Wafer test with simultaneous stimulation of sensor devices

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Technical Innovation – Physical Solutions

Introduction

Functional principle

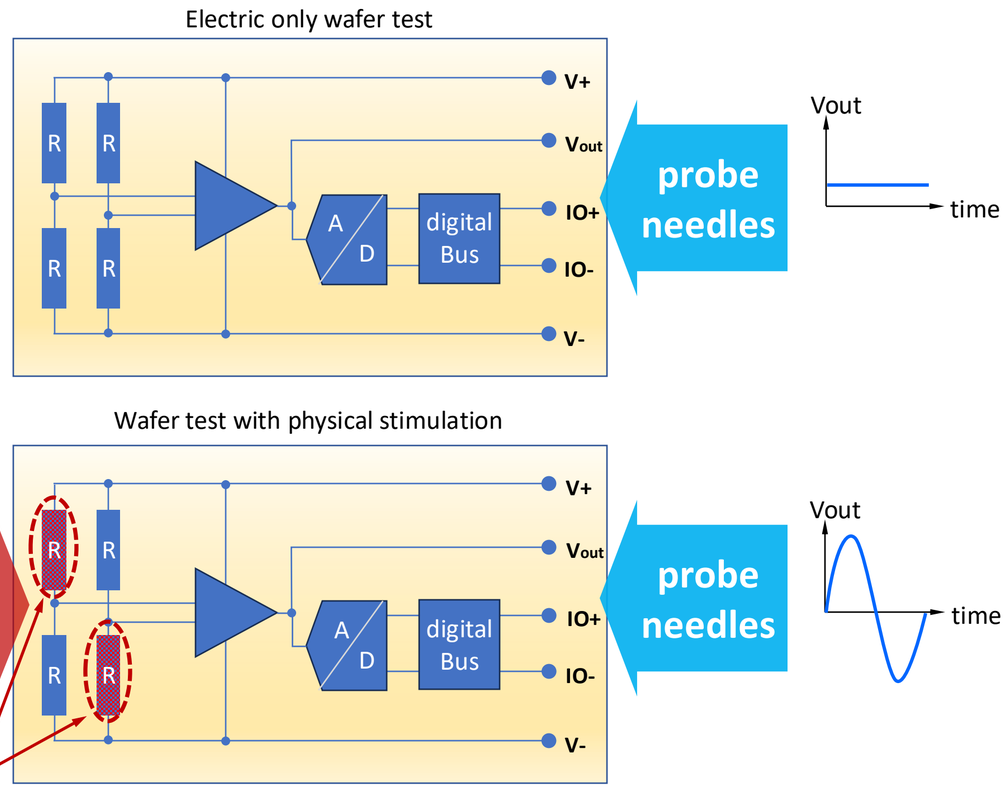
In a typical device the sensing structure is a resistor that changes its resistance proportional to a physical quantity like mechanical strain or magnetic flux.
It is converted into an electric signal using a Wheatstone bridge and amplification circuitry.

Electric only wafer test

In a standard wafer test only amplifier and digital interface can be tested.

Wafer test with physical stimulation

For testing functional parameters like sensitivity or linearity of the sensor additional physical stimulation is needed.



Magnetic Stimulation

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 Internet of Things.

The sensing element changes its electric resistance if a magnetic field is applied in a direction perpendicular to the electric current.

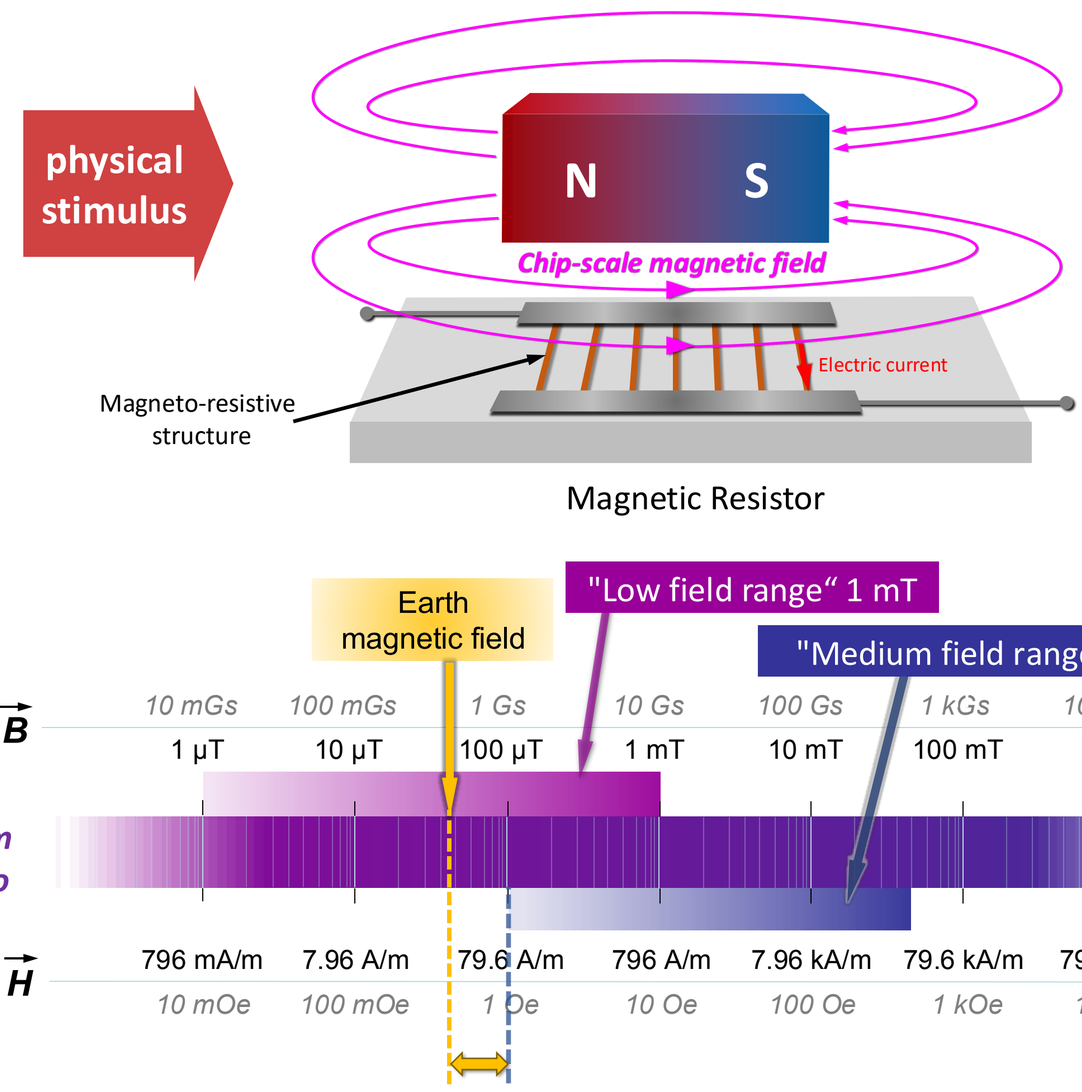
Field size

For wafer test only a the tested die must be stimulated hence the field is "chip scale" size.

Field range

Most applications require up to 50 mT ("medium field"), where the whole range is well above the earth magnetic field to avoid interference.

Applications like compasses typically need a flux density of less than 1 mT ("low field").



Pressure Stimulation

Sensor principle

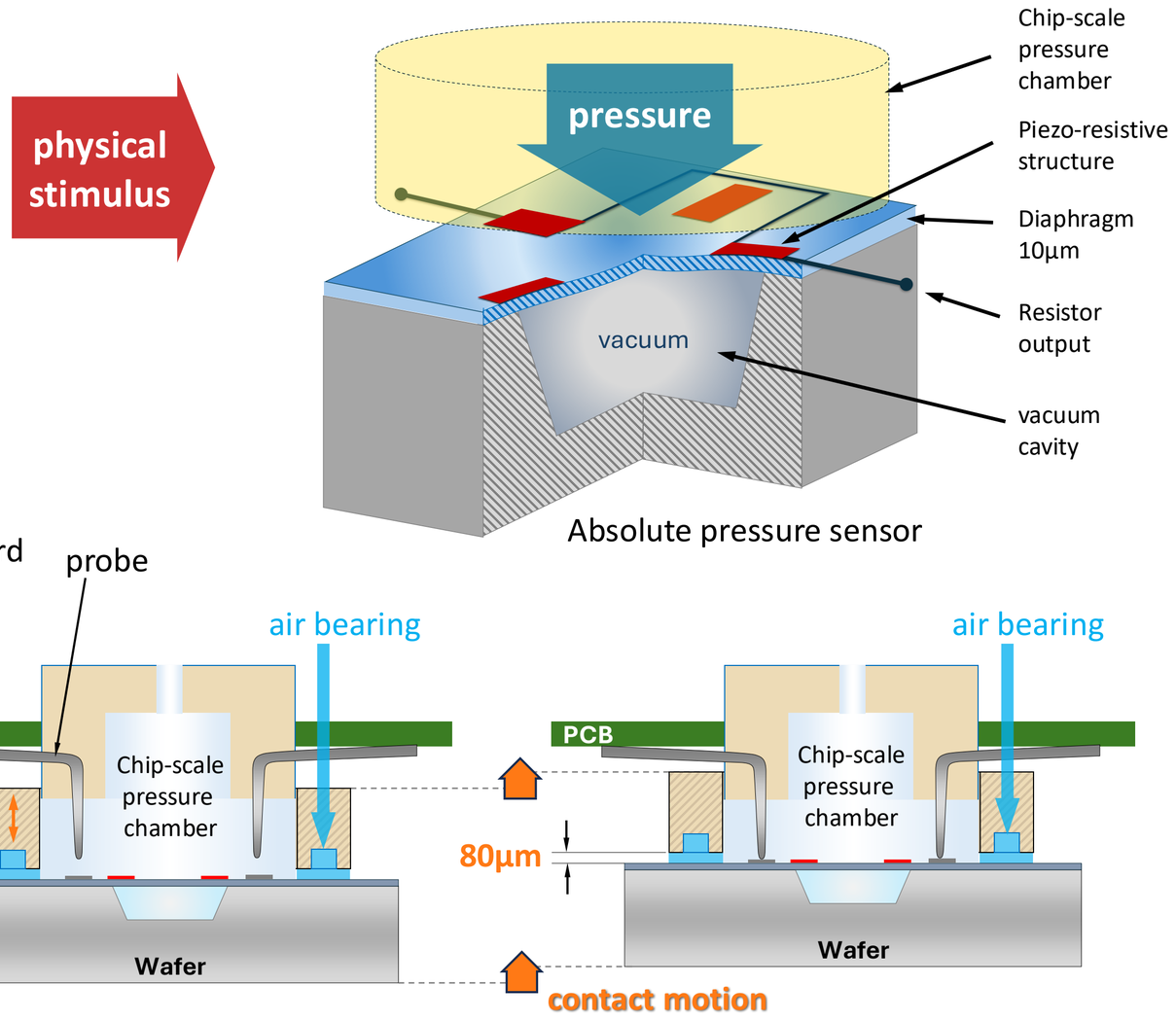
A thin diaphragm deflects under applied pressure causing bending strain. Piezo-resistive structures change their resistance proportional to the pressure.

Pressure application

For wafer test only a small area around the die is set under pressure with a „chip scale“ chamber.

The pressure chamber has a non-contact moveable seal to account for the prober Z-motion.

This "LuPo" air bearing seal assures a constant gap distance to the wafer.



Magnetic Wafer Test

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.

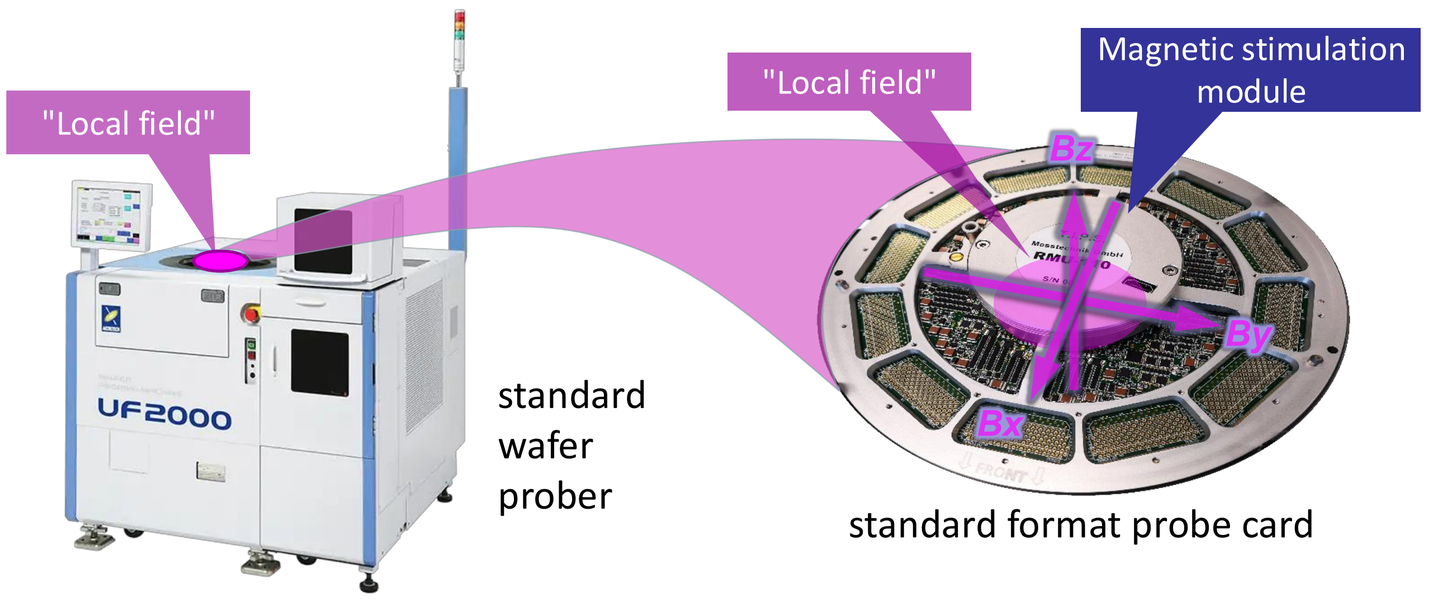
This local field has a short range and requires only components in close proximity to be non-magnetic. These are mainly the wafer chuck, the probe card and parts of the tester interface.

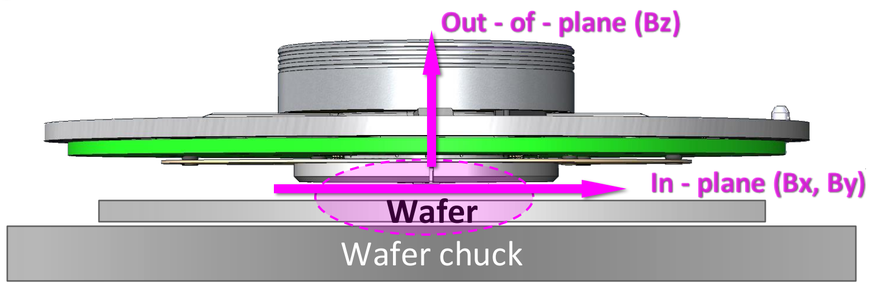
Modular design

For ease of maintenance and reduced cost the stimulation is detachable from probe card and probe head. Modules can be combined as needed.

Integrated Operation

The stimulation modules are powerd and controlled by the tester and have built-in magnetic reference sensors for monitoring. Modules are connected by spring contacts via the probe card to the tester.





Field generation

Permanent magnets

The in-plane field can be excited by a permanent magnet with fixed field strength in the range of 10 to 80mT with good uniformity of strength and direction.

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

Coreless coils

Coils have the advantage of variable field strength that is directly proportional to the coil current.
Out-of-plane fields of up to 50mT with good uniformity can be achieved. Coil arrays for in-plane fields can reach only up to 10mT.

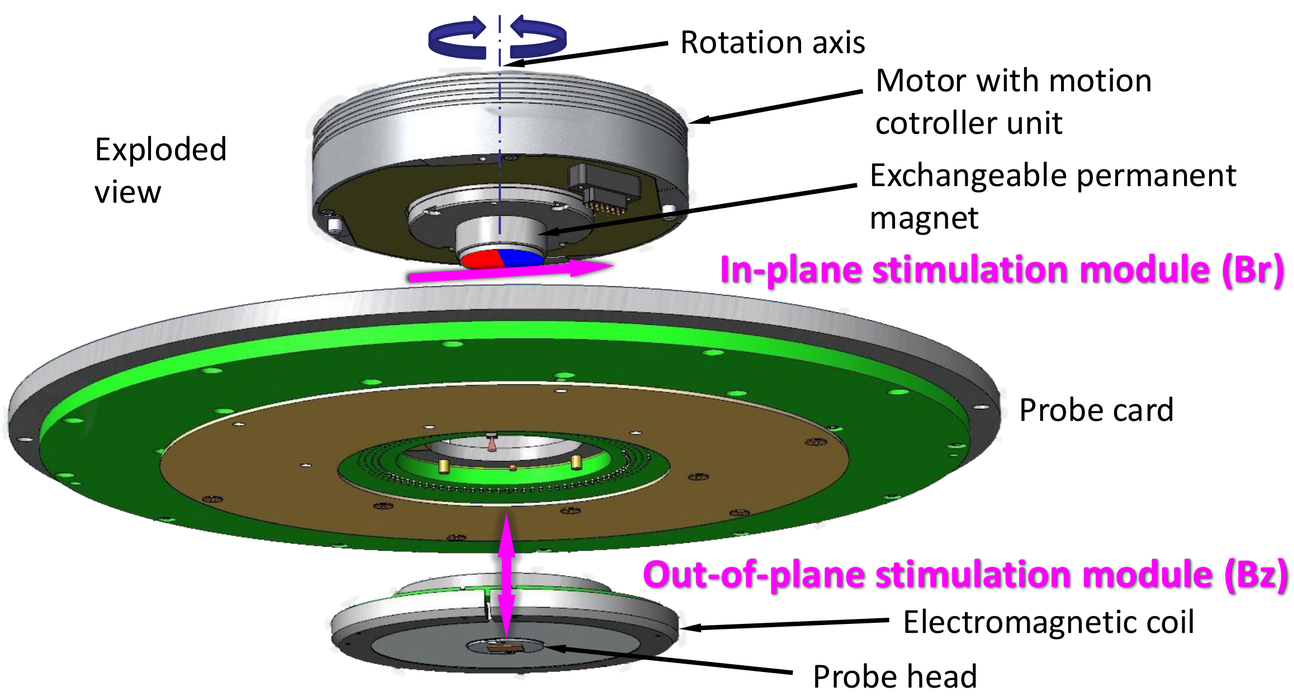
3D limitations (50 mT design)

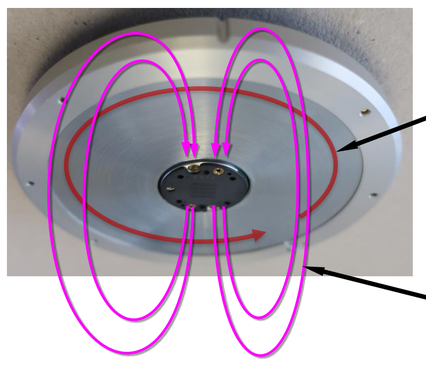
Since the amplitude of the in-plane field is fixed, the amplitude of coil and permanent magnet combined is always between 50 and 72 mT and the magnetic vector can only pivot up to ± 45˚ out of the plane.

Coil and yoke - multipole

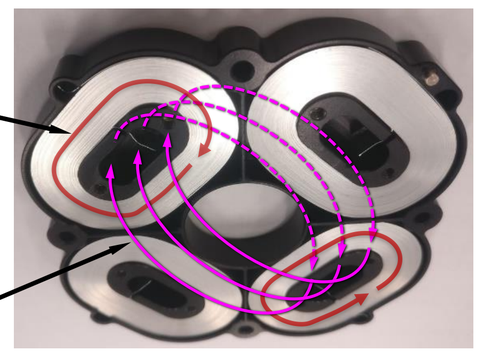
Stronger variable strength in-plane fields up to ± 35mT can be achieved with ferromagnetic yokes. In this range the magnetic flux is linearly proportional to the coil current.

Magnetic hysteresis is reduced to the lowest possible level by using a special alloy for the yokes.
Magnet field variation speed is limited to about 10 Hz.

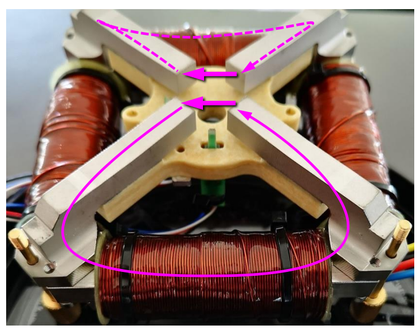




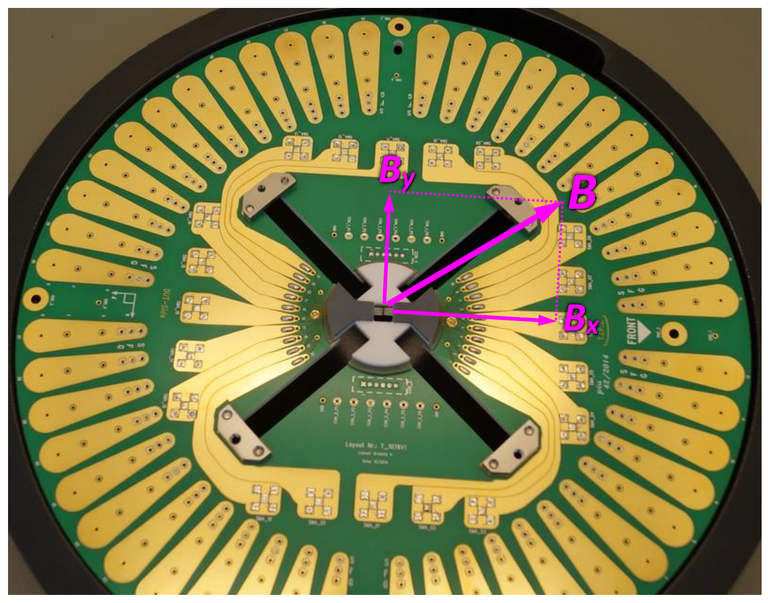
Coil for out-of-plane field



Coil array for in-plane field



Quadrupole unit



Cantilever probe card for quadrupole

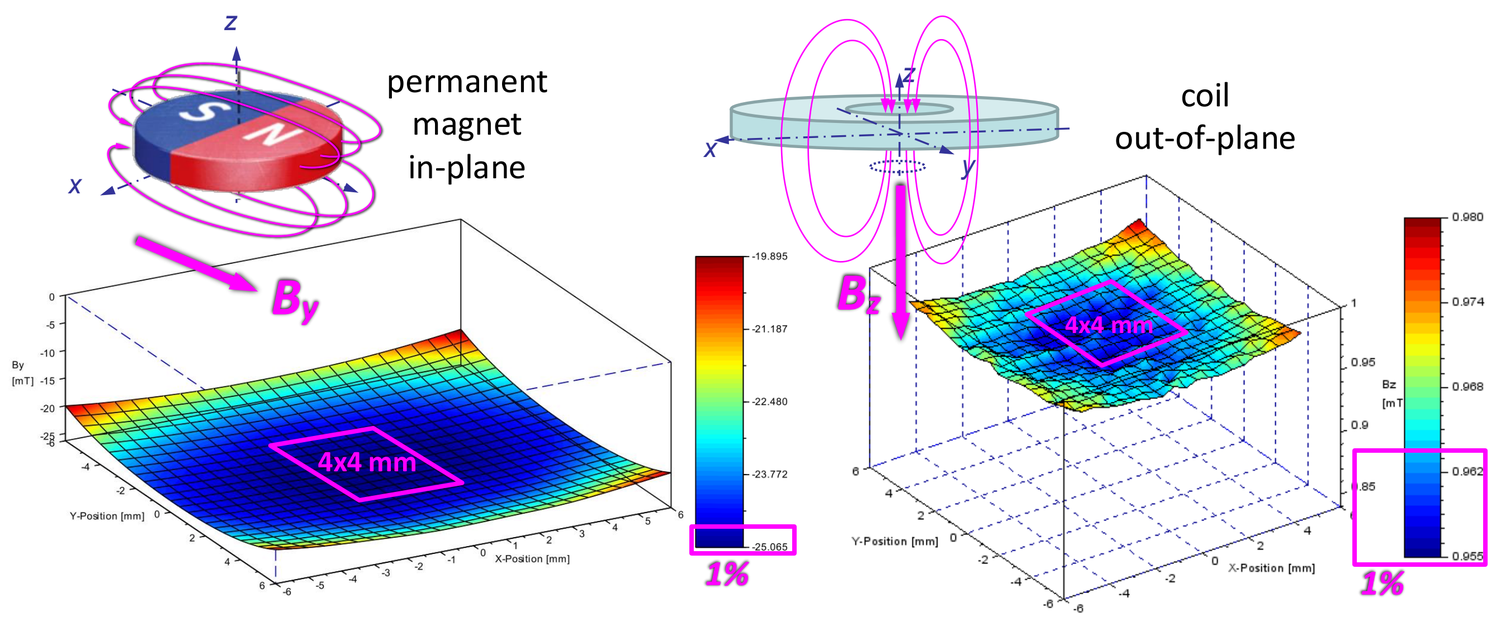
Field Uniformity

Measurements

Flux density was measured using a 3D high-resolution magnetic scanner on a probe area of 4x4 mm.

Plots of the medium field flux magnitude show the same uniformity of 1% for both in-plane and out-of-plane field directions.

In-plane field lines of the permanent magnet are almost parallel. Deviation on the probe area is ± 0.5˚ to the y-direction.



Pressure Wafer Test

Pressure chamber

The chip scale pressure chamber features three hose connections: chamber input, chamber sense and air bearing.

The air bearing must be always on to keep the LuPo seal hovering, causing a small outward air flow.

If the chamber pressure is switched „on“ to the target pressure level, that flow increases.

Pressure range

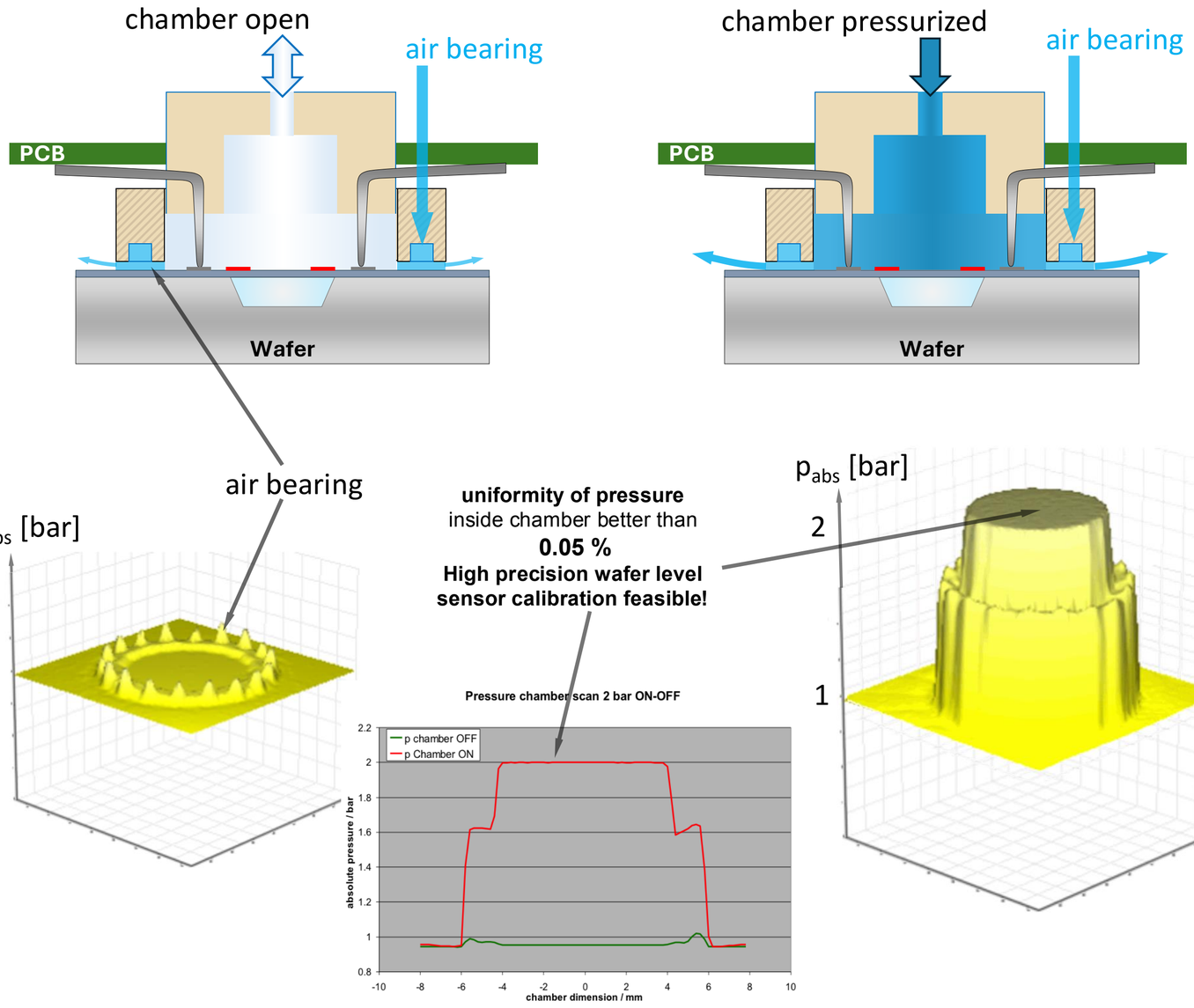
Generally pressures in the range from -0.6 to +5 bar are possible. LuPo regulator units for smaller pressure ranges are available with matched controller and reference sensors.

Pressure uniformity

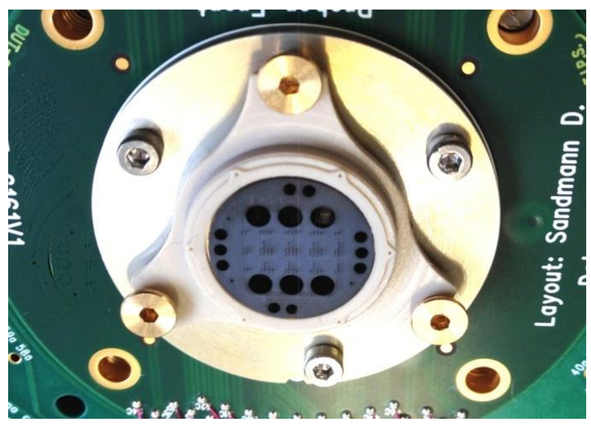
Due to the static pressure generation the pressure profile inside the chamber has a very good uniformity. Pressure variation is less than 0.05%.

Probe card technologies

LuPo pressure chambers are available in various sizes from 5 to 14 mm diameter and for both cantilever and vertical probe technologies. With probe areas up to 10x10mm and larger multi-site probing is possible.



LuPo cantilever probe card



LuPo vertical probe card

Pressure test equipment

Lupo pressure regulator

The regulator is a stand-alone unit to be placed on the prober. On the front panel are some status indicators, 3 hose connections to the probe card and a connector for electric signals.

On the back panel are the supply inputs for compressed air and power.

Operation

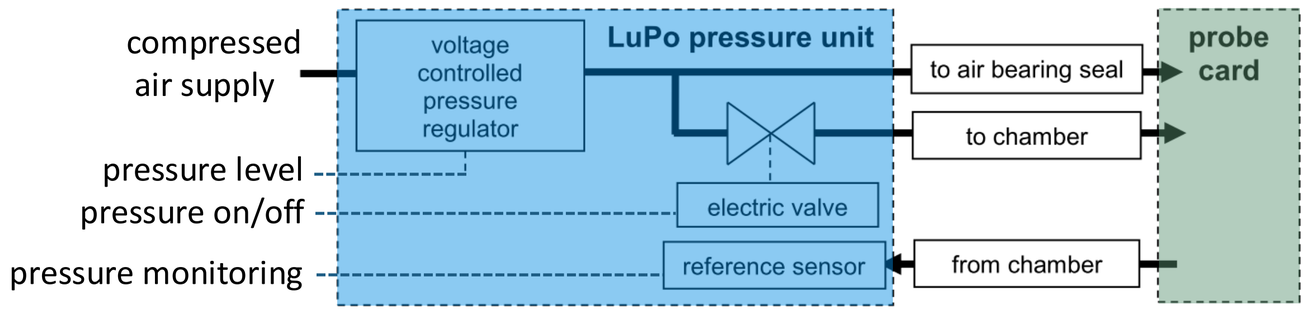
An analog voltage input sets the pressure level. The standard pressure range is 0.3 to 3 bar but other ranges are available, including application of vacuum.

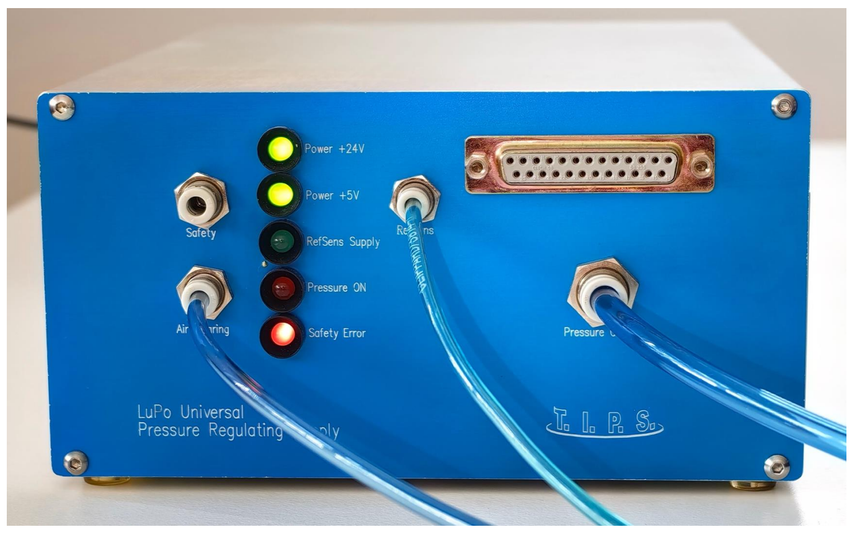
Another voltage input switches a valve between „on“ and „off“ pressure level of the pressure chamber.

For precise monitoring of the absolute chamber pressure a high-precision reference sensor is used that is connected by a sense hose to the chamber.

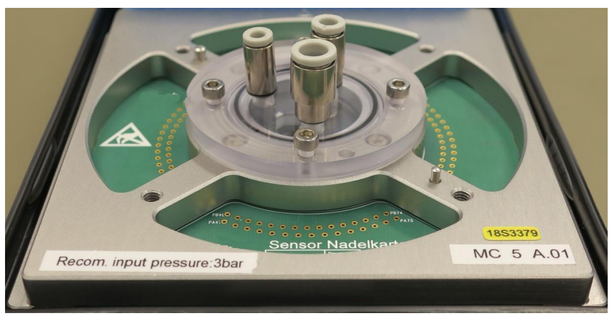
Characteristics

The pressure output from the unit is very stable. However due to the control characteristics of the regulator the settling time from „off“ to „on“ state is longer than venting the chamber to atmospheric pressure („off state“).

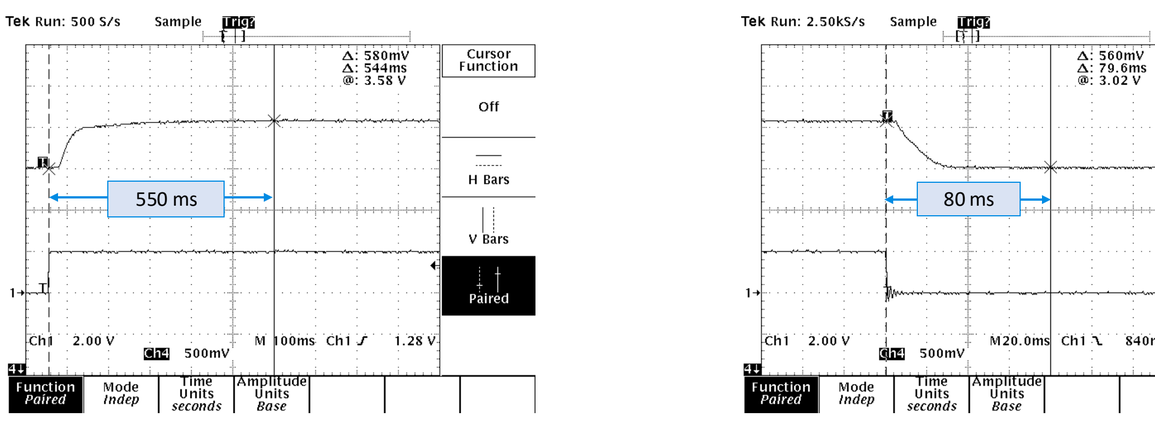




LuPo pressure regulating unit



LuPo pressure probe card



Rise time, fall time of chamber pressure at switching from atmospheric pressure to approx. 1 bar overpressure

Contact

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