SWTEST 2021 CONFERENCE
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30TH ANNIVERSARY

3D magnetic sensor stimulation New solutions for wafer probing

T.I.P.S.
Technical Innovation Physical Solution

Rainer Gaggl
Sebastian Salbrechter
Georg Franz
T.I.P.S. Messtechnik GmbH

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Overview

- **Magnetic Sensors**
  - Sensing technology – XMR sensor evolution
  - Sensor applications – from current to geomagnetic sensing
  - Magnetic stimulation – field strength range
  - 3D magnetic stimulation in wafer test – "magnetic" probe cards
- **3D Medium field stimulation**
  - Probe card with rotating perament magnet and ring coil
  - Magnet for in-plane-, Coil for out-of-plane-stimulation
  - Magnetic field characteristics – strength, accuracy and homogeneity
- **3D Low field stimulation (geomagnetic)**
  - Probe card with 2 sets of dipole coils and ring coil
  - Dipole coils for in-plane-, ring coil for out-of-plane-stimulation
  - Magnetic field characteristics – strength, accuracy and homogeneity

XMR Sensors

Anisotropic Magneto Resistance | Giant Magneto Resistance | Tunnel Magneto Resistance

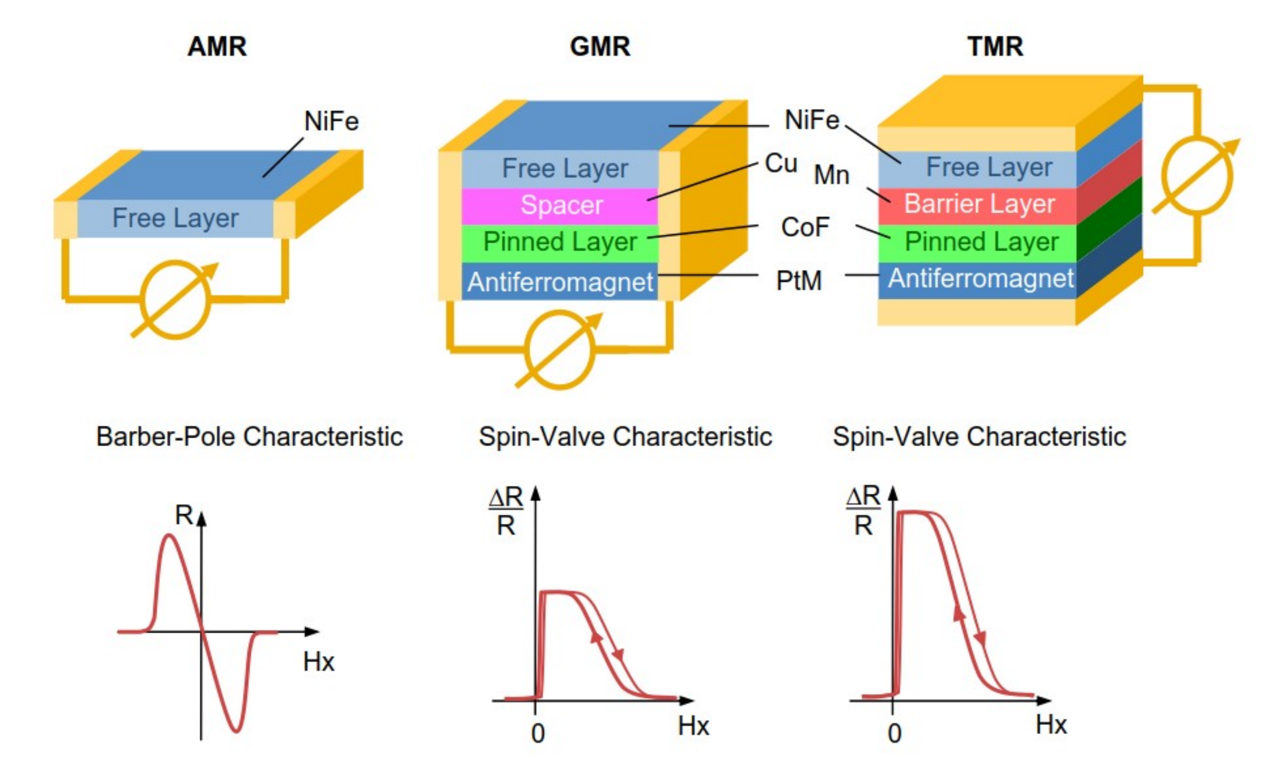


Image source: M.Meyer, Chances of XMR sensors in Automotive Applications, 11. MR-Symposium

Technology Comparison

Technology	Hall Effect	AMR	GMR	TMR
Power Consumption (mA)	5 ~ 20	1 ~ 10	1 ~ 10	0.001 ~ 0.01
Die Size (mm^2)	1 × 1	1 × 1	1 × 2	0.5 × 0.5
Field Sensitivity (mV/V/Oe)	~ 0.05	~ 1	~ 3	~ 100
Dynamic Range (Oe)	~ 10000	~ 10	~ 100	~ 1000
Resolution ($nT/Hz^{1/2}$)	>100	0.1 ~ 10	1 ~ 10	0.1 ~ 10
Temperature Performance (℃)	< 150	< 150	< 150	< 200

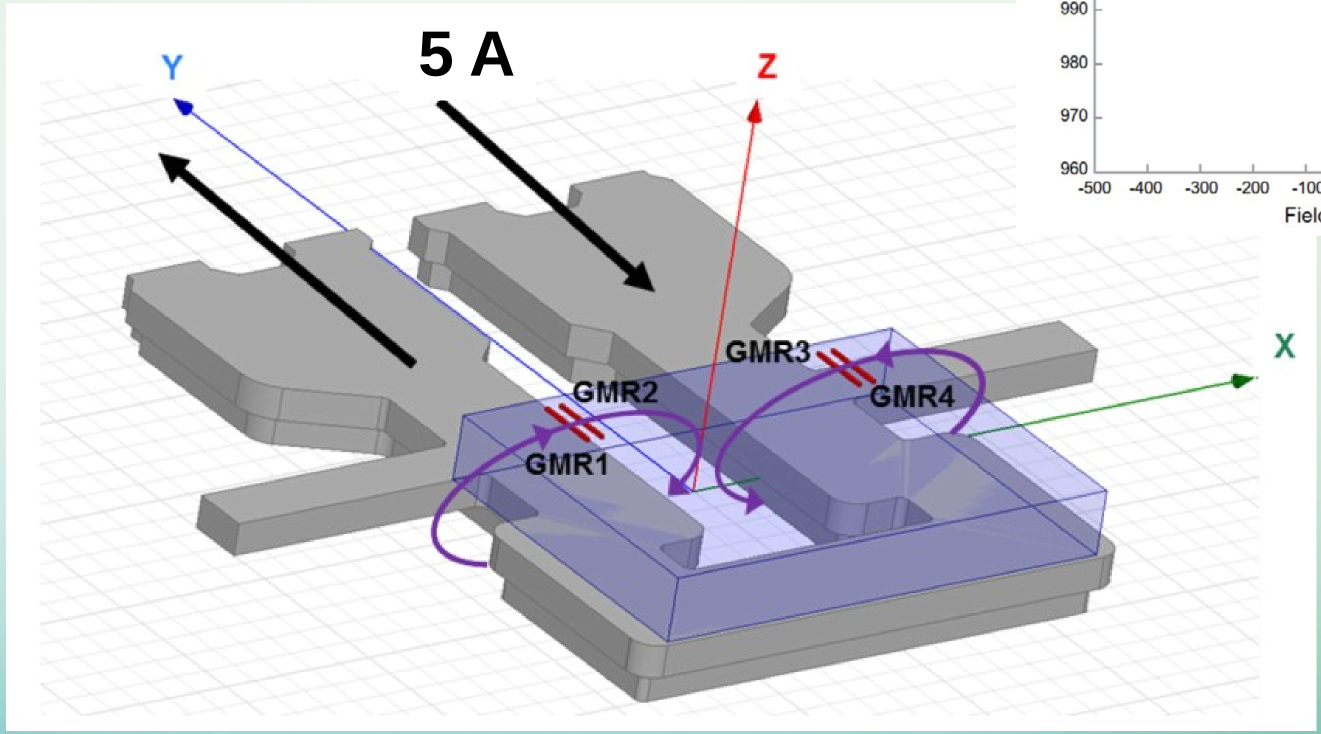
Image source: www.dowaytech.com

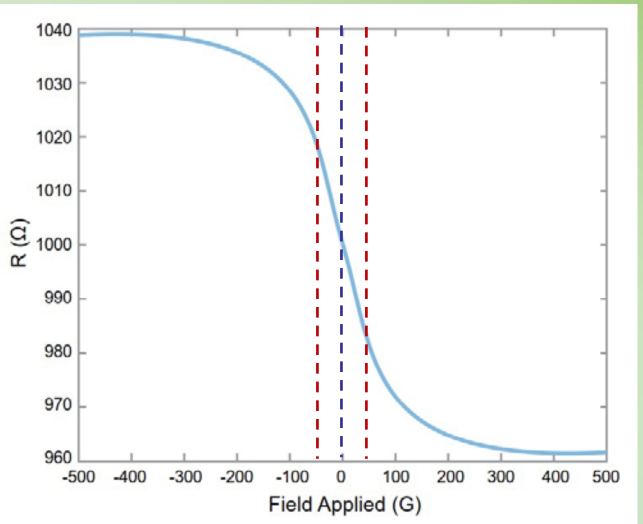
Timeline R&D

XMR Sensors

GMR example

- Application: current sensor
- Current range: 5 A
- Field range: +/- 5 mT
- Supply: 3.3 V

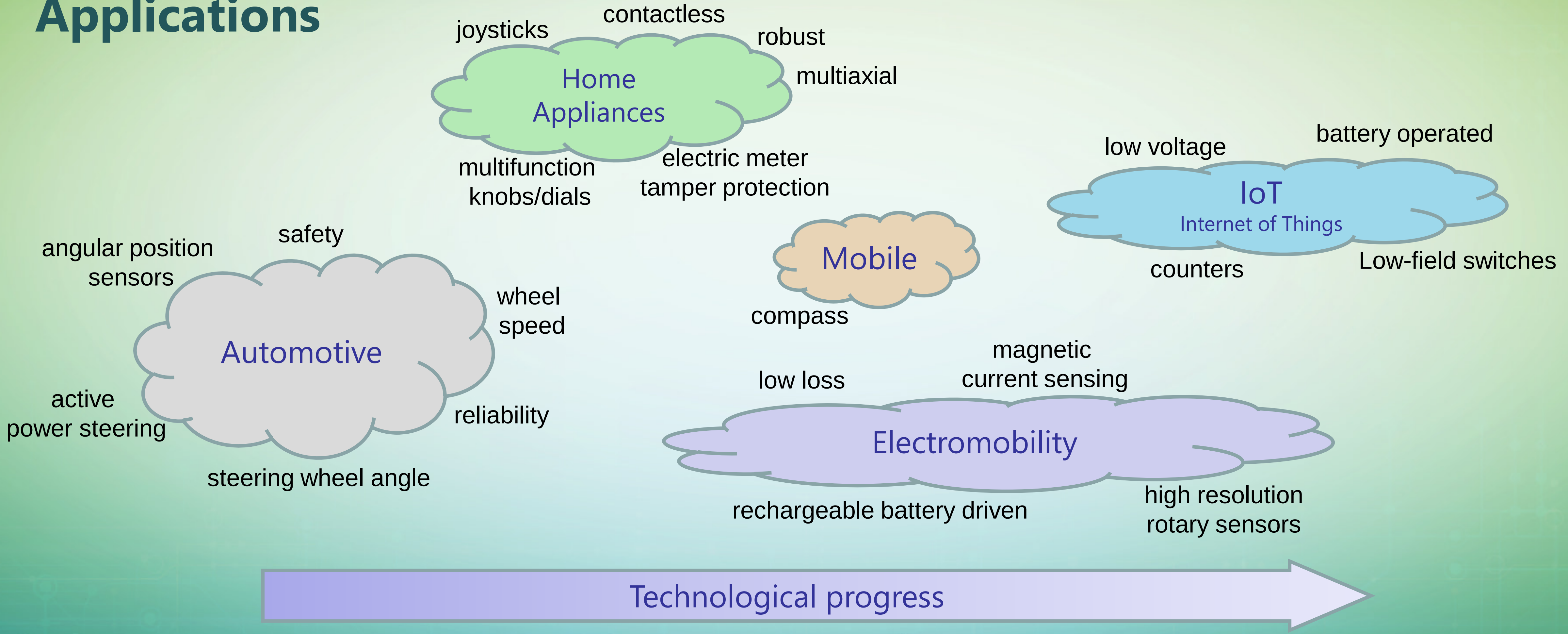




Images source: www.allegromicro.com datasheet

XMR Sensors

Applications



Field Strength Range

For air: $\vec{B} = \mu \cdot \vec{H}$

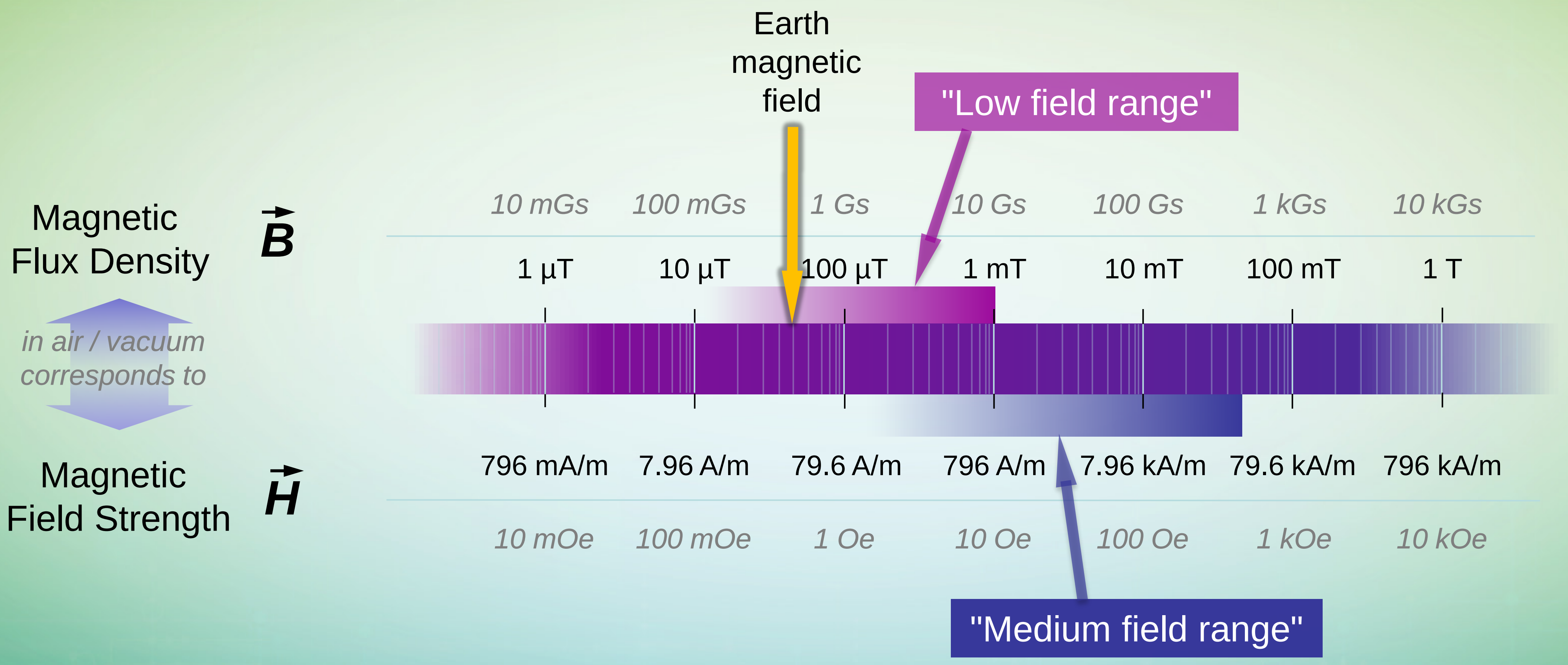
$\mu = \mu_r \cdot \mu_0$
$\mu_r = 1.0000004 \approx 1$
$\mu_0 = 4\pi \cdot 10^{-7} Vs/Am$

	10 mGs	*100 mGs*	*1 Gs*	*10 Gs*	*100 Gs*	*1 kGs*	*10 kGs*
Magnetic Flux Density $\vec{B}$	1 µT	10 µT	100 µT	1 mT	10 mT	100 mT	1 T
Magnetic Field Strength $\vec{H}$	796 mA/m	7.96 A/m	79.6 A/m	796 A/m	7.96 kA/m	79.6 kA/m	796 kA/m
	10 mOe	*100 mOe*	*1 Oe*	*10 Oe*	*100 Oe*	*1 kOe*	*10 kOe*

in air / vacuum corresponds to

CGS / Gaussian units for reference only (deprecated)

Stimulation Ranges

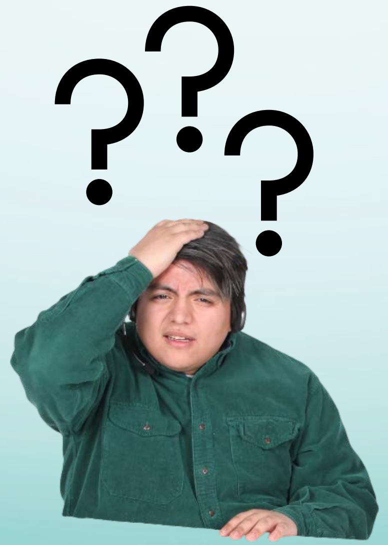


3D Magnetic wafer probing

"Global field" approach

Wafer prober

Image source: www.accretech.eu



Helmholtz coil

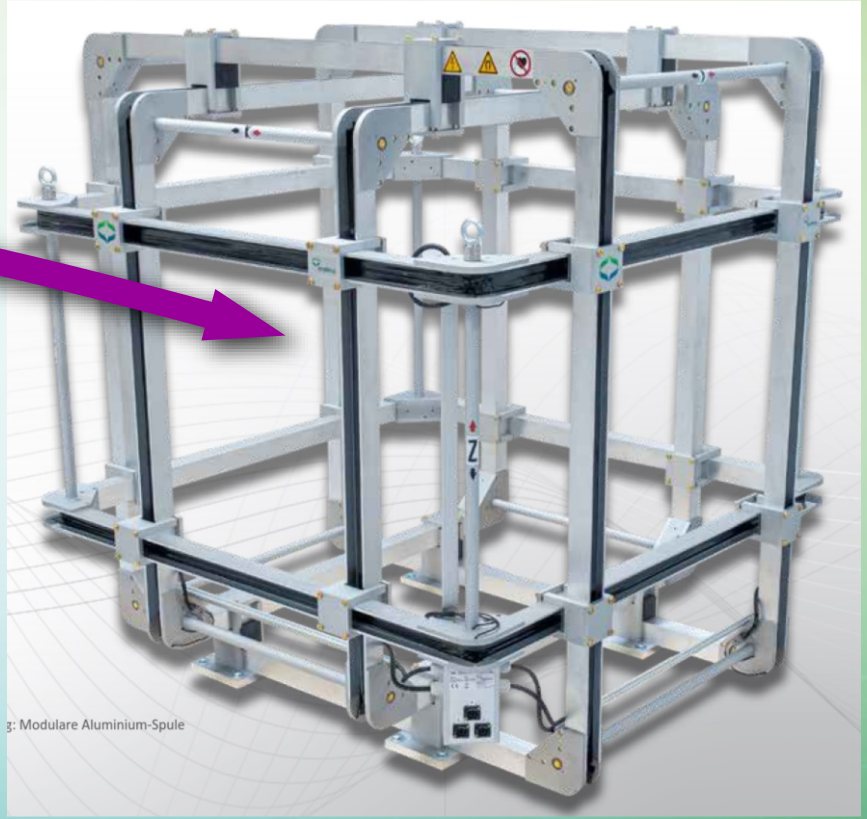


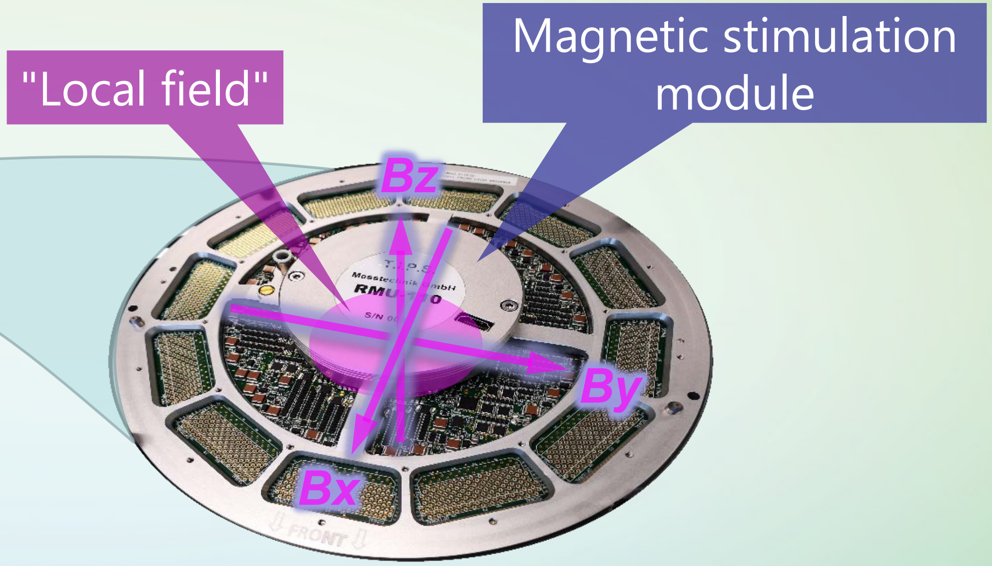
Image source: www.matesy.de

3D Magnetic wafer probing

"Local field" approach

Image source: www.accretech.eu

"Standard" wafer prober
(non-magnetic chuck)

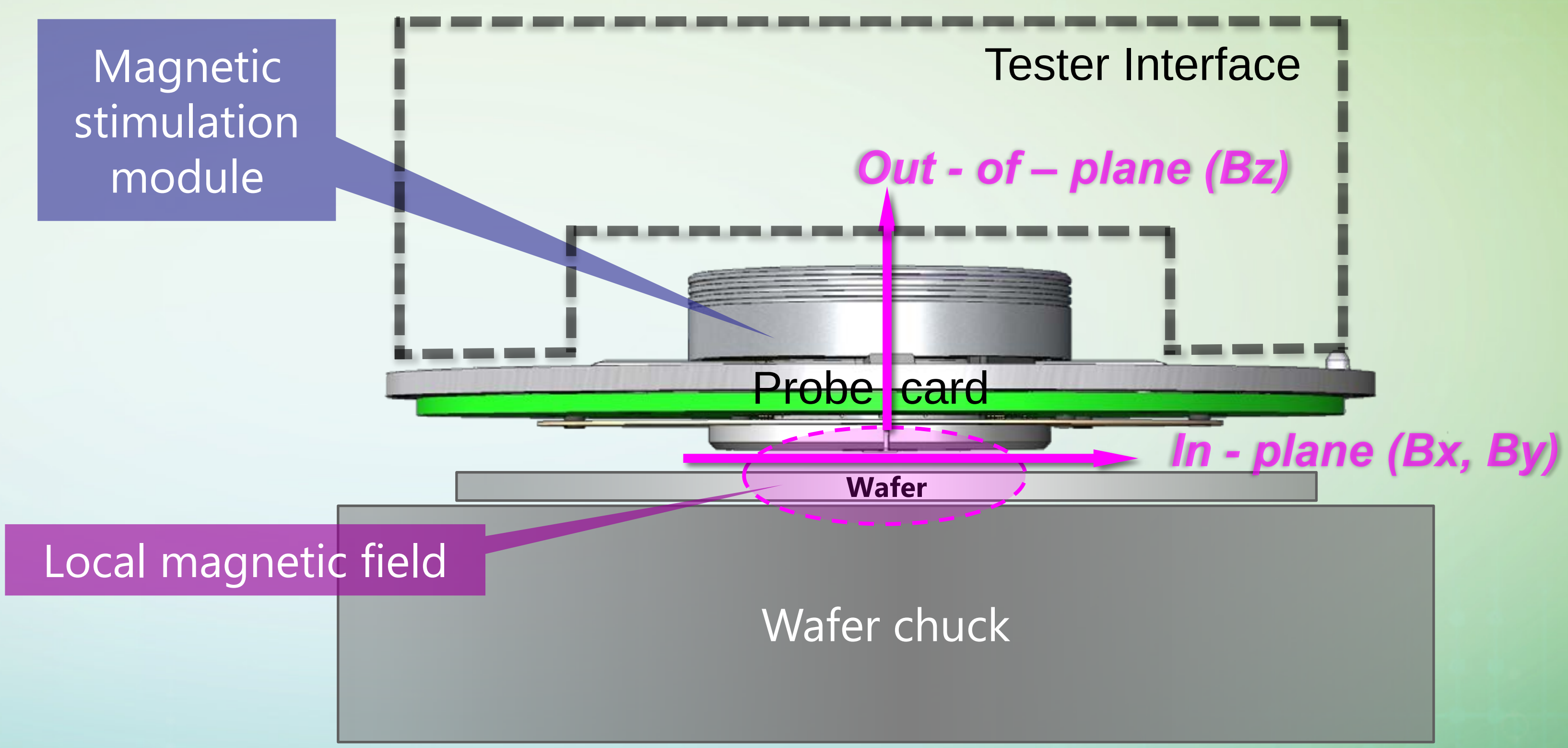


"Standard" format probe card
(non-magnetic components)

3D Magnetic wafer probing

Constraints

- one-sided access
- tester interface
- probe head
- test temperature



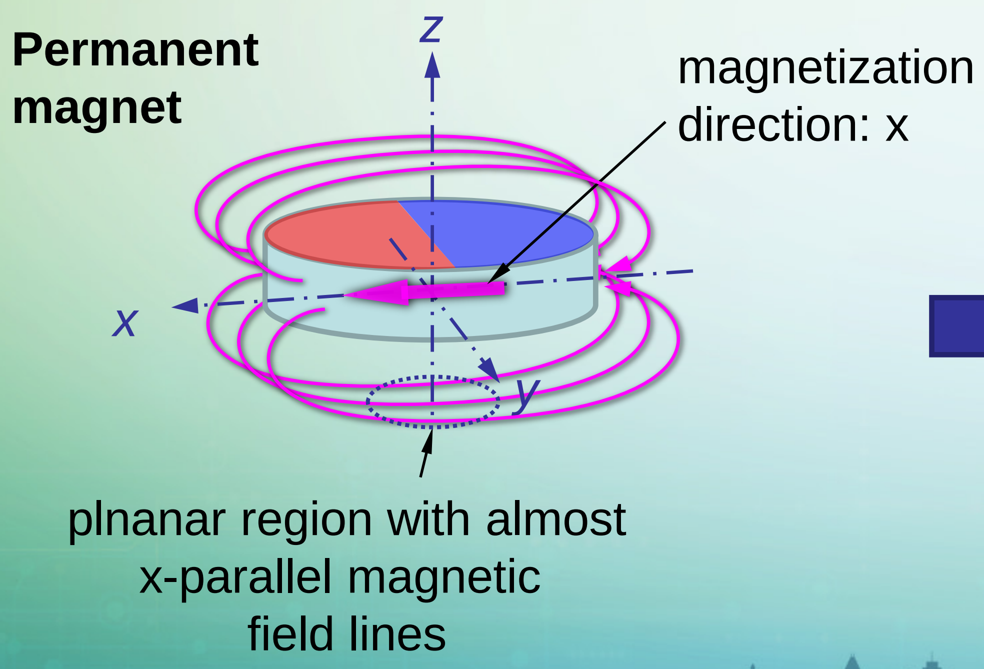
3D Medium Field Stimulation

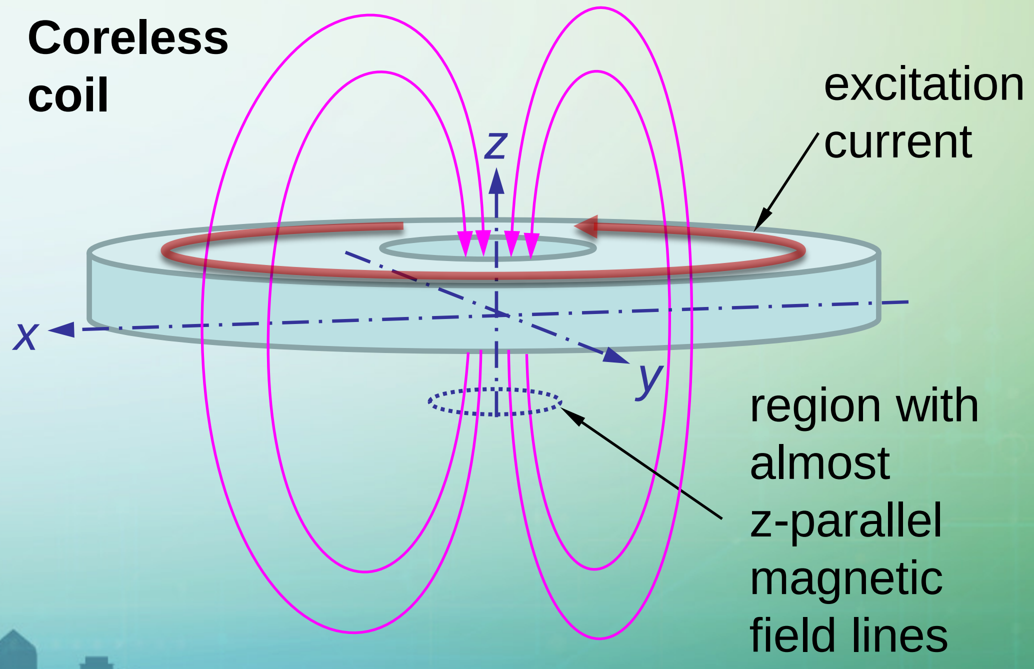
Concept

- **Superposition: linear addition of two magnetic fields**

In – plane stimulation

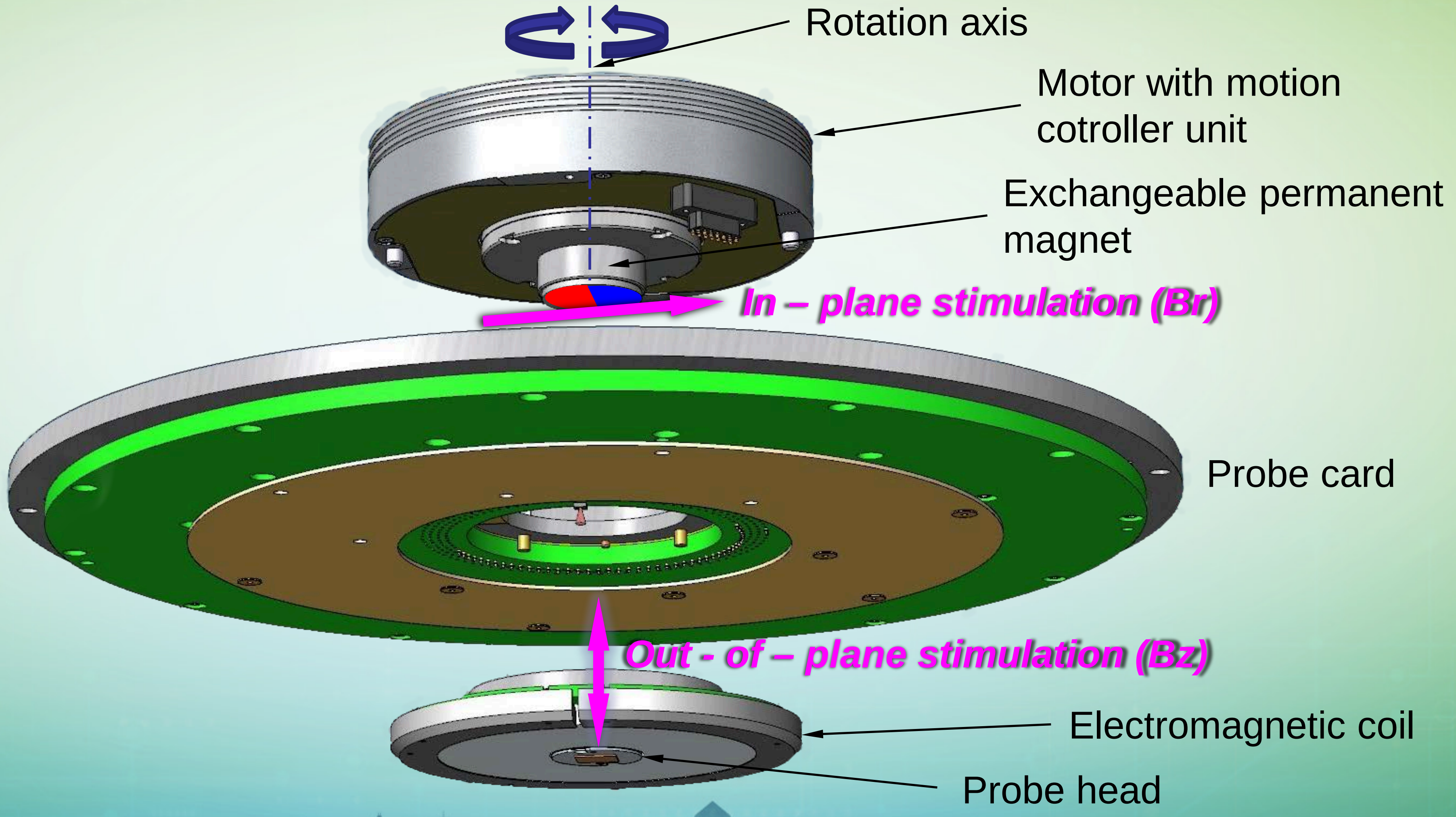
Out - of – plane stimulation





3D Medium Field Stimulation

Solution



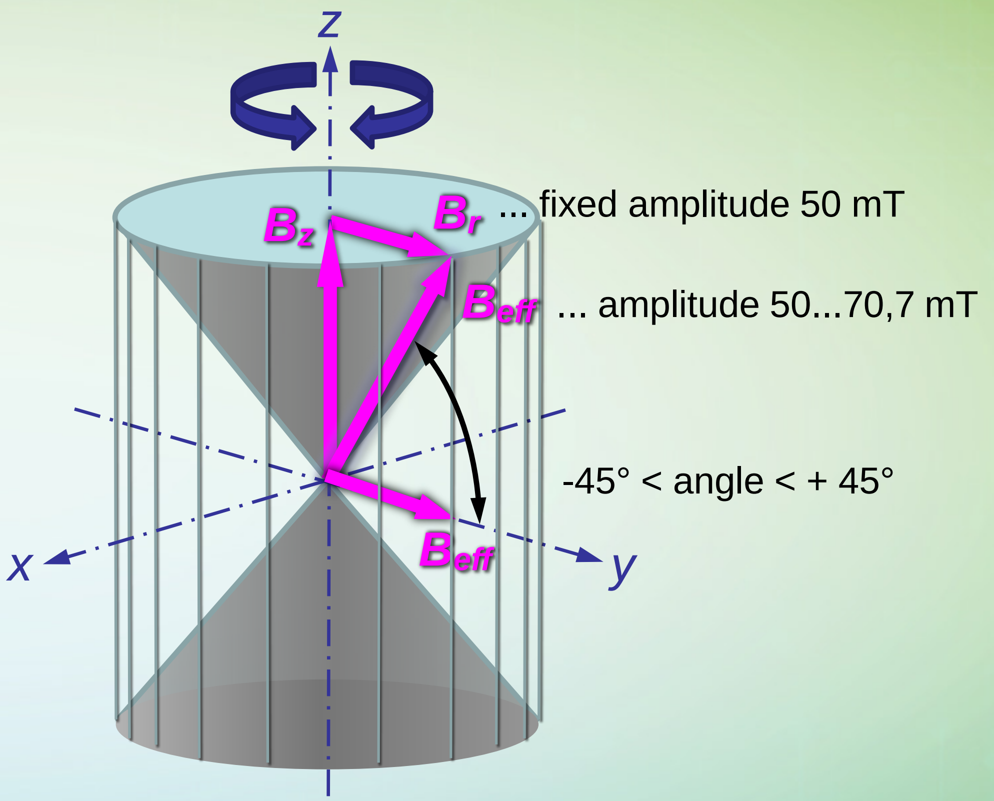
3D Medium Field Stimulation

Effective field directions

- Bx and By coupled
- Bz independent

Effective strengths

- Amplitude Br fixed 50 mT
- Amplitude Bx, By coupled
- Bz variable -50 mT … +50 mT



3D Medium Field Stimulation

Rotary unit specifications

- angular position repeatability 0.02°
- min. continuous speed 60 rpm
- max. continuous speed 2000 rpm
- exchangeable permanent magnets for 10 ... 50 mT

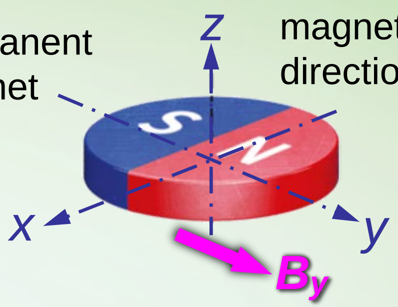
Coil specifications

- Coreless aluminium ribbon coil
- Power dissipation 38W at 50 mT / 10% duty cycle

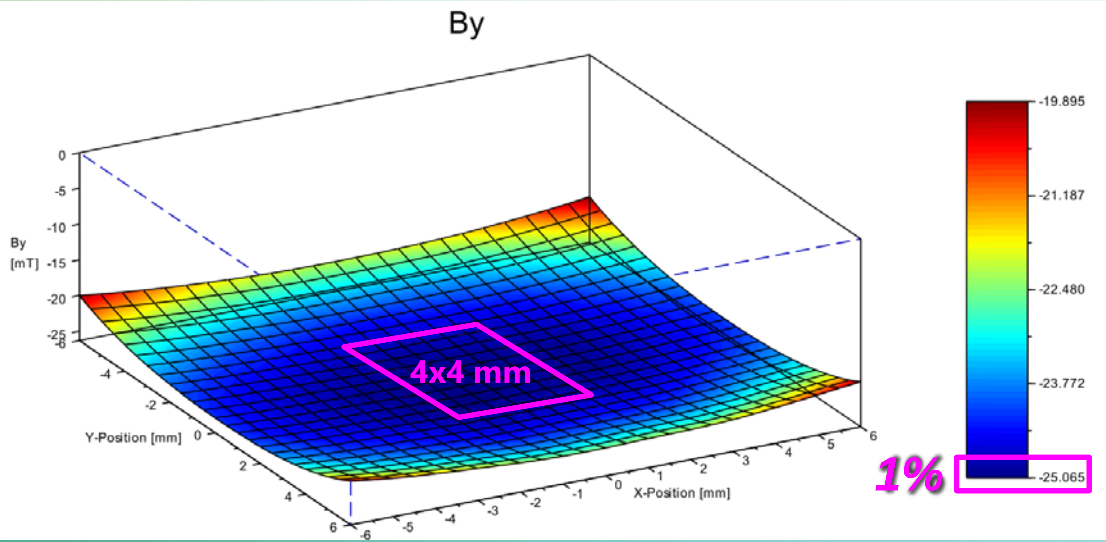
3D Medium Field Stimulation

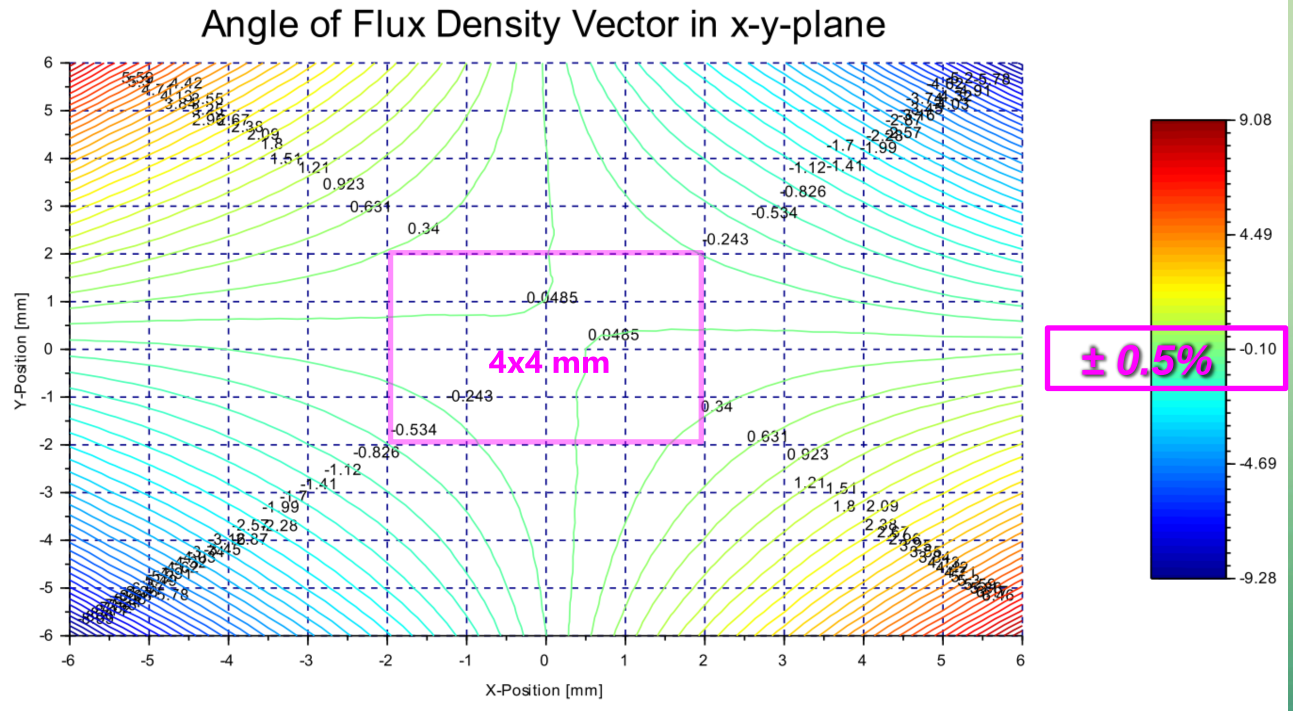
Magnet field uniformity

- for multisite testing
- measured with hi-res 3D magnetic scanner
- measured in wafer plane



Variation of y-component of magnetic flux density

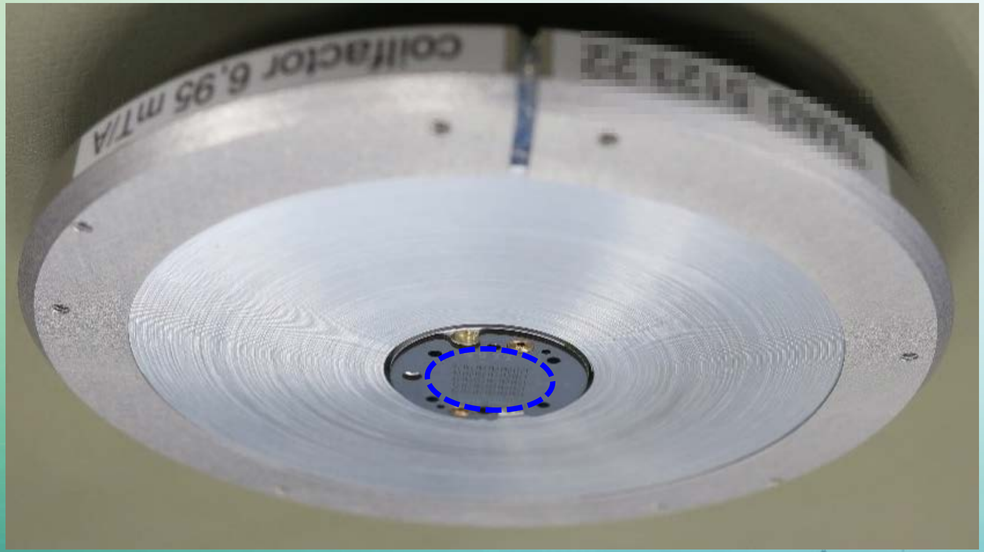




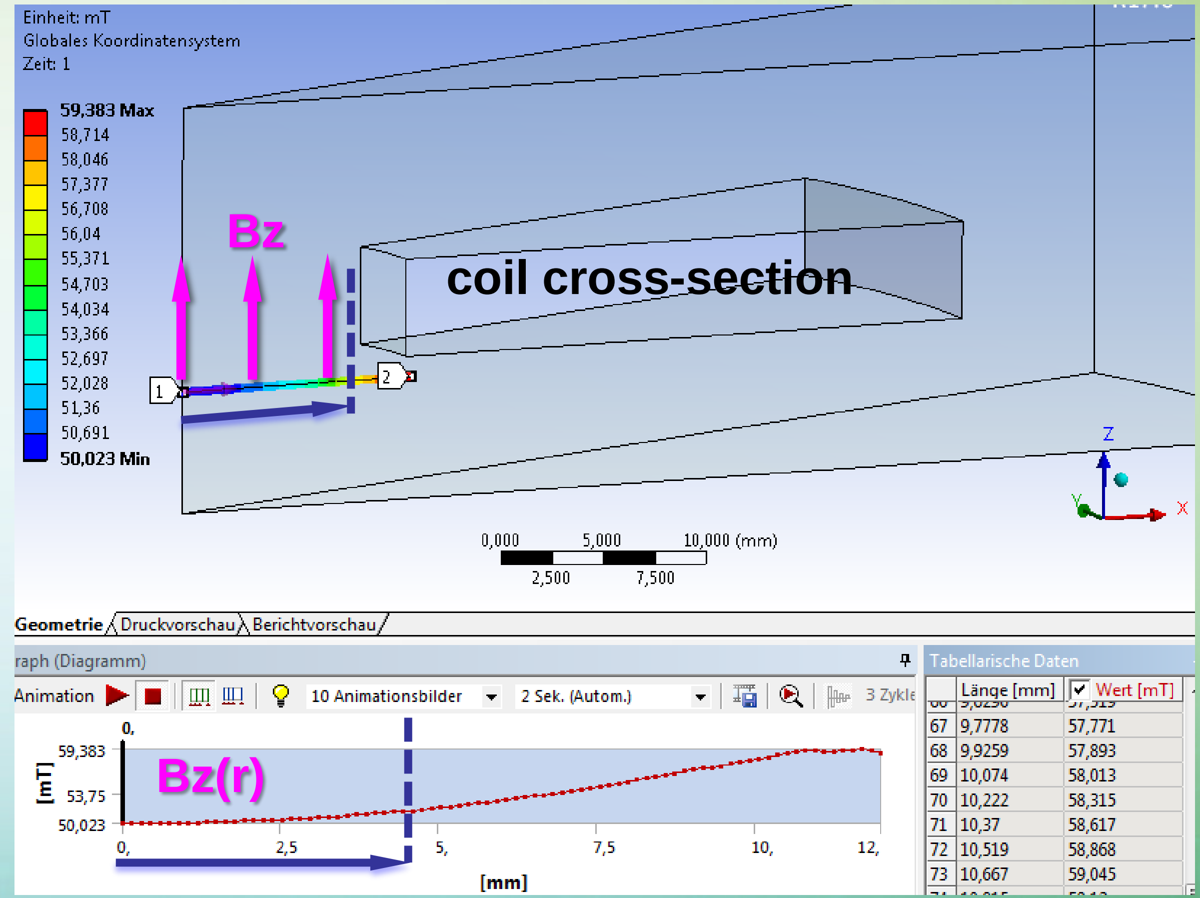
3D Medium Field Stimulation

Magnet field uniformity

- for multisite testing
- calculated with FEM
- verified with Gaussmeter
- max deviation 1.5 mT (3%)



FEM simulation (rotational symmetry)



3D Medium Field Stimulation

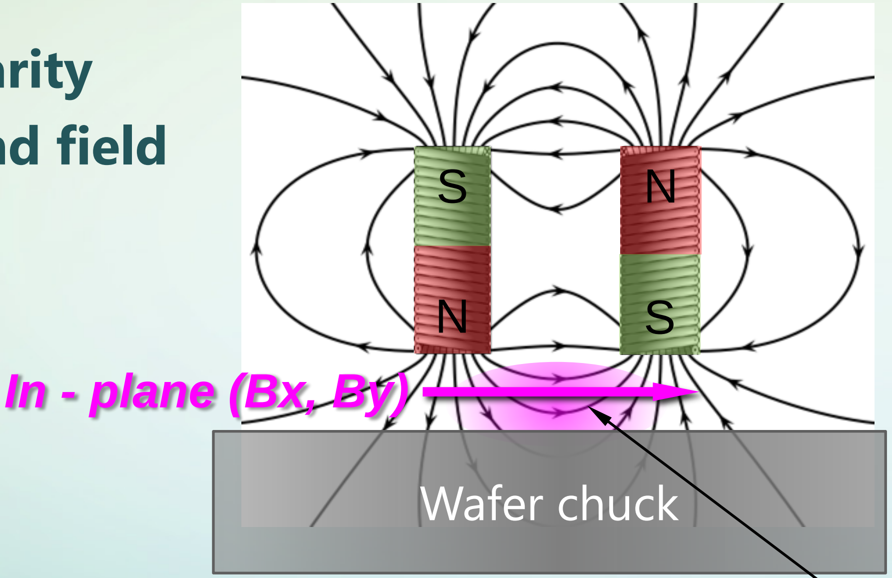
Conclusion

- almost full "3D" stimulation
- 50 mT sufficient to drive many sensors in saturation
- currently only solution without hysteresis
- high precision
- high speed (rotation)
- compact size – 50mm height

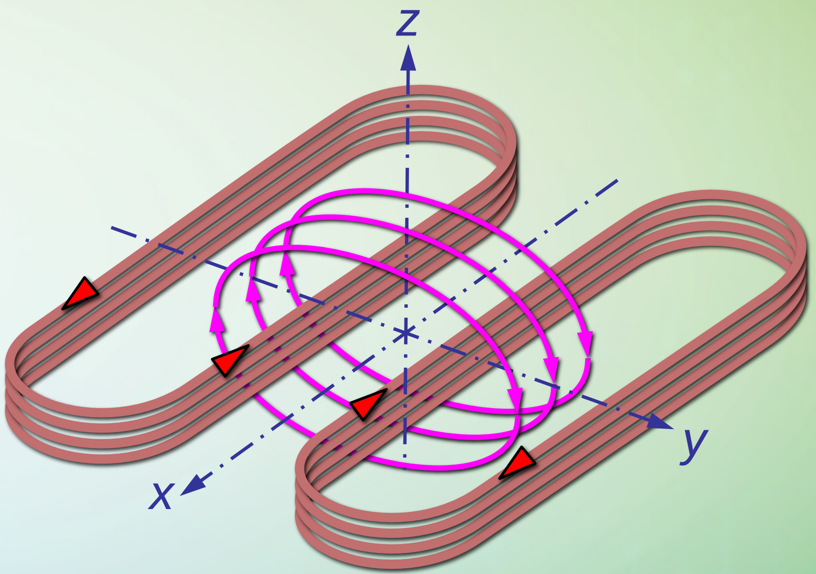
Dipole coil field

Principle

- coil pair
- antisymmetric polarity
- "oval coil" to extend field



region with almost wafer-parallel magnetic field lines

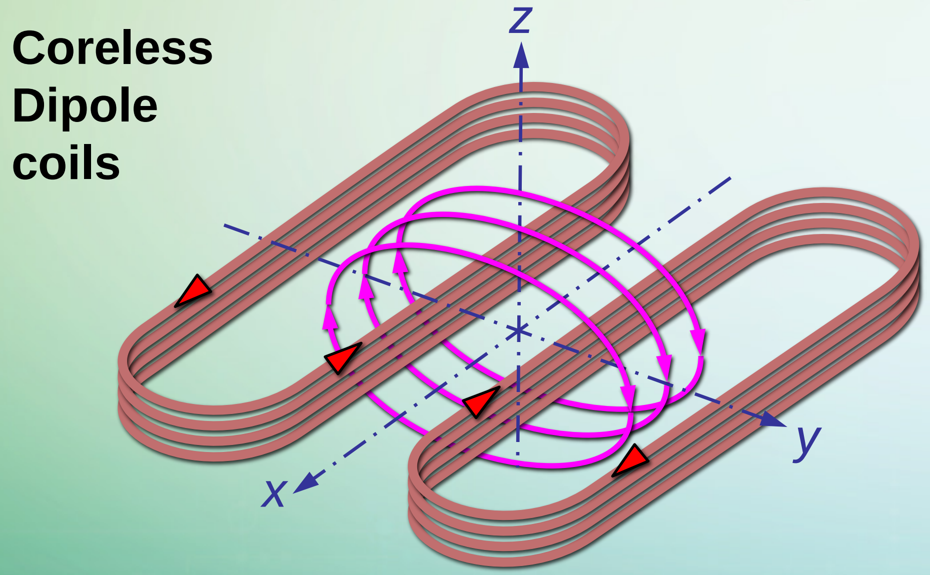


3D Low Field Stimulation

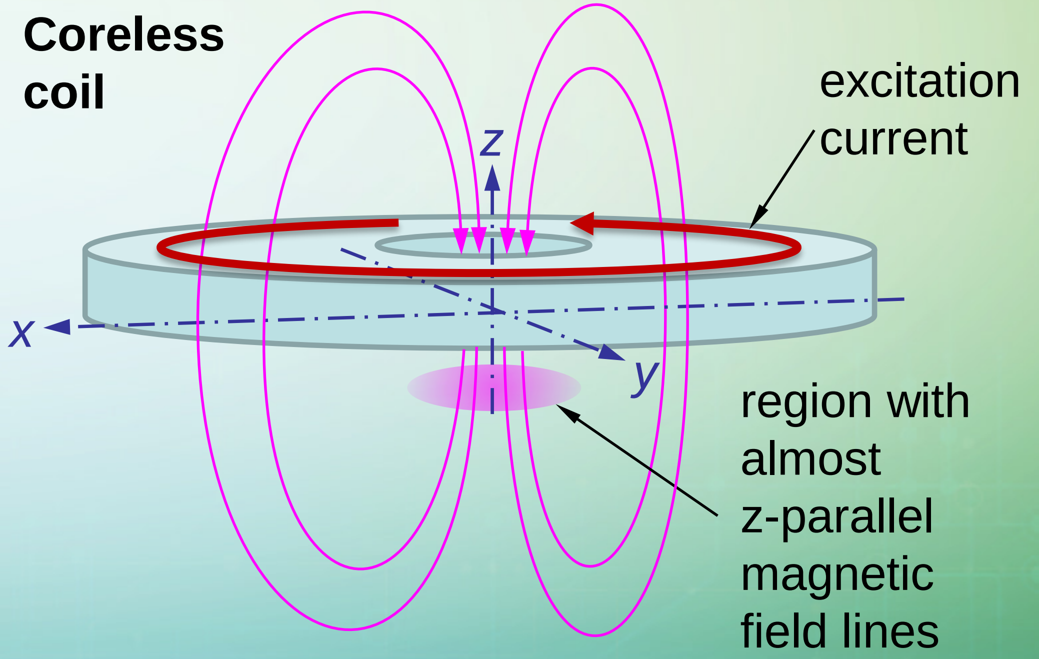
Concept

- **Superposition: linear addition of three magnetic fields**

In – plane stimulation : By



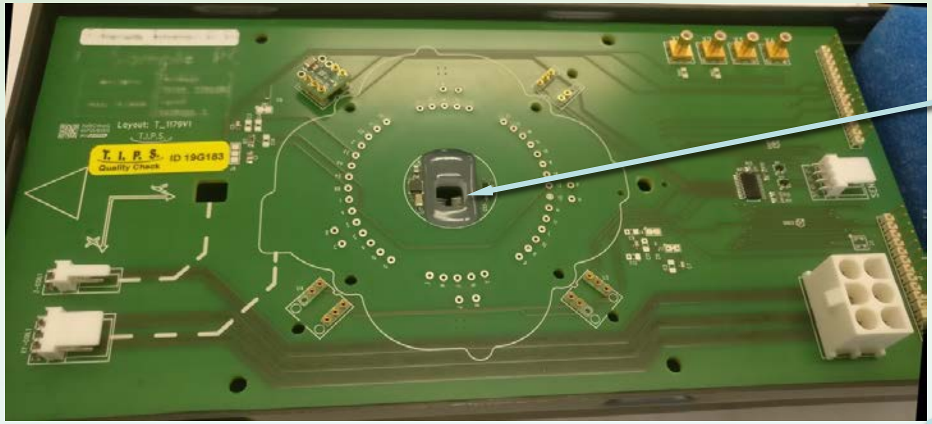
Out - of – plane stimulation



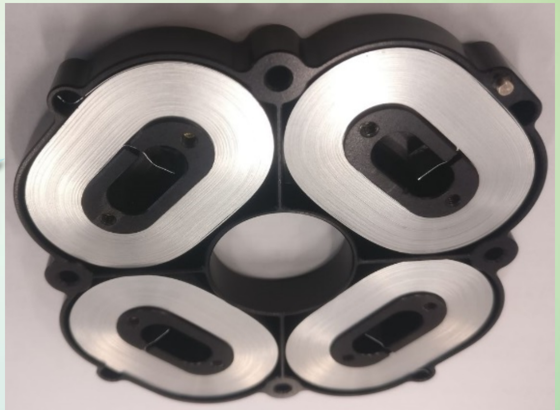
3D Low Field Stimulation

Solution

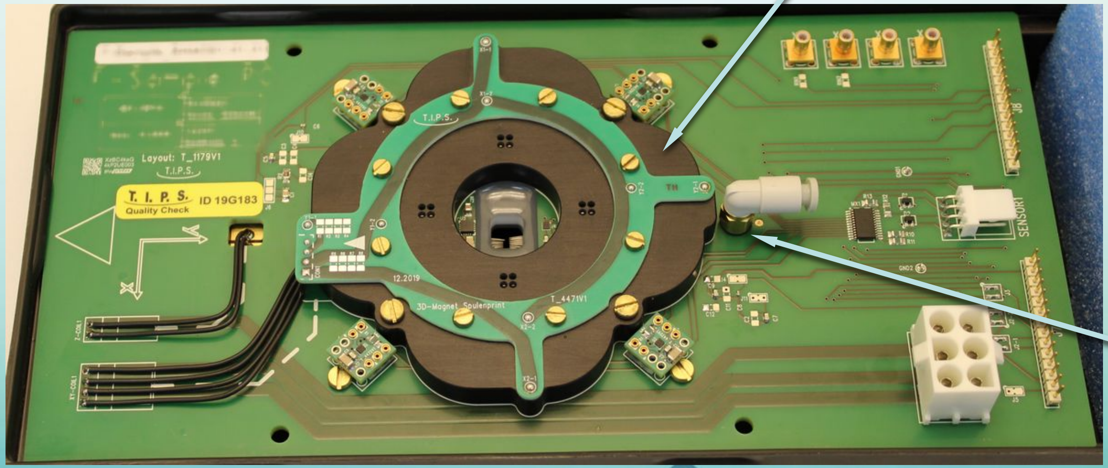
4.5" probe card



cantilever probes



X-Y-coil module



X-Y-coil module
(bottom view)

Z-coil module on
bottom of PCB

3D Low Field Stimulation

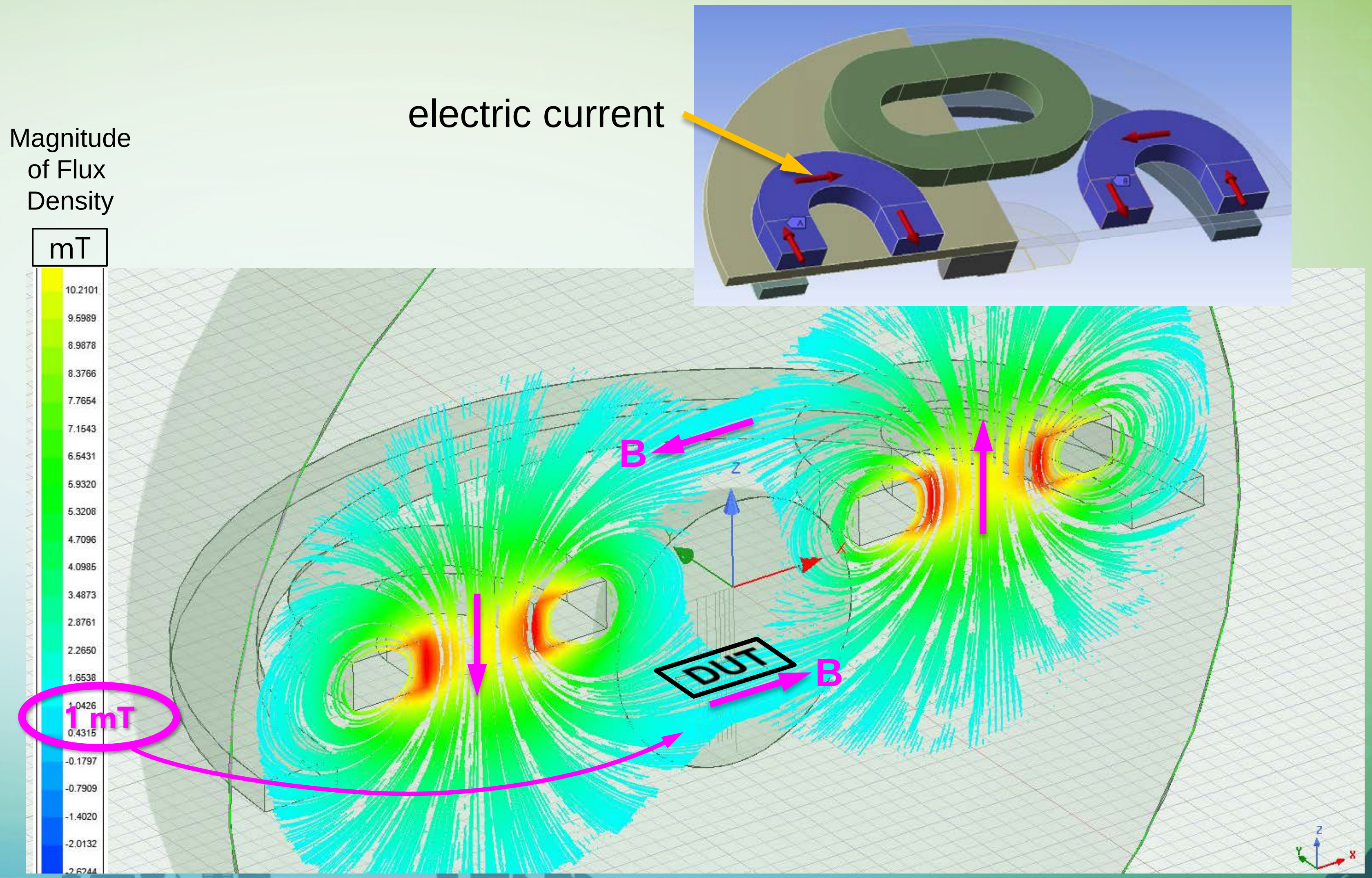
Features and Specification

- All axes independent from each other
- Fully linear system – no hysteresis
- Fields directly proportional to applied coil currents
- Target flux density ± 1 mT per axis
- Active air cooling with CDA necessary

3D Low Field Stimulation

FEM simulation dipole

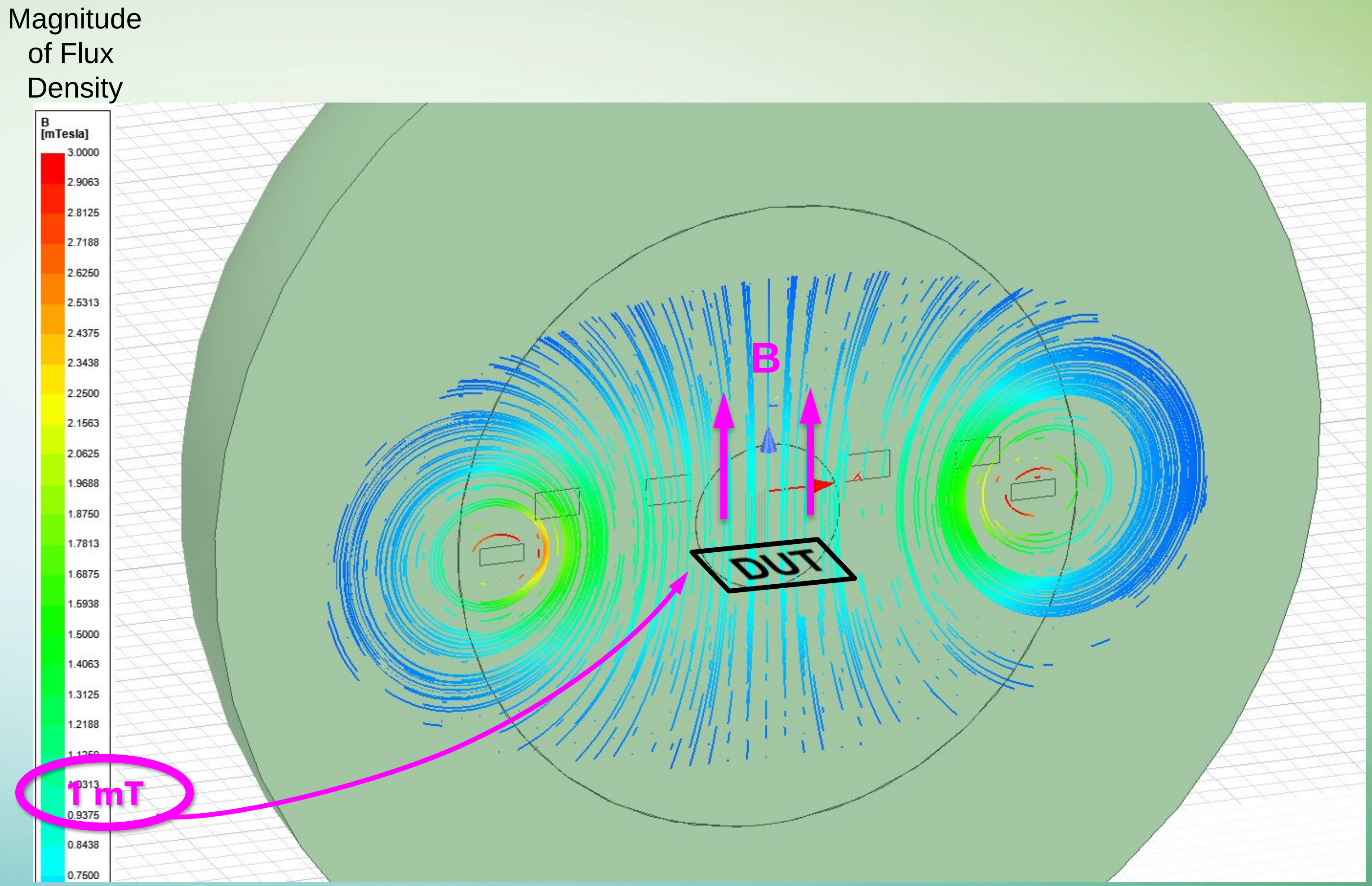
- used for dimensioning
- required flux density 1 mT
- given vertical stackup
- find coil geometry / excitation current



3D Low Field Stimulation

FEM simulation z-coil

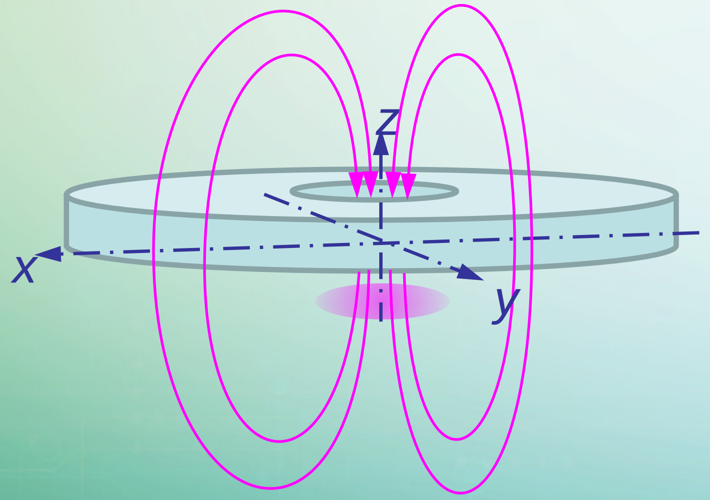
- used for dimensioning
- required flux density 1 mT
- given vertical stackup
- find coil geometry / excitation current

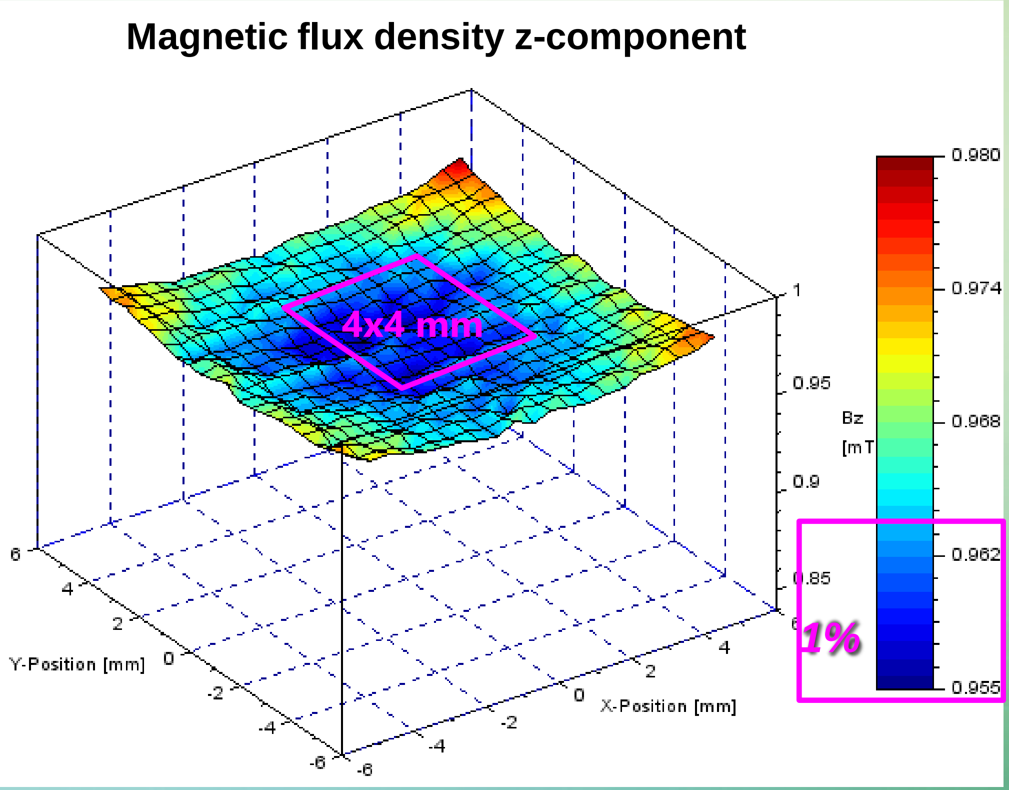


3D Low Field Stimulation

Magnet field uniformity

- measured with hi-res 3D magetic scanner
- measured in wafer plane
- only z-coil powered

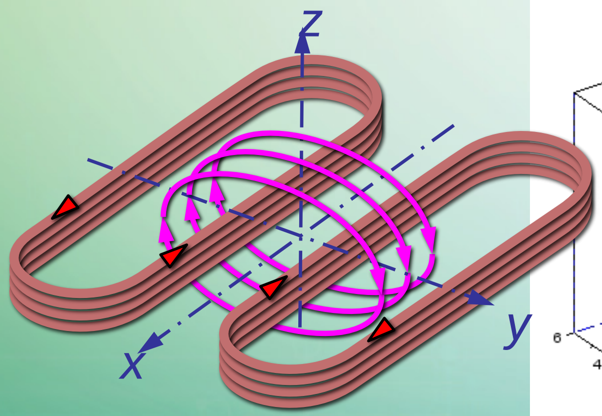


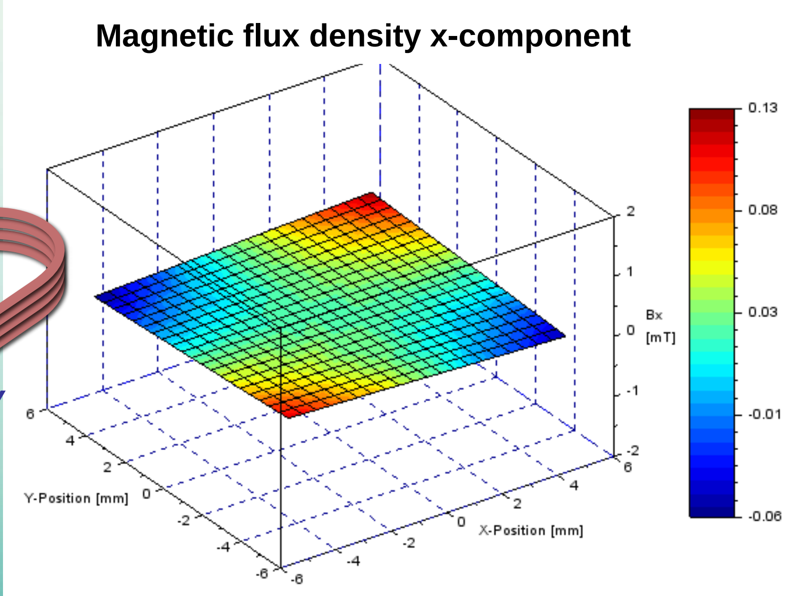


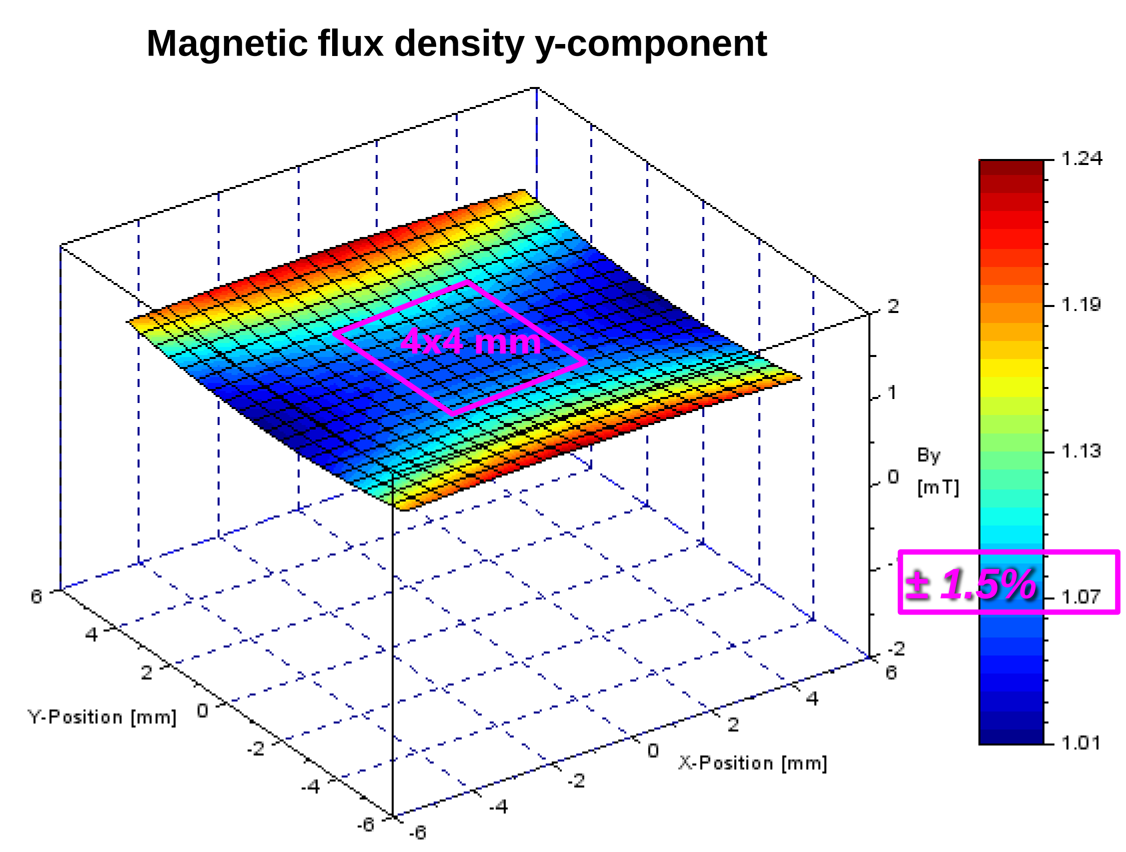
3D Low Field Stimulation

Magnet field uniformity

- measured with hi-res 3D magetic scanner
- measured in wafer plane
- only one dipole powered: "Y" makes By= 1mT







3D Low Field Stimulation

Conclusion

- Design optimized by FEM for best field uniformity
- Precision aluminium ribbon coils
- Modular design for easy probe card integration
- Very compact size

Contact Information

In case of questions or for additional information please conatct:

Mr. Georg FRANZ

T.I.P.S. Messtechnik GmbH

g.franz@tips.co.at

+43 4242 319 720 19