Magnetic Testing - Wafer probing with 3D magnetic stimulation

Technical Innovation Physical Solution

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Introduction

XMR technology

Sensor devices based on magneto-resistive technology have evolved to always higher sensitvity. At the same time power consumption has significantly decreased, enabling many new applications like sensors for the IoT.

Sensing elements can be arranged to measure the magnetic field in 1, 2 or even 3 perpendicular directions on a single die.

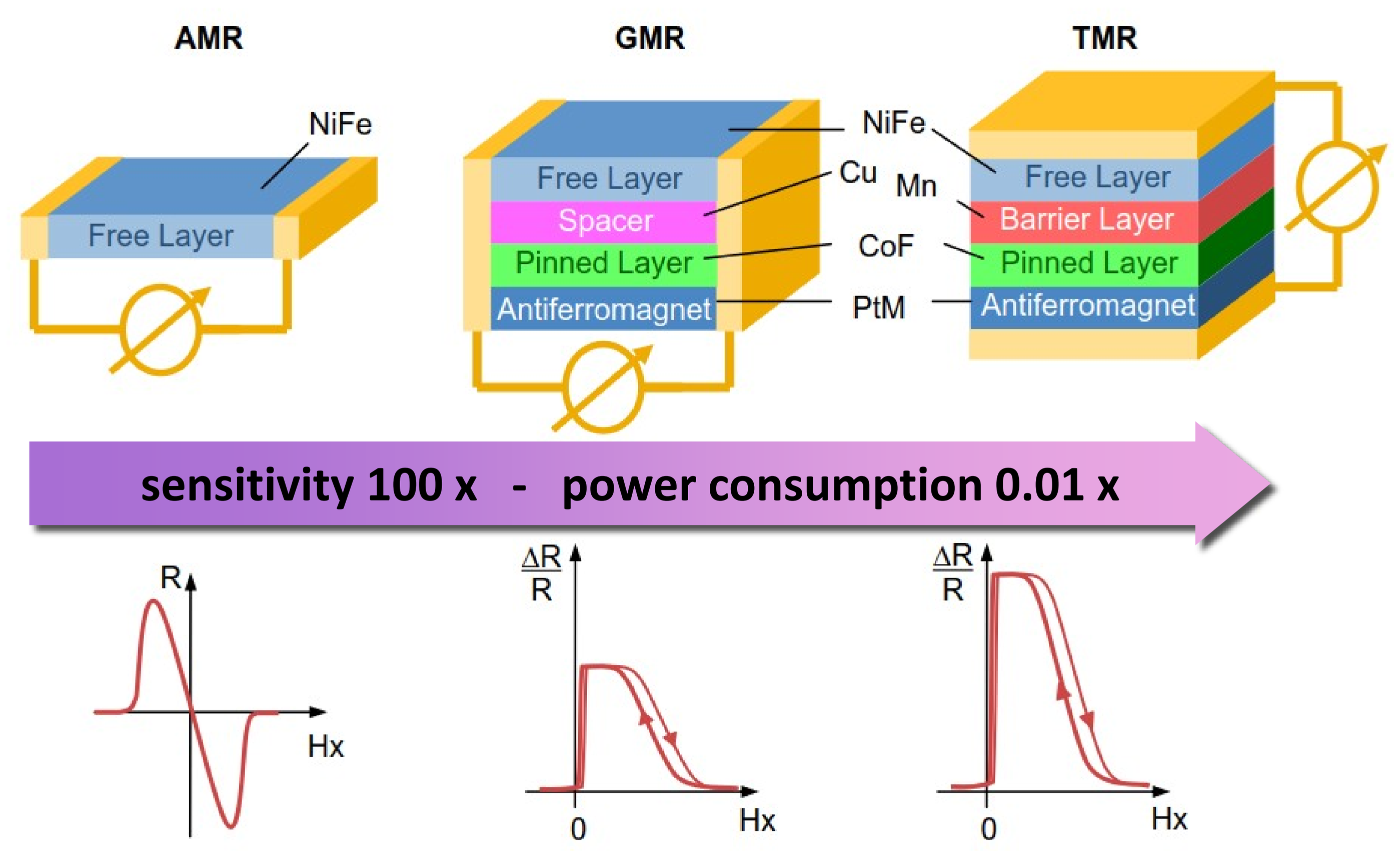
Applications

- low loss current sensing
- contactless position / angle sensing
- position & direction relative to earth magnetic field

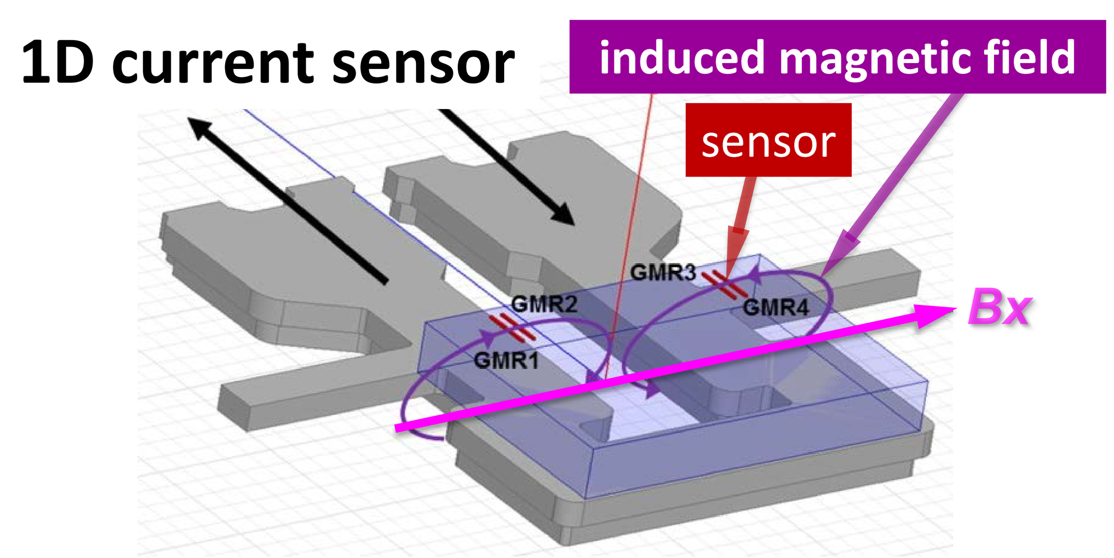
just to name a few

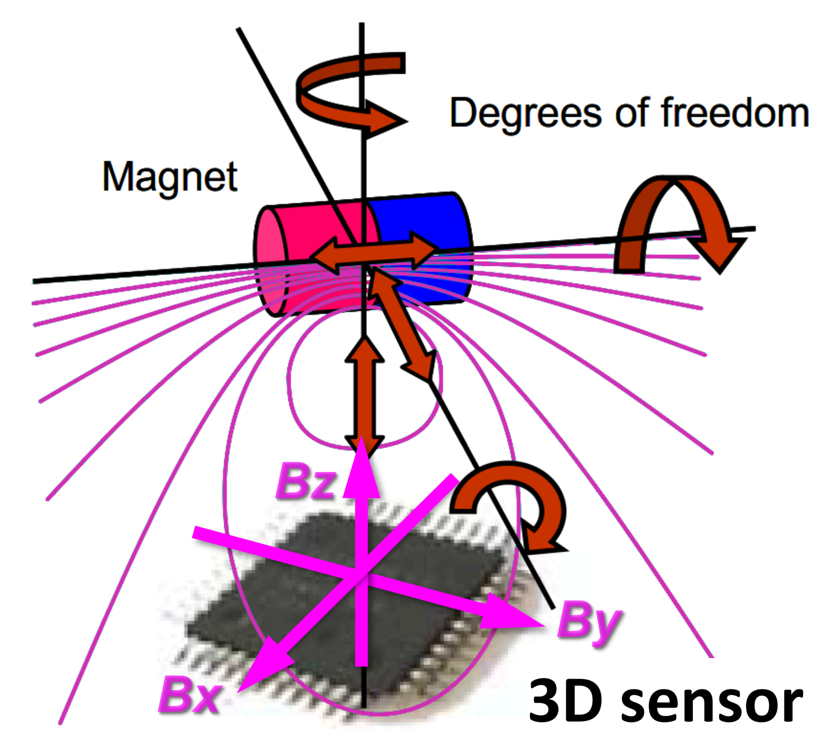
Motivation

These low-cost devices for the mass market require the move away from package test towards more cost-effective wafer sort.



» more applications
» mass production
» cost reduction
» **wafer test**



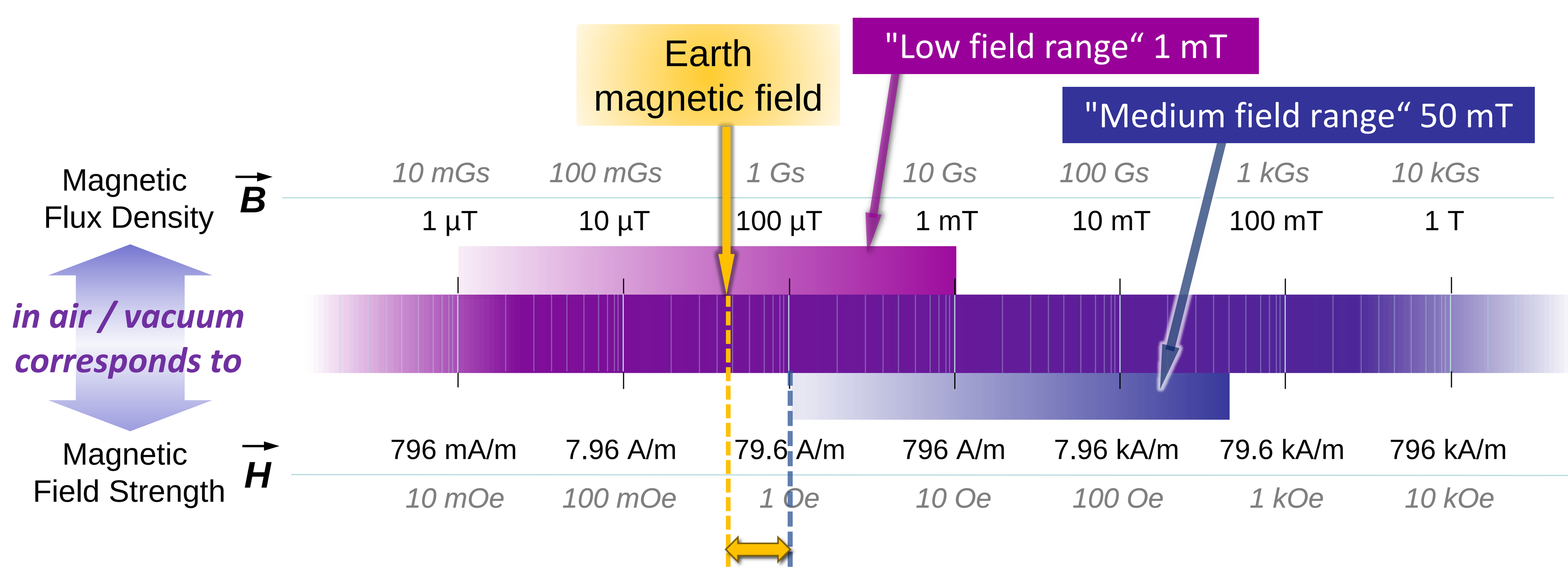


Magnetic Stimulation

How strong?

Sensors designed for the earth magnetic field can be tested with a field up to 1mT ("low field").

Sensors designed for permanent magnets see stronger fields up to 50 mT ("medium field"), where the whole range is well above the earth magnetic field to avoid interference.



Method

Global field

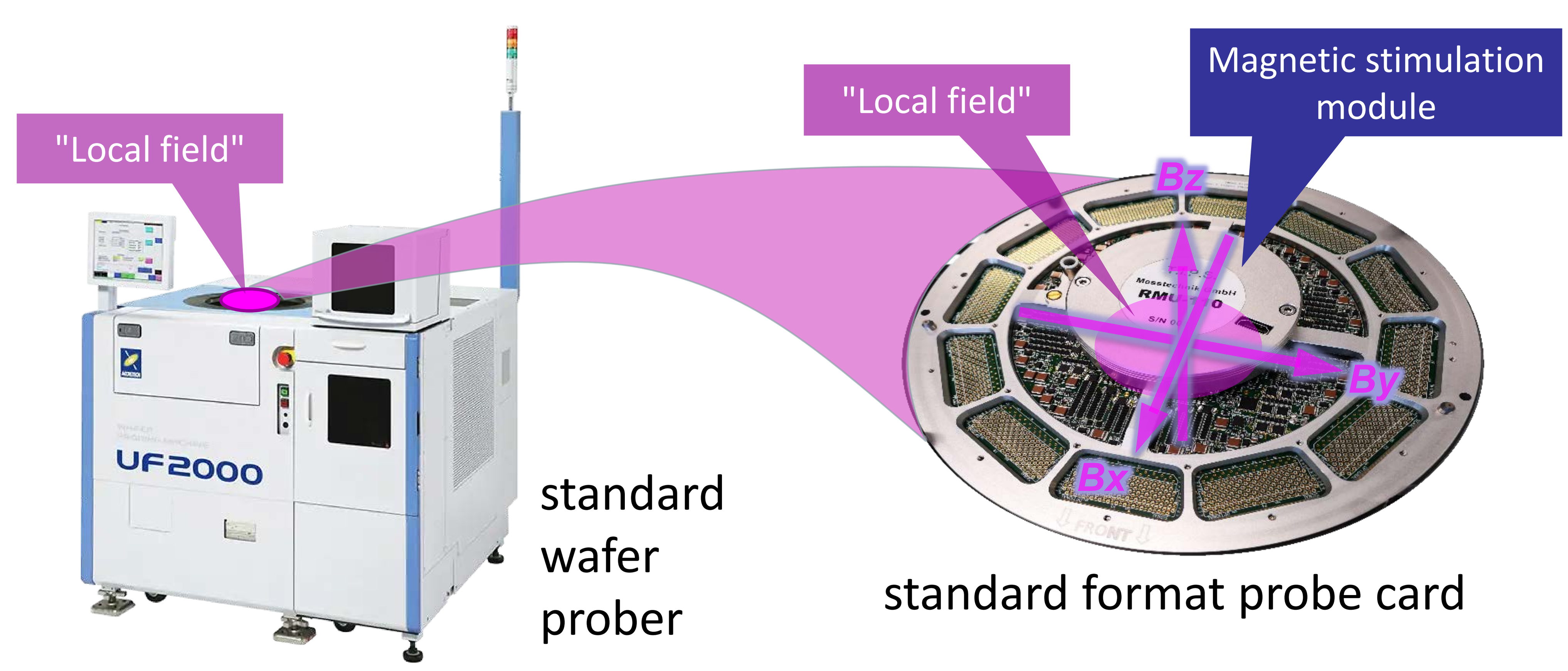
Applying a magnetic field by external coils would require huge coils and very special non-magnetic tester & prober hardware. Such solutions exist, however they are bulky, quite pricey and everything but standard hardware found on test floors!

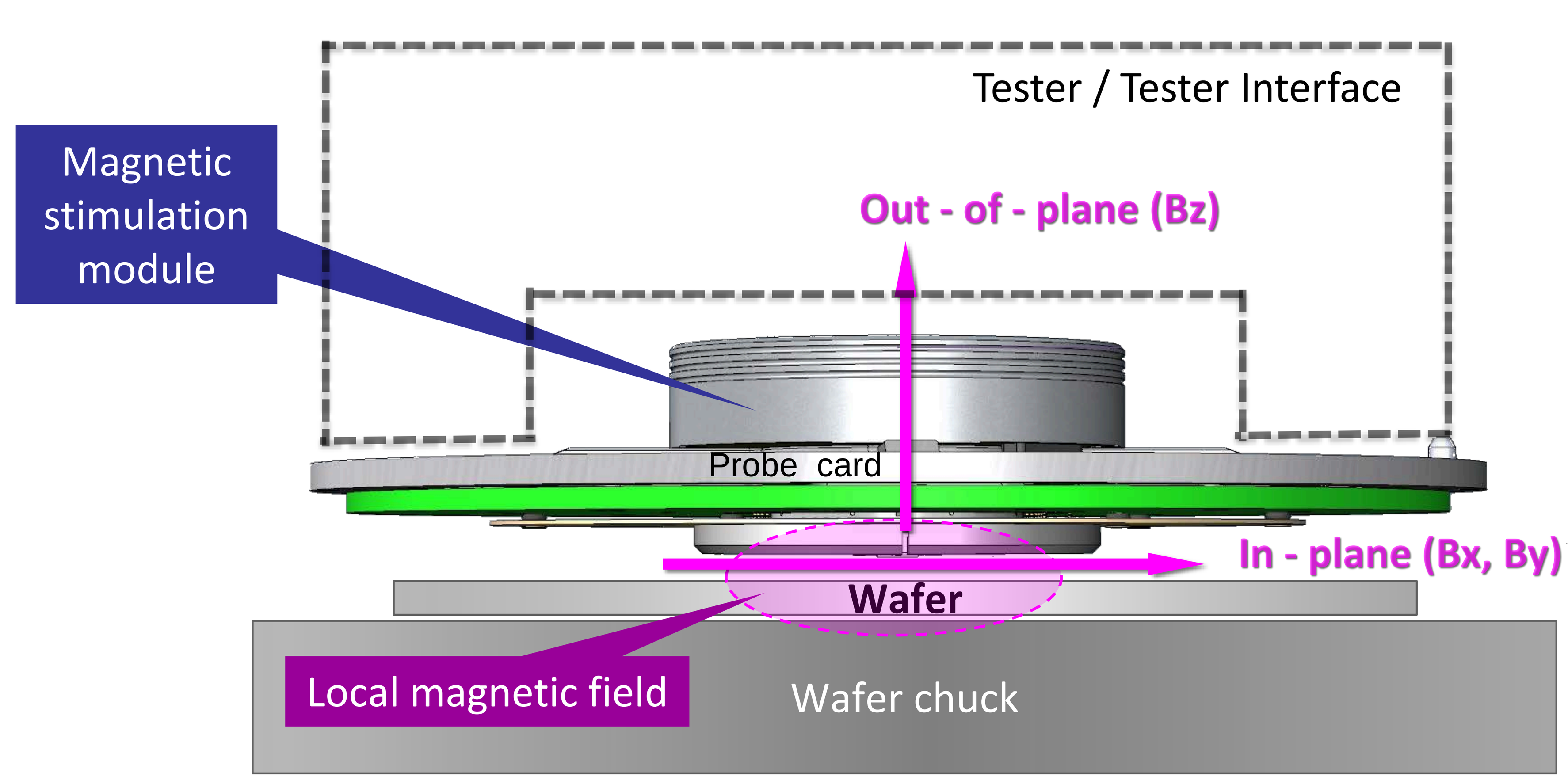
Local field

To keep cost down for volume production, almost standard hardware needs to be used. Therefore a small local magnetic field generated by the probe card is proposed.

This local field has a short range and requires only components in close proximity to be non-magnetic. These are mainly the wafer chuck, the probe card and parts of the tester interface.

This approach does not allow to enclose the device under test in a magnetic shield so the earth magnetic field is always present.





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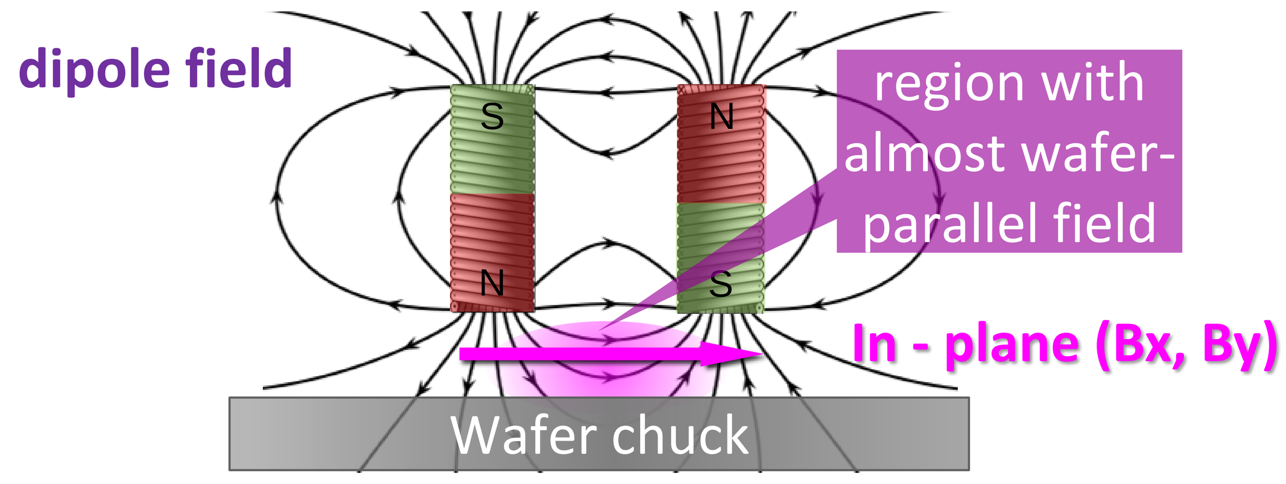
3D low field equipment

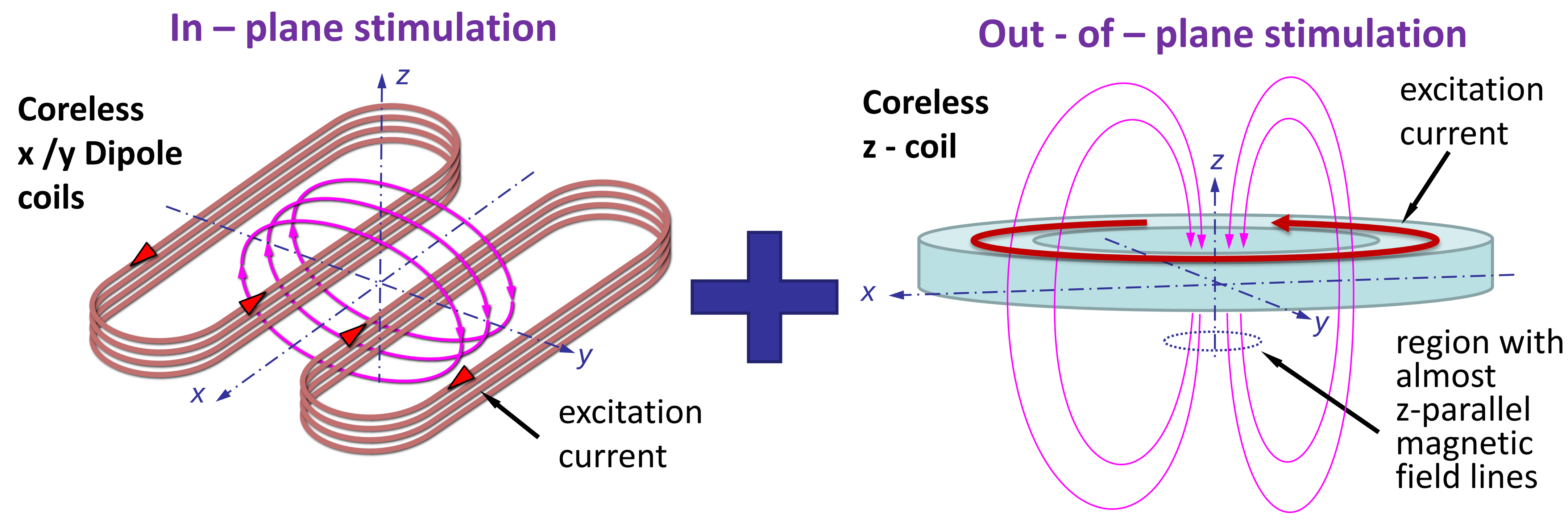
Stimulation concept

Under the given space constraints an antisymmetric coil pair ("dipole") was introduced to generate an in-plane field vector.

Together with a second, perpendicular dipole and a circular coil for out-of-plane all 3 axes can be excited independently.

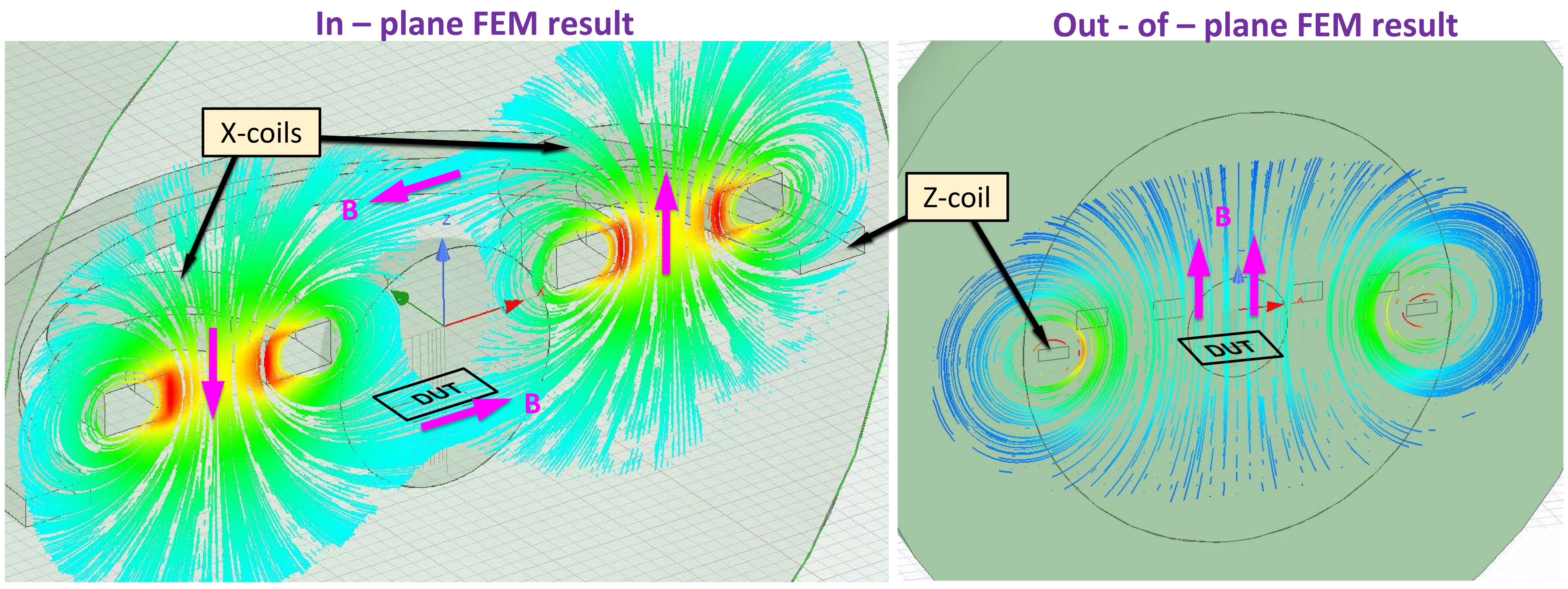
All 3 magnetic fields just add and are linearly dependent on the coil currents.





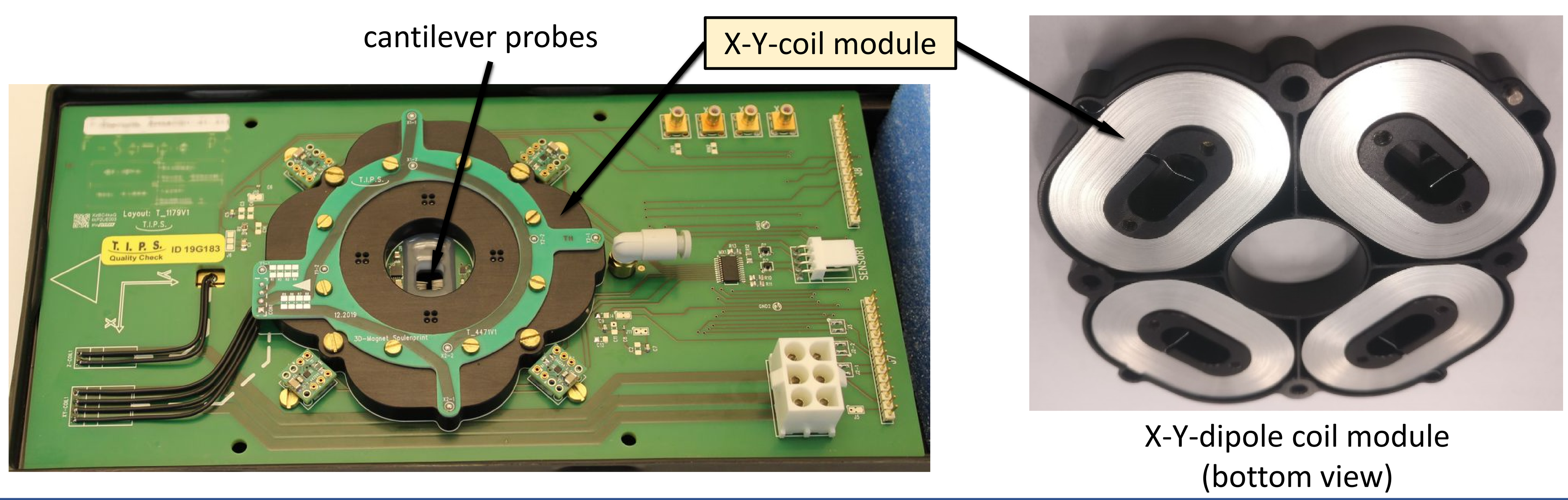
Finite element simulation

By running FEM simulations an arrangement of all 3 coils could be found which satisfied the required field of 1 mT at a given uniformity over the DUT area and at the same time meet the space and cooling constraints.



4.5" probe card

Top view with detachable x/y coil module. Even for a 1 mT field air cooling of the coils is required.



X-Y-dipole coil module (bottom view)

3D medium field equipment

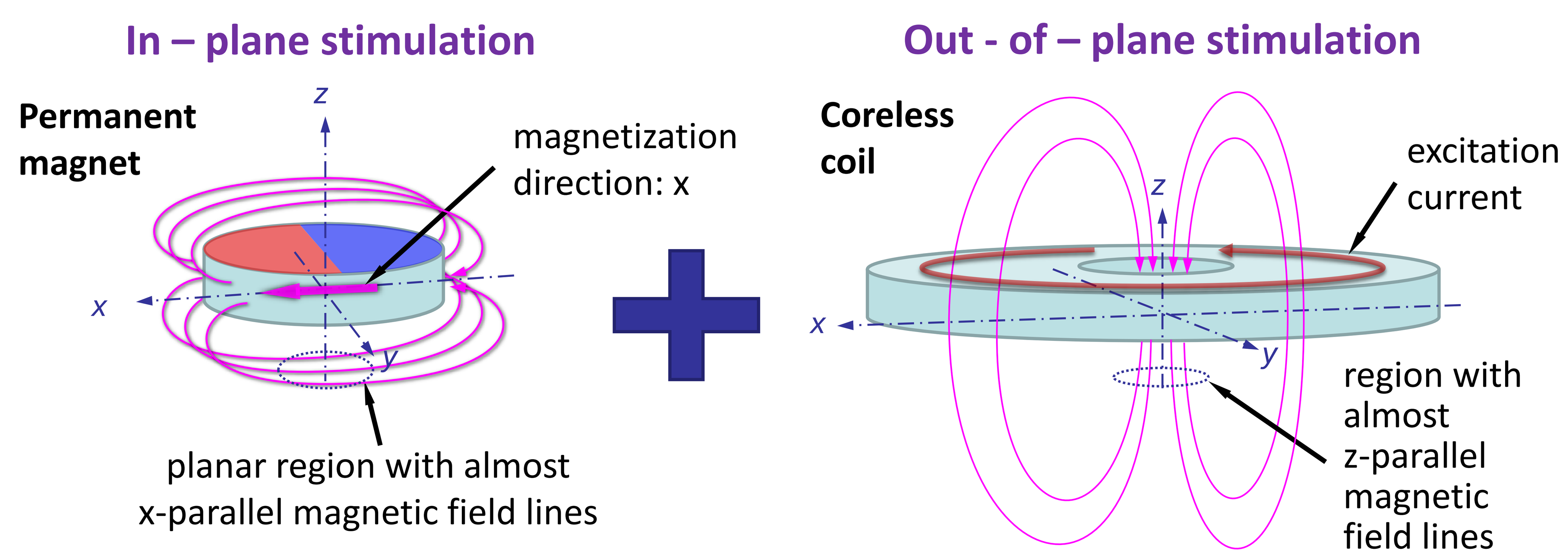
Stimulation concept

The in-plane field is excited by a permanent magnet and has a fixed amplitude of 50 mT with good uniformity of strength and direction.

The magnet is mounted on a rotary stage with high speed and high positioning accuracy (2000 rpm, 0.09° repeatability).

Together with a circular coil for out-of-plane capable of 50 mT all 3 axes can be excited, however not fully independently.

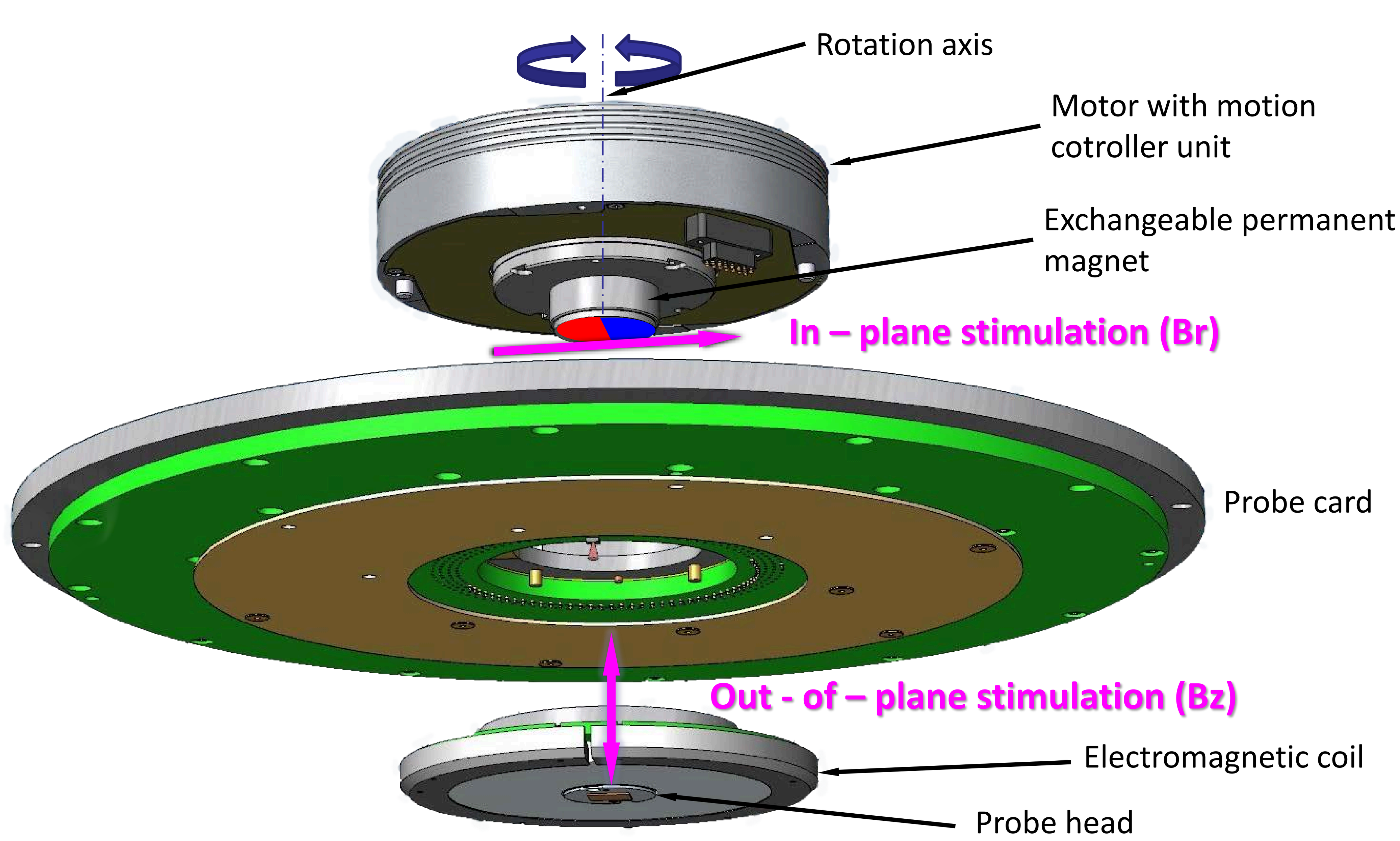
Also here the magnetic fields of permanent magnet and coil just add only that the in-plane field is always present.



Modular probe card

The main probe card PCB has a detachable probe head with integrated coil and vertical (buckling beam) probes.

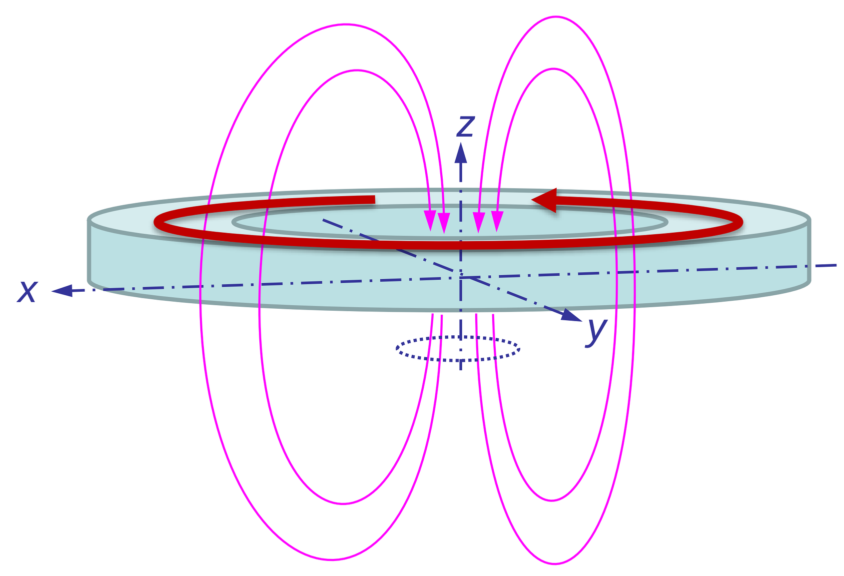
On top is a detachable rotary magnet unit featuring exchangeable magnets for different field strengths.



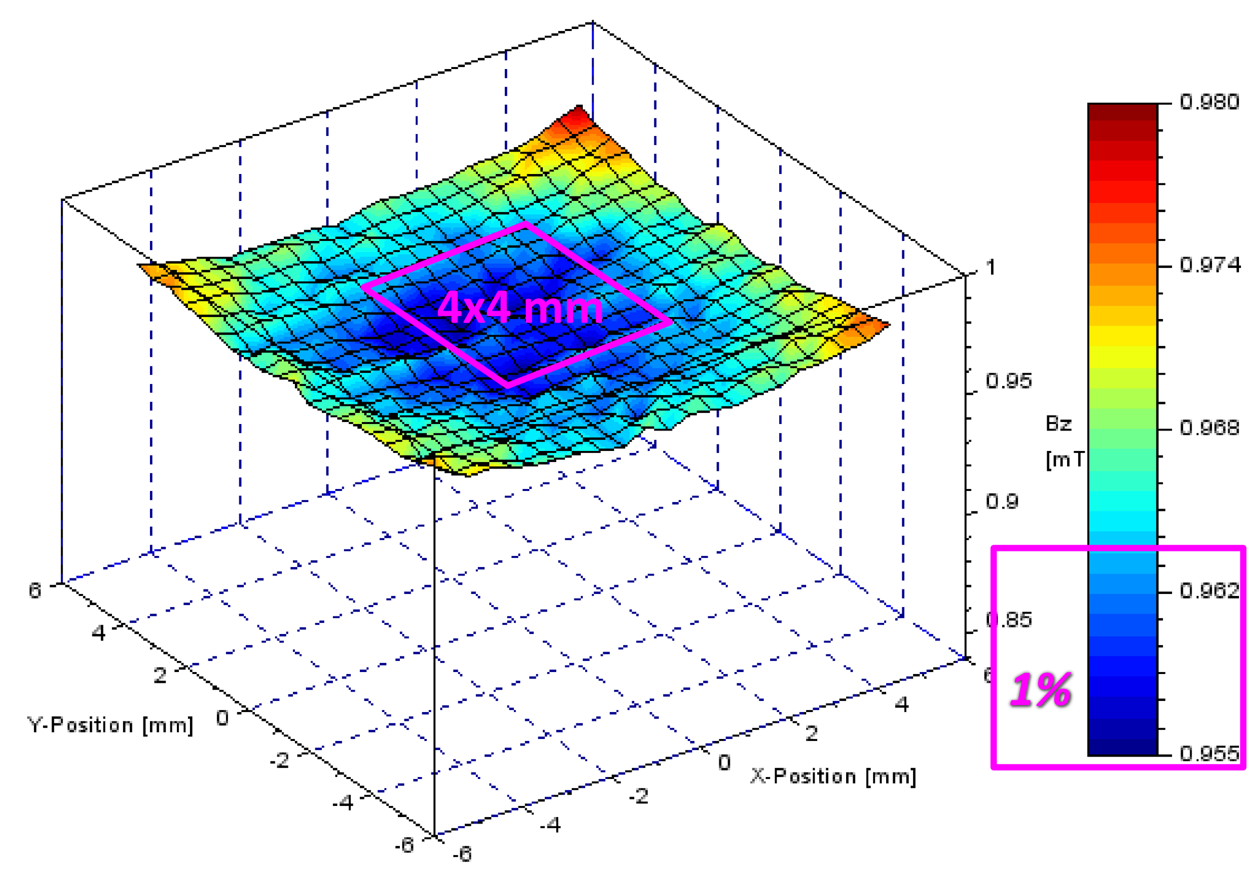
3D low field results

Measurements
with a hi-res 3D magetic scanner in the wafer plane match the results of the FEM simulation.

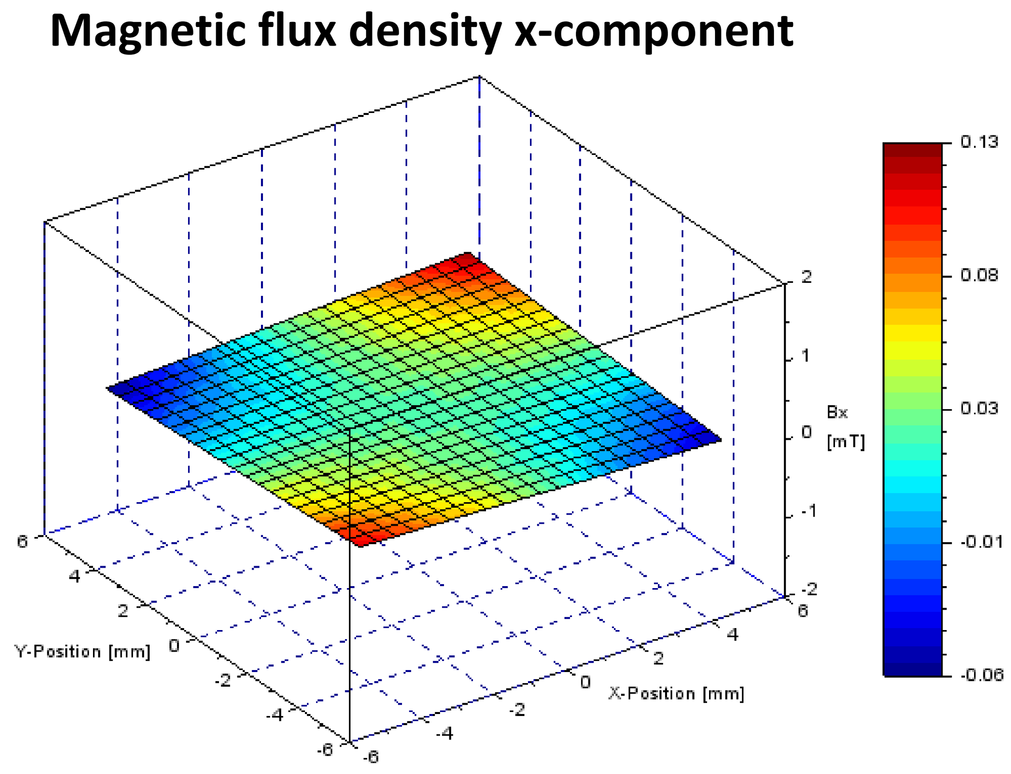
Uniformity of the field vector components are within the anticipated range. The DUT area of 4x4 mm and the related range on the scale are highlighted.

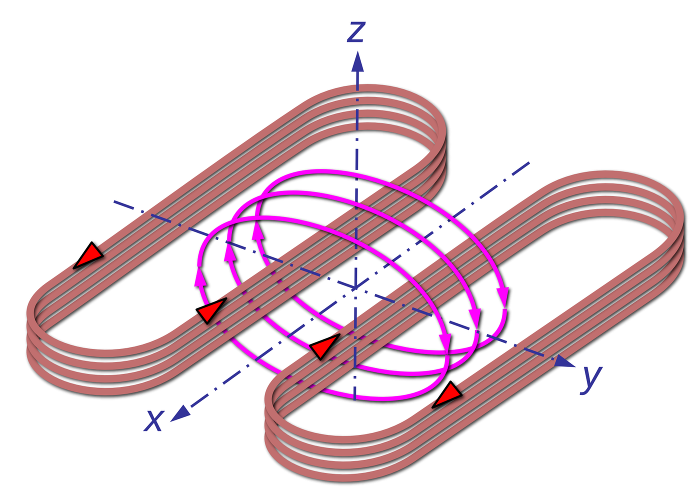


Magnetic flux density z-component

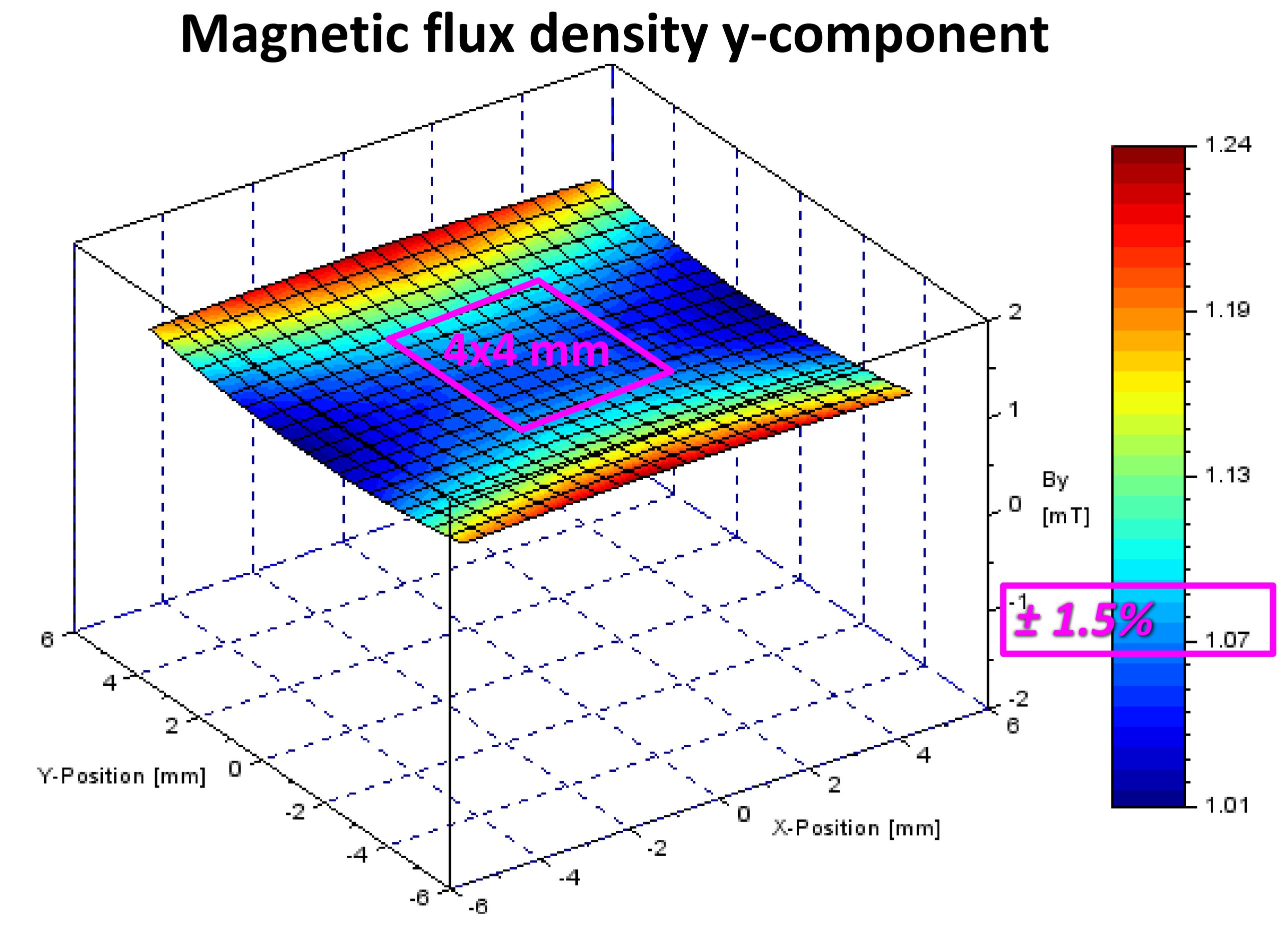


Magnetic flux density x-component





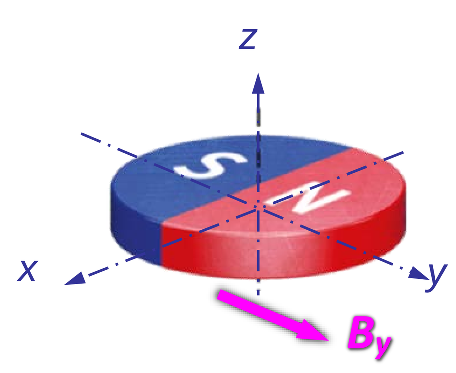
Magnetic flux density y-component



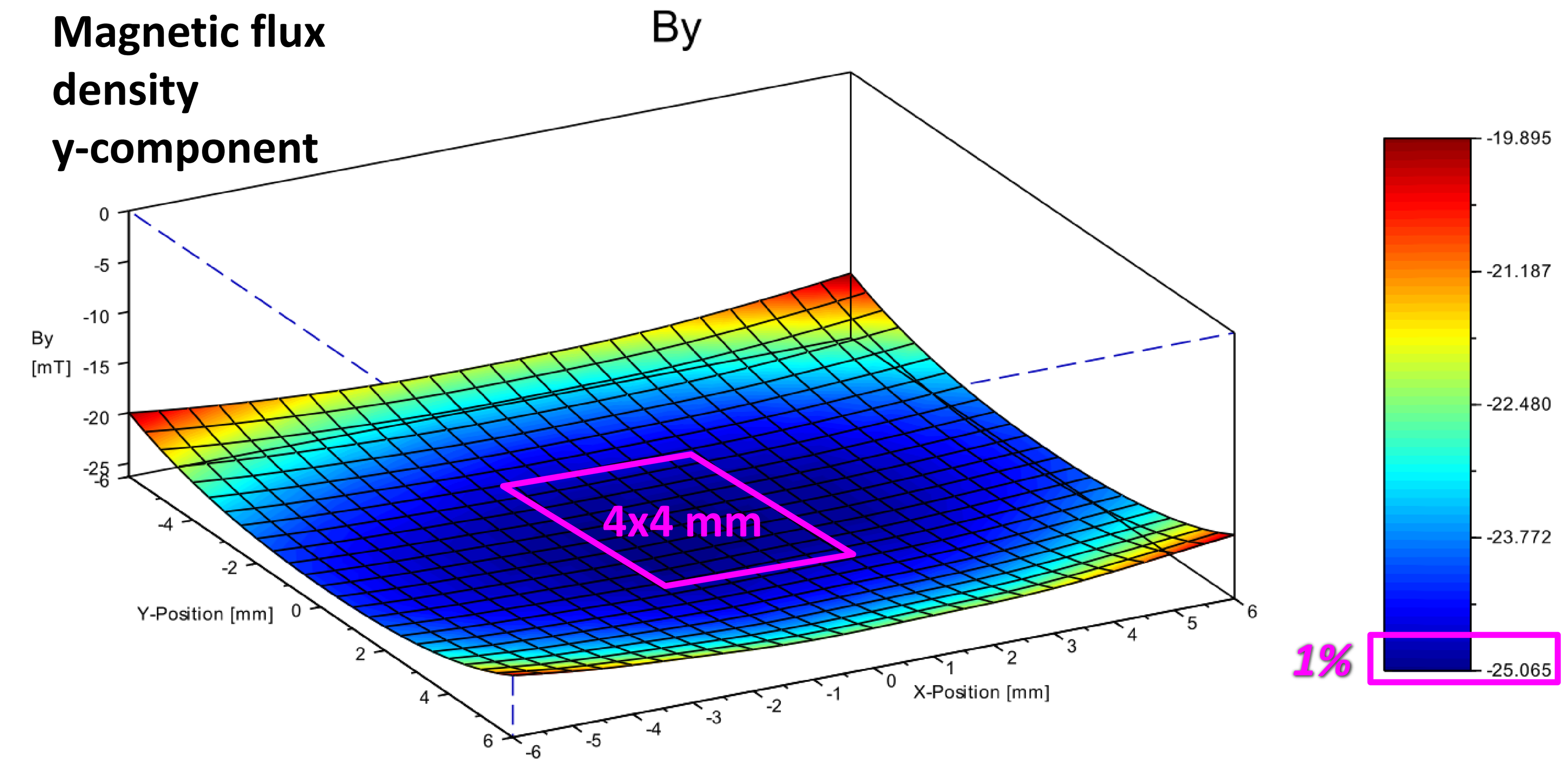
3D medium field results

Field Measurements
of the permanent magnet were done on the same hi-res 3D magetic scanner in the wafer plane. They show good uniformity on the 4x4mm DUT area. Field strength and angular deviation are low.

The field of the z-coil has similar uniformity as for the low field solution but higher amplitude.



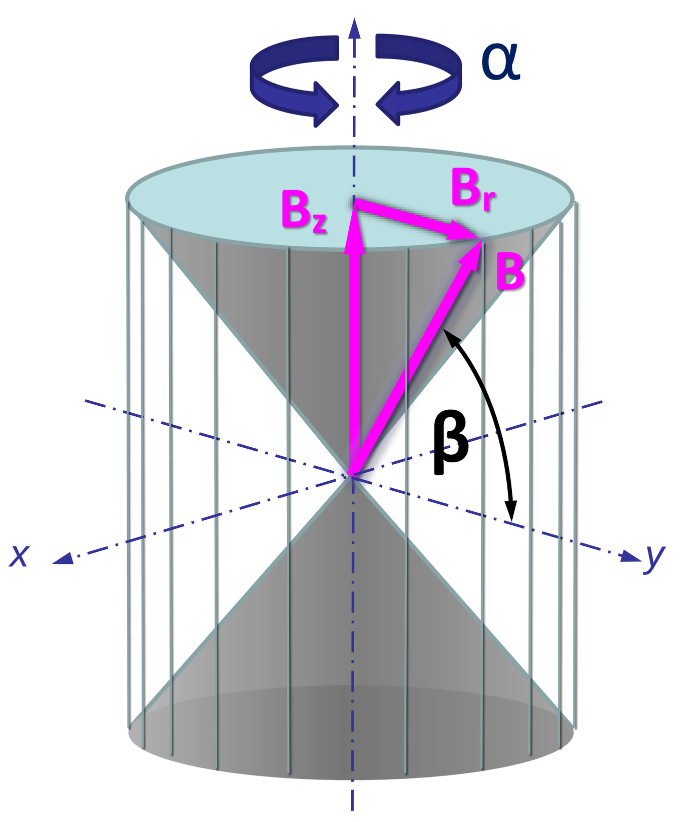
Magnetic flux density y-component



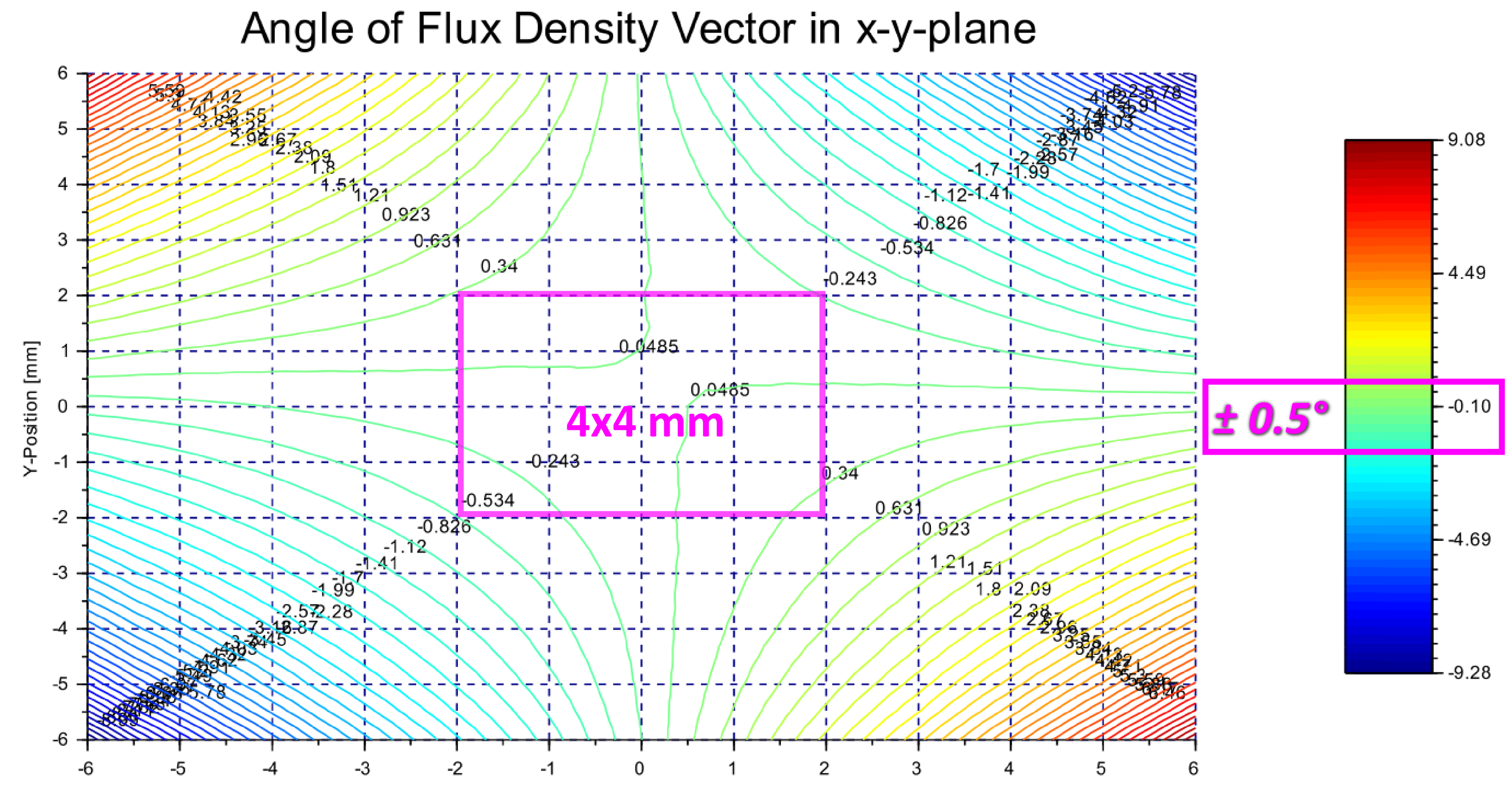
3D limitations
The in-plane field is defined by a fixed amplitude **Br** (50 mT) and the rotation angle α.

Bz is proportional to the coil current with a limit of ±50 mT and pivots B out of the plane by the angle **β** (-45° .... +45°).

The amplitude of **B** is then always between 50 and 71 mT.



Angle of Flux Density Vector in x-y-plane



Conclusion

Low field 1 mT
The coil array can generate arbitrary magnetic field directions directly proportional to the coil currents with ±1 mT per axis and good uniformity on a 4x4mm area, achieving full 3D capability at a very compact size.

Medium field 50 mT
This solution generates fixed strength in-plane field vector of 50 mT that can rotate with high speed and also position with high precision. A coil can pivot this vector out of the plane by ±45° to achieve a sort of limited 3D capability.

Contact

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