Magnetic field measurements with magneto optical indicator films (MOIF): Terms and Definitions, Key Control Parameters (KCPs) and typical values

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1. MOIF Terms and definitions

1.1. General terms related to magnetic stray field characterization

1.1.1
magnetic-force microscopy
MFM
atomic force microscopy mode employing a probe assembly that monitors both atomic forces and magnetic interactions between the probe tip and a surface
[SOURCE: ISO 18115-2:2013, 3.15]

1.1.2
magneto-optical indicator film technique
MOIF technique
method of mapping the magnetic field above a sample surface by a thin magneto-optical Faraday-active indicator film.
Note 1 to entry: The magnetic fields induce a declination of the magnetization from equilibrium direction in the active layer of the sensor, which is recorded with the Faraday effect.

1.2. Terms related to the MOIF measurement method

1.2.1
magnetic field distribution
spatially resolved magnetic field data array in the x-y-plane with the x-, y-direction: in the sample plane and the z-direction: sample surface normal with a spatial resolution, dx, dy, at a distance d above the surface of a test sample

1.2.2
MOIF raw data distribution
$\boldsymbol{S(Nx,Ny)}$, $\boldsymbol{S(x,y)}$
Pixel position dependent, $S(Nx,Ny)$, for array sensors in wide field microscopes, or spatially resolved, $S(x,y)$, for sample scanning measurements in confocal microscopes, detector signal data array of a MOIF measurement. The signal data type depends on the applied analysis technique. For direct MOIF measurements, raw data depict sensor dependent converted intensity distribution data in appropriate units. For differential, lock-in based MOIF measurements, raw data depict lock-in amplitudes in units of Volt

1.2.3
measurement height
h
value of the distance between the MOIF active layer surface facing the sample surface. h results as the sum of the measurement gap height g, the reflective coating thickness d^{rc} and the protective coating thickness d^{pc}

1.2.4
measurement plane
x-y-plane at the measurement height.
Note 1 to entry: The MOIF measurement technique detects a signal which results from an averaging of field values over the sensor thickness. MOIF raw data therefore do not a priori represent the field distribution at the measurement height

1.2.5
non-magnetic spacer
To adjust the measurement height, a non-magnet flat spacer can be placed in between the SUT and the sensor. Spacers are non-magnetic, if their permeability $\mu = \mu_0$

1.2.6
MOIF observation variable
Raw data output of the detection unit. The data type depends on the applied analysis technique. For direct MOIF measurements, raw data depict intensity distributions in appropriate units. For differential, lock-in based MOIF, raw data depict lock-in amplitudes in units of Volt

1.2.7
signal detection unit
system to detect the light intensity distribution imaged by the imaging system after passing the polarizer. The signal detection unit, typically a photo diode or an array sensor converts light intensity into a digital signal

1.2.8
z-scanner
element for the realization of the vertical displacement of the sample during x-y-scanning
Note 1 to entry: See ISO 18115-2:2013, 5.136

1.2.9
magnetic field reference sample
magnetic sample whose magnetic field distribution above the sample surface is well-known

1.2.10
image size
Sx*, *Sy
length and width of the sample area that is mapped into a 2D raster image

1.2.11
pixel (ISO 10934:2020(en) 3.1.116, modified)
smallest element of the digital image to which attributes are assigned

1.2.12
pixel index
(*Nx*, *Ny*)
integer values indexing the position of a sensor unit in an array sensor. These values also index the pixels of the mapped 2D raster image

1.2.13
pixel size
$\Delta A = \Delta x \times \Delta y$
length and width of the sample area represented by each measured point in a 2D raster image. The values for Δx and Δy are determined by the imaging geometry

1.2.14
lateral position on the sample
(*x*, *y*)
values in units of meters depicting the position on the sample under test

1.2.15
Geometrical imaging function
describes in the case of a wide-field measurement geometry how a position on the sample $(\boldsymbol{x}, \boldsymbol{y})$ is mapped to the sensor pixels (Nx, Ny). The geometrical imaging function establishes an unambiguous and invertible relation between pixels and a set of discretized sample positions. In this sense, (x, y) and (Nx, Ny) can be used equivalently

1.2.16
Sample under test
SUT
material whose magnetic field distribution is to be measured

1.2.17
pseudo-Wiener deconvolution
deconvolution applying a pseudo-Wiener-filter for noise suppression in a deconvolution in Fourier space with regularization parameter
Note 1 to entry: The formula that applies is as follows, where the asterisk marks the complex conjugate:

$$A(k,z) = \frac{B(k,z)}{C(k,z)} \quad \rightarrow \quad A(k,z) = B(k,z)\frac{C^*(k,z)}{|C(k,z)|^2 + \alpha}$$

1.2.18
regularization parameter
$\boldsymbol{\alpha}$
constant in the *pseudo-Wiener deconvolution* (3.3.34) that approximates the noise characteristics of the image

1.2.19
transfer function
TF
2D arrays of complex data that represent operations on data that can be described by a convolution

1.2.20
Field transfer function
$\boldsymbol{TF^H}$
Transfer functions that mediate operations on magnetic field distributions and effective charge density distributions. Field transfer functions are used to calculate field distributions at heights different from the measurement plane. Further field transfer functions allow calculating the projection of the magnetic field onto any arbitrary direction from any measured magnetic field component

1.2.21
discrimination
data treatment process where the data entries in a data distribution are dichotomized resulting in a binary data set with entries +1 or −1
Note 1 to entry: The dichotomization is effected on the basis of a threshold value t as discrimination criterion. Data entries less than t are assigned the value −1, data entries greater than or equal to t are assigned the value +1

1.2.22
In-plane (ip) magnetic fields
magnetic fields with field components entirely in the measurement plane

1.2.23
out-of-plane (oop) magnetic fields
magnetic fields with field-components entirely perpendicular to the measurement plane

1.3. Terms related to the magneto optical indicator film (MOIF)

1.3.1
Magneto-Optical indicator Film
MOIF
Thin film magneto-optically active layer which is part of the MOIF sensor layer structure. It serves to detect magnetic fields exploiting the magneto-optical Faraday effect. Typical MO films are based on ferrimagnetic bismuth-substituted rare-earth iron garnet, which are deposited on single-crystalline gadolinium gallium garnet (GGG) wafers by liquid phase epitaxy (LPE)

1.3.2
MOIF active layer
Magneto-optically active MOIF film volume

1.3.3
MOIF active layer thickness
d^{MOIF}
thickness of the magneto-optically active MOIF film volume

1.3.4
MOIF type
U/P
Defines the anisotropy type of the MOIF. "P" defines a planar (P-MOIF) with quality factor Q < 1. "U" defines an uniaxial MOIF (U-MOIF) with $Q > 1$

1.3.5
MOIF reflective coating
reflective coating on the surface of the MOIF facing the sample. Typically a metallic coating or a dielectric mirror

1.3.6
reflective coating thickness
d^{rc}
thickness of the reflective coating

1.3.7
MOIF protective coating
protective coating on the surface of the MOIF sensor that faces the sample. Typically an oxide coating or a hard coating

1.3.8
MOIF protective coating thickness
d^{pc}
thickness of the protective coating

1.3.9
MOIF magnetic anisotropy constants
K_{uoop}, K_{uip}, K_{c}
constants of the magneto-crystalline anisotropy that describe the dependency of the material's free energy on the orientation of the magnetization. Here, the K_{uoop}, K_{uip}, K_{c} represent the out-of-plane (oop), in-plane (ip) and cubic anisotropy contributions, respectively

1.3.10
MOIF magnetic anisotropy fields
B_{uoop}, B_{uip}, B_{c}
magnetic anisotropy fields describe the dependency of the material's free energy on the orientation of the magnetization. Here, the B_{uoop}, B_{uip} *and* B_{c} represent the out-of-plane (oop), in-plane (ip) and cubic anisotropy contributions, respectively. *A*nisotropy constants and anisotropy fields are related *via* $K_{ani} = B_{ani} \cdot M_{S,MOIF}/2$

1.3.11
MOIF saturation magnetization
$\boldsymbol{M}_{\mathbf{S,MOIF}}$
saturation magnetization $M_{\mathrm{S,MOIF}}$ of the MOIF active layer in perpendicular direction. $M_{\mathrm{S,MOIF}}$ typically is temperature dependent, $M_{\mathrm{S,MOIF}}$ (T) and thus needs to be given for the MOIF temperature T_{MOIF} during the measurement

1.3.12
MOIF temperature
$\boldsymbol{T}_{\mathbf{MOIF}}$
Temperature of the MOIF during the measurement process. Typically, a MOIF is used at room temperature. Special application in the cryogenic range is also possible

1.3.13
MOIF magnetization vector
$\vec{\boldsymbol{M}}, \boldsymbol{M}_x, \boldsymbol{M}_y, \boldsymbol{M}_z,$ **or** $\boldsymbol{M}, \theta^{\boldsymbol{M}}, \varphi^{\boldsymbol{M}}$
magnetization vector of the MOIF active layer either as a vector or in the form of the vectors cartesian or cylindrical coordinates. In the latter case, M, $\theta^{\boldsymbol{M}}$ and $\varphi^{\boldsymbol{M}}$ depict magnitude and the polar and azimuthal angle of the magnetization vector, respectively in a coordinate system with the polar direction perpendicular to the MOIF surface

1.3.14
MOIF normalized magnetization vector
$\vec{\widehat{\boldsymbol{M}}}$, *or* $\widehat{\boldsymbol{M}}_x, \widehat{\boldsymbol{M}}_y, \widehat{\boldsymbol{M}}_z,$ **or** $\widehat{\boldsymbol{M}}, \theta^{\boldsymbol{M}}, \varphi^{\boldsymbol{M}}$
Normalized magnetization vector of the MOIF active layer $\vec{\widehat{M}} = \frac{\vec{M}}{|M|}$, either as a vector or in the form of the vectors cartesian or cylindrical coordinates

1.3.15
saturation of the MOIF sensor
situation where the MOIF magnetization is aligned perpendicular, i.e., $\widehat{M}_x = 0, \widehat{M}_y = 0, \widehat{M}_z = 1$,.
Note: saturation may only be reached asymptotically. This requires to the definition of a cut-off criterion for $\widehat{\boldsymbol{M}}_{\boldsymbol{z}}$

1.3.16
saturation field strength
$\boldsymbol{H}_{\boldsymbol{z}}^{\boldsymbol{sat}}$
Perpendicular magnetic field for which the MOIF reaches saturation. It defines the operating range of the MOIF sensor where a calibration can be performed
Note: Saturation may only be reached asymptotically. H_z^{sat} then has to be chosen in a meaningful way, e.g. as the H_z value where the interpolated linear part of the $M_z(H_z)$ curve reaches M_z =1

1.3.17
MOIF quality factor Q
$\boldsymbol{Q}$
Parameter characterizing ferromagnetic thin films with an easy axis of magnetization normal to the film plane

$$Q = 2K_{uoop}/\mu_0 M_S^2,$$

where K_{uoop} is the uniaxial anisotropy constant. The Q-factor defines the ratio between the energy of magneto-crystalline anisotropy and maximum energy density due to shape anisotropy. For $Q > 1$, the film will be uniaxial with out-of-plane easy direction, while for $Q < 1$, the magnetic moments will tend to be oriented in the plane of the film due to shape anisotropy

1.3.18
MOIF figure of merit
$\boldsymbol{FOM}$
Describes the merit of a MOIF by comparing Faraday effect amplitude and optical absorption. A high value of the FOM is required for imaging a wide spectrum of object feature sizes.
Note: the MOIF figure of merit is calculated from the optical absorption, γ, and the Faraday rotation in saturation, α_{sat} as $FOM = 2\ \alpha_{sat}/\gamma$

1.3.19
Verdet constant
v
parameter of the MOIF material that quantifies the Faraday effect strength at a particular wavelength of light. v is a function of the material and of the wavelength, $v=v(\omega)$

Note: The Faraday rotation linearly depends on the Verdet constant, the length of the path of the light through the optically active medium and to the perpendicular magnetization component M_z of the optically active medium. For MOIF measurements, the Faraday rotation in reflection is given by $\alpha=2\ d_{MOIF}\ v(\omega)\ M_z$ **4**

1.4. Terms related to Faraday rotation

1.4.1
Faraday rotation
α
Angle of rotation of the polarization plane of the light passing the MOIF sensor due to the local perpendicular magnetization component M_z of the sensor.
The Faraday rotation is also wavelength dependent and increases with decreasing wavelength (VIS). The typical absorption band below 530 nm results in increased Faraday ellipticity. Thus, the typical wavelength range in the application is between 530 and 630 nm, depending on the properties of the MO film. Monochromatic light can be used, but also white light

1.4.2
Malus law
Gives the intensity I of polarized light after passing a polarizer at an angle θ. The intensity is given by

$$I = I_0 \cos^2(\theta)$$

1.4.3
absorption constant
γ
Wavelength dependent material parameter that determines how far light of a particular wavelength can penetrate into the material before it is absorbed

1.1.4.4
effective anisotropy field
B_A
Effective perpendicular anisotropy field of the MOIF active layer that results from the interaction of crystalline anisotropy contributions and the demagnetization field

1.4.5
Demagnetization field
B_{demag}
Effective field caused by the sample magnetization due the sample shape that describes the tendency to reduce the total magnetic moment of the specimen. It is quantified by the demagnetization tensor

1.4.6
MOIF transfer function
TF^{MOIF}
The MOIF sensor with its finite active layer thickness averages magnetic field values over its thickness. The MOIF transfer function is used to calculate the real field distribution at the surface of the sensor that faces the sample from the measured raw field distribution

1.4.7
MOIF flatness parameters
W, AW, Wx, Wte
mean depth of waviness motifs (*W*), mean spacing of waviness motifs (*AW*), maximum depth of waviness motifs (*Wx*) and amplitude of the upper envelope (*Wte*)

1.4.8
MOIF nominal surface plane
Mathematically defined surface plane as specified by the design

1.4.9
MOIF roughness parameters (guide.digitalsurf.com/en/guide-iso-12085-parameters.html)
R*, *Ar*, *Rx
mean depth of roughness motifs (*R*), mean spacing of roughness motifs (*Ar*) and maximum depth of roughness motifs (*Rx*)

1.5. Terms related to the magneto optical measurement setup

1.5.1
Magneto-optical measurement setup
Entirety of the light source, optical system, MOIF itself and detection unit, possibly with magnetization unit to apply magnetic fields to the sample

1.5.2
Optical system
Entirety of the optical devices forming the optical path, including light source, analyzer, polarizer, beam splitter, Faraday rotator, objective and lenses, if applicable

1.5.3
Light ray
Light traveling in any direction in a straight line

1.5.4
Light beam
Bundle of light rays

1.5.5
Wide field imaging measurements
Measurement technique where the entire sample are is exposed to light and the sample is imaged to an array sensor

1.5.6
Spot measurements
Measurement technique where only one spot on the sample is exposed to light and light reflected from the spot is detected by a sensor

1.5.7
Measurement gap
g
distance between the surface of the MOIF sensor facing the sample (either the surface of the reflective coating or the protective coating or, if no coating is used, the surface of the active layer) and the sample surface

1.5.8
angle of rotation of the plane of polarization
β
angle of rotation of the polarized light in the reflected light beam after passing the MOIF twice relative to the plane of polarization of the incoming light

1.5.9
light source
optical device to create light with a defined optical spectrum, typically an LED or LED array, an arc source or a laser which may be combined with bandpass filters

1.5.10
intensity (ISO 10934:2020(en) 3.1.79)
I
general term for the strength of a radiation which is proportional to the square of the amplitude of the electromagnetic wave

1.5.11
filter (ISO 10934:2020(en) 3.1.55)
an optical device designed to control selectively the wavelengths, color temperature, vibration direction, and/or intensity of the radiation which it transmits or reflects

1.5.12
radiation (ISO 10934:2020(en) 3.1.123)
energy in the form of electromagnetic waves or particles

1.5.13
light (ISO 10934:2020(en) 3.1.88)
electromagnetic radiation directly capable of causing a visual sensation

1.5.14
polarizing filter (ISO 10934:2020(en) 3.1.55.12)
filter (ISO 10934:2020(en) 3.1.55) acting as a polar (ISO 10934:2020(en) 3.1.118) by total or partial absorption of light (ISO 10934:2020(en) 3.1.88) vibrating in certain directions

1.5.15
polarizer
polarizing filter that is used to filter light in such a way, that only linearly polarized light in a given orientation is transmitted. In the optical path, it is placed after the light source and before the optically active medium (MOIF)

1.5.16
analyzer
the analyzer has the same functionality as the polarizer but is used to analyze the orientation of the polarization plane of the light by converting it to an intensity contrast. In the optical path, it is placed after the polarizer and the optically active medium (MOIF) before the detection unit

1.5.17
analyzer operating angle
θ
Clockwise deviation of the angle of the analyzer from the crossed position of polarizer and analyzer when looking in the direction of propagation of the beam

1.5.18
beam splitter
Optical device that is used to split an incoming light beam into two separate light beams which may have different intensities
Note: in magneto-optical setups with normal or near normal incidence of the incident light beam, a beam splitter may be used to separate the beam paths of incoming light and the light reflected from the sensor. The reflected light is thereby deflected to the detection unit.
Note: Typically, the ratio of reflection and transmission is 50/50 at an angle of incidence of 45°

1.5.19
Faraday rotator
Optical device that induces a certain rotation of the polarization plane of polarized light. In MOIF measurements this adds to the polarization rotation of the light beam reflected from the MOIF sensor which is caused by the MOIF magnetization M_z

1.5.20
Faraday modulator
Adjustable Faraday rotator that induces a small periodic deviation of the light polarization. In MOIF measurements this periodic deviation of the light polarization adds to the rotation of the polarization plane of the light reflected from the MOIF reflective coating before passing the analyzer. In combination with lock-in detection this works as an analog differentiator for the light intensity Terms related to optical microscopy

1.5.21
objective
the objective is used in optical microscopy to enhance the resolution

1.5.22
imaging optics
part of the optical system that images or projects the object plane on the detection unit. In MOIF measurements, the measurement plane at the measurement height is mapped to the detection unit

1.5.23
microscope (ISO 10934:2020(en) 3.1.99, modified)
instrument designed to extend visual capability, i.e., to make visible minute detail that is not seen with the unaided eye

1.5.24
scanning optical microscope (ISO 10934:2020(en) 3.1.99.12, modified)
microscope specially designed to scan the object plane in a raster pattern

Note 1 to entry: There are two techniques of scanning: one is based on movement of the illuminating beam with the object remaining stationary, the other on the movement of the object, the beam remaining stationary. The instrument may be operated in the confocal imaging mode

1.5.25
MOIF setup
Entirety of the MOIF system including light source, optical system, MO sensor and detection unit, possibly with magnetization unit to apply magnetic fields to the sample

1.6. Terms related to the setup calibration process

1.6.1
sensor signal
***S*, *S* (*Nx*, *Ny*)**
signal of a sensor in appropriate representation (as example Volt for a photodiode or a 12-bit integer for a CCD / CMOS chip). For array sensors, S is a distribution of signal values over the pixel indices i and j, $S(i, j)$

1.6.2
Sensor sensitivity function
s(I)*, *s(Nx, Ny, I)
relates the light intensity of the light at the position of the sensor to the measured Signal, $S = s(I)$. For array sensors, s is a function of the pixel indices (i, j), and thus $S(i, j) = s(i, j, I)$. Sensors are linear if the relation between signal and intensity can be described by a relation

$$S = C \cdot I, \text{ and thus } s(I) = C \cdot I$$

with a constant factor C

1.6.3
Light intensity at the detection unit
I^{det}, I^{det} (*Nx*, *Ny*)
Light intensity at the position of the detection unit. For array sensors, I^{det} is a function of the pixel indizes (Nx, Ny), and thus $I^{det}(Nx, Ny)$

1.6.4
Light intensity of the incident light at the sensor position
I^{inc}, I^{inc} (*x*, *y*)
Light intensity of the incident light in the measurement plane. For array sensors, I^{inc} is a function of the position on the sample (x,y), and thus $I^{inc}(x, y)$

1.6.5
Intensity of the light reflected from the sensor
***Irefl*, *Irefl* (*x*, *y*)**
Light intensity of the light reflected from the sensor in the measurement plane. For wide-field images, I_{refl} is a function of the position on the sample (x,y), and thus $I_{relf}(x, y)$

1.6.6
MOIF calibration array in out-of-plane magnetic fields
$F^{cal,fit}(Nx, Ny)$
Parametrized fit to the $F^{cal}(Nx, Ny)$ or rules for numerical interpolation of the $F^{cal}(Nx, Ny)$ data that allows to relate a measured signal S to a unique H_z value (with sign) for each pixel (Nx,Ny)

1.6.7
MOIF calibration curve in out-of-plane magnetic fields
$\boldsymbol{F^{cal,fit}(Nx, Ny)}$
Parametrized fit to the $F^{cal}(Nx, Ny)$ or rules for numerical interpolation of the $F^{cal}(Nx, Ny)$ data that allows to relate a measured signal S to a unique H_z value (with sign) for each pixel (Nx,Ny)

1.6.8
setup calibration range
field range for which the calibration is valid

1.7. Terms related to the magneto-optical measurement process

1.7.1
lateral resolution in x and y
$\Delta x, \Delta y$
minimum distance at which two distinct magnetic features of a specimen are distinguishable. The lateral resolution depends on the optical system, the pixel size of the detection unit and on the properties of the MOIF

1.7.2
field biasing
applying a magnetic field to the MOIF during measurement process

1.7.3
magnification (ISO 10934:2020(en) 3.1.90, modified)
process of changing the apparent dimensions of an object by optical techniques

1.7.4
dynamic measurement range
ratio between the largest and smallest magnetic field value H_z that can be detected by a particular MOIF setup

1.7.5
image
representation of the MOIF measurement raw data, corresponding to points in the sample
Key control characteristics measured according to this standard

1.7.6
Data acquisition time
t
time period over which the detection unit integrates the intensity of the incoming light.

1.7.7
frame averaging (ISO 10934:2020(en) 3.2.22, modified)
averaging the pixel values from sequential images recorded under identical conditions

Note 1 to entry: Used to increase signal-to-noise ratio

1.7.8
number of averages
N
Number of averages used in the frame averaging of the MOIF images to enhance signal-noise-ratio

1.7.9
sensor calibration temperature
$T^{cal,sensor}$
Temperature of the sensor during the calibration. The temperature must not be identical with the environmental temperature during calibration since the sensor is heated by the illuminating light

1.7.10
environmental calibration temperature
$T_{cal,env}$
Temperature of the environment during calibration

1.7.11
sensor measurement temperature
Tcal,sensor
Temperature of the sensor during the calibration. The temperature must not be identical with the environmental temperature during calibration since the sensor is heated by the illuminating light

1.7.12
environmental measurement temperature
$T^{cal,env}$
Temperature of the environment during calibration.
Terms related to the magnetic field distribution of the sample

1.7.13
magnetic field distribution of a magnetic sample
H_z^{SUT}
magnetic field distribution of the perpendicular magnetic field component of the sample under test (SUT) in the measurement plane

1.7.14
raw magnetic field distribution of a magnetic sample
H_z^{raw}
Magnetic field distribution measured by the calibrated MOIF system without correcting for the MOIF sensor thickness effects and for contributions from in-plane components. This may significantly deviate from real magnetic field distribution

1.7.15
Effective magnetic charge density of a magnetic sample
σ_{eff}
Effective magnetic charge distribution of the perpendicular magnetic field component of the reference sample in the measurement plane or at the sample surface

1.7.16
magnetic field distribution of the sample under test
H_z^{SUT}
Spatial distribution of the perpendicular magnetic field component of the sample under test in the measurement plane

2. Key Control Parameters (KCPs) and typical values

2.1. Terms related to the magneto-optical measurement process

Key control characteristics	Identifier	Typical value	Comment	Category
MOIF sensor quality factor	Q		should be Q <1 for calibrated stray field measurement	
thickness of the MOIF	d^{MOIF}	5 µm	shall be small compared to typical structure sizes	
thickness of the reflective coating	d^{rc}	3 µm	should provide sufficient reflectivity	
MOIF anisotropy field	$B_{uoop,}$	110 mT		sensor parameter
calibration range		+/- 125 mT	~ 20% lower than B_{sat}	
saturation field	B_{sat}	160 mT		
Thickness of the protective coating	d^{pc}	2 µm		
polarizer rotation angle	(	45 °		
image size pixel size pixel number	$Sx \times Sy$ $\Delta x \times \Delta y$ $Nx \times Ny$	18 mm × 13 mm 5 µm × 5 µm 4140 × 2884		instrument parameter
measurement height	h	3 µm	average distance of sample effective surface to sensor	measurement parameter
z-component of the magnetic field distribution of the sample unter test	$H_z^{SUT}(x,y,z)$	within calibration range		sample data
measured raw data distribution	$S(x,y)$			measurement data
external perpendicular magnetic field for calibration	$H_z^{ext}(x,y)$	equal or larger than calibration range		setup data
MOIF calibration array in out-of-plane magnetic fields	$F^{cal}(Nx, Ny)$			calculated data

2.2. Ambient conditions during measurement

Key control characteristics	Identifier	Typical value	Comment
temperature	T	(23 ± 1.5) °C	Shall be kept within the specified range. The impact on the measurement depends on the setup.
humidity	H	(50 ± 4) %	Shall be kept within the specified range. The impact on the measurement depends on the setup.

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