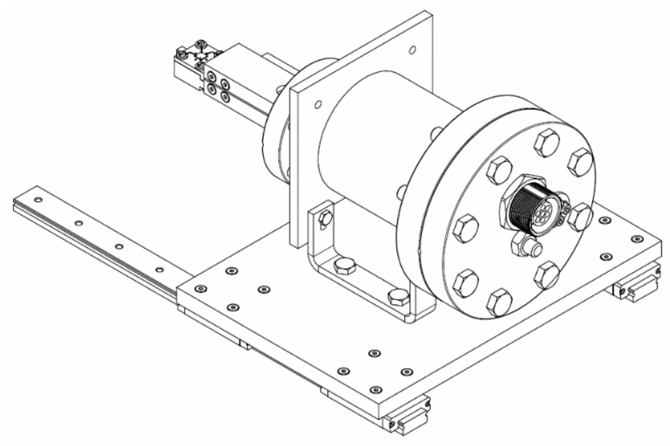
Selected Materials

- PEEK (insulator)
- AlO-Ceramics (insulator)
- Copper (conductor)
- Aluminum (strucutre)
- stainless Steel (strucutre)
- Molybdenium (strucutre)

The New Measurement System

Construction



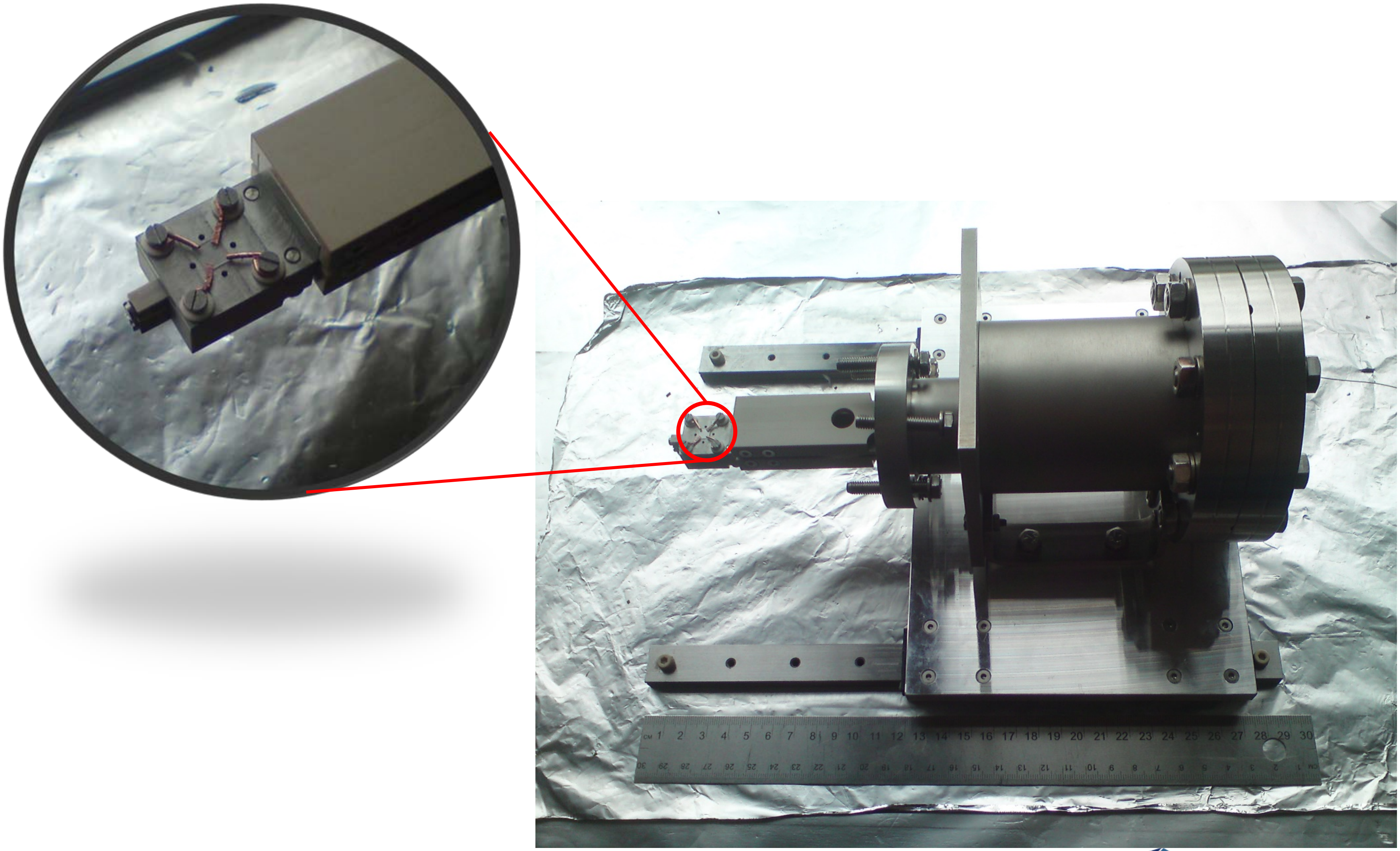


- Heating up to 400+ K
- Chamber reaches high vacuum conditions

  (leakage rate $10^{-10}\, mbar \cdot l/s$)

⟹ important for running the ion gun

Construction of the Measurment System



Construction of the Measurment System

Safety - High voltage is not your friend !!!

Ion irradiation

- Creates charging effects of the sample stage about 5 kV
- ➢ No transfer of the charge to any touchable parts
- ➢ Secured grounding of this charge

→ PEEK as high performance polymer with a dielectric strenght of **75 kv/mm**

Conclusion

Possible measurements

- Measuring the GMR via layer resistivity with applied external magnetic field
- Measuring the phase transition temperature vs. ion flux via the layer resistivity
- Under high vacuum conditions

Acknowledgements

You don't reach your goals without some friends.

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Thank you !