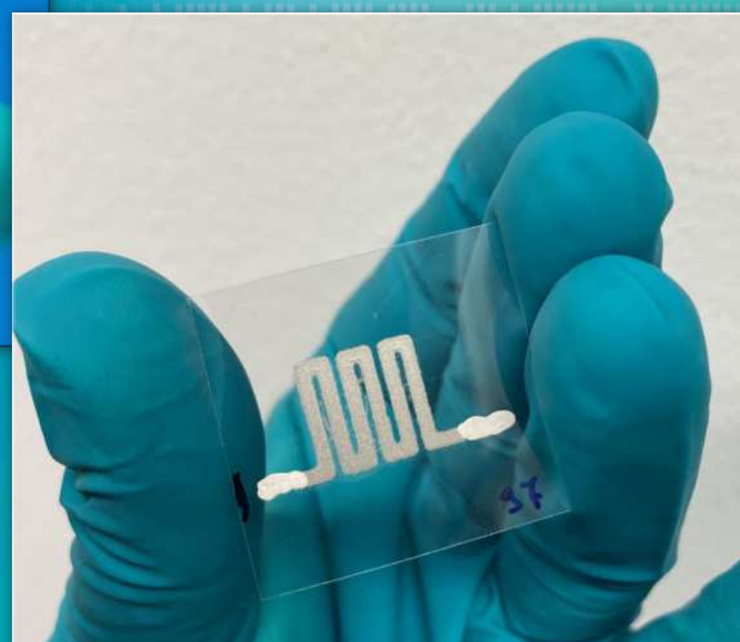
CONTRIBUTED PRESENTATION
IN POWERPOINT FORMAT
FROM THE 2023 TECHCON

Adapted from a Powerpoint Presentation that was presented at the 2023 66th TechCon

Synthesis of Magnetic Particles for Printable Inks and Pastes by Sputtering for Sensor Applications



By Morris Ott[1], Thomas Preussner[1], Mykola Vinnichenko[2], Clemens Voigt[2], Sindy Mosch[2], Denys Makarov[3], Eduardo Sergio Oliveros Mata[3], Kerstin Täschner[1], Jörg Neidhardt[1]

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Printed magnetoresistive sensors are paving the way for novel applications like contactless flexible electromagnetic switches and touchless human-machine interfaces. The reported sensors, which can be processed with industrial printing methods, are based on non-saturating large magnetoresistance materials like bismuth. However, due to their limited sensitivity in the low field range certain applications like smart textile technologies and safety wearables are still not accessible. To overcome these limitations, a scalable technological approach, called MAG4INK, will be presented for the preparation of printed flexible anisotropic magnetoresisitve (AMR) sensors with a sensitivity in the low field range.

The combination of high quality PVD layers, utilizing the superior process control for the synthesis of ultrapure magneto resistive material with an adjustable morphology and structure, and advanced printing technologies is the core of the MAG4INK technology. Therefore, 100 nm thin magnetic films were coated on a sacrificial layer, released by a lift off process and processed via ultrasound milling to powder. By using this powder to formulate printable inks and pastes for printing in combination with innovative high-power diode laser array post-processing, it is currently possible to realize sensors with a magnetoresistive effect of about 0.5 % in magnetic fields of ±6 mT, with the goal of shifting the sensitivity into sub mT range.

The utilization of high rate tubular cathodes and high throughput in-line PVD equipment ensures yields of several grams of powder per day. The approaches for solving the challenges of manufacturing of iron (Fe) and permalloy (NiFe) thin films as well as the source technology for stable magnetic sputtering will be shown. The synthesis-structure-property relations of the resulting films will be presented.

Note from Managing Editor: We are delighted to share with the readers of the Bulletin some of the interesting Powerpoint Presentations from past TechCons. We hope you find them as interesting as we do.

Sue Taube/Managing Editor

Synthesis of Magnetic Particles for Printable Inks and Pastes by Sputtering for Sensor Applications

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SYNTHESIS OF MAGNETIC PARTICLES FOR PRINTABLE INKS AND PASTES BY SPUTTERING FOR SENSOR APPLICATIONS

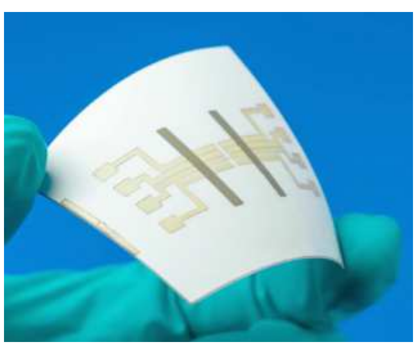
Fraunhofer FEP | HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF | Fraunhofer IKTS

Synthesis of magnetic particles for printable inks and pastes by sputtering for sensor applications

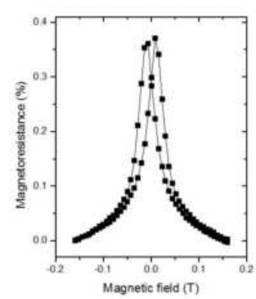
Morris Ott, Thomas Preussner, Mykola Vinnichenko, Clemens Voigt, Sindy Mosch, Denys Makarov, Eduardo Sergio Oliveros Mata, Kerstin Täschner, Jörg Neidhardt

11th May 2023 session thin film sensors SVC

Anisotropic Magnetoresistance as an sensor application



changing the direction of an external magnetic field, applied on an AMR sensor, leads to a change in sensors resistance



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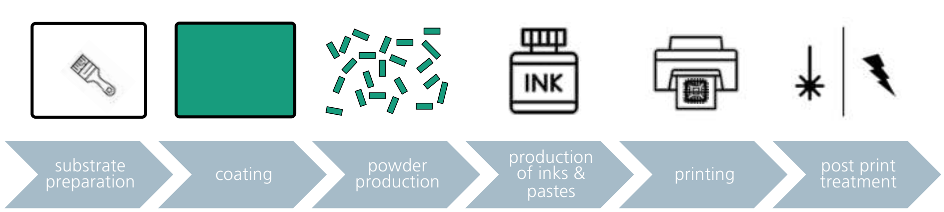
Processing Chain for magnetic particles for an AMR sensor application



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Processing Chain for magnetic particles for an AMR sensor application

substrate preparation

cleaning of the float glass

1200 x 600 mm²
+
coating with organic sacrificial layer

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Fraunhofer FEP

Substrate preparation

- Ultrasonic wet cleaning using detergent
- max. 600 x 1200 mm²
- 30 µm … 6 mm
- Water conductivity

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Fraunhofer FEP

Processing Chain

coating

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Fraunhofer FEP

SYNTHESIS OF MAGNETIC PARTICLES FOR PRINTABLE INKS AND PASTES BY SPUTTERING FOR SENSOR APPLICATIONS

Pilot coating equipment at FEP

10 process stations

DC and PMS
PVD and PECVD
Planar and cylindrical

max. 600 x 1200 mm²

Room temperature
Pre- and Postannealing
FLA

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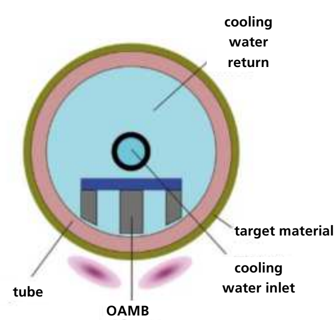
AMG TITANIUM ALLOYS & COATINGS GfE Fraunhofer FEP

Iron sputtering with an In-situ adjustable magnetbar



e-REFLEX In-situ adjustable magnetbar

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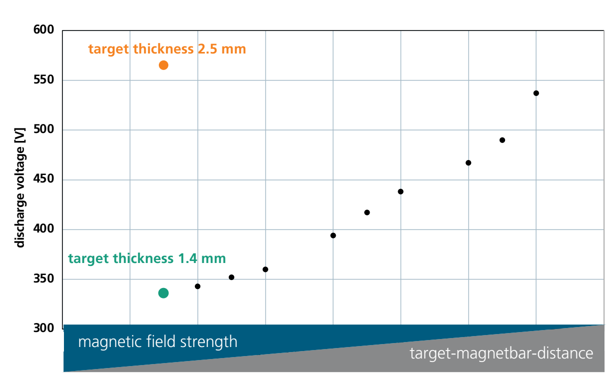
Fraunhofer FEP

Iron sputtering with an In-situ adjustable magnetbar

$R_{dyn}=22\ldots28\ \frac{nm \cdot m}{min}$ (P= 4 $\frac{kW}{m}$)

Targeted control of the discharge voltage and particle energy by adjusting the magnetic field



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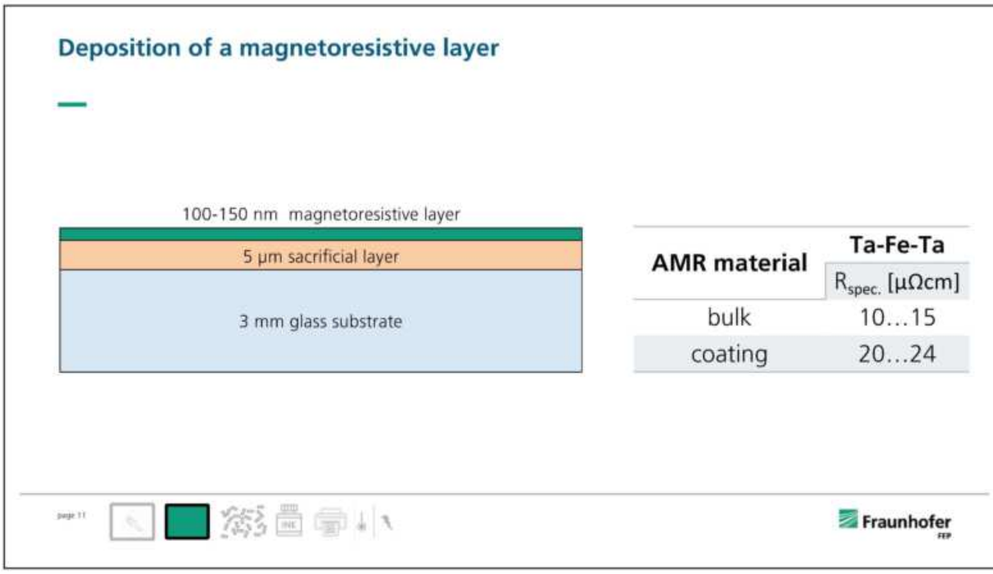
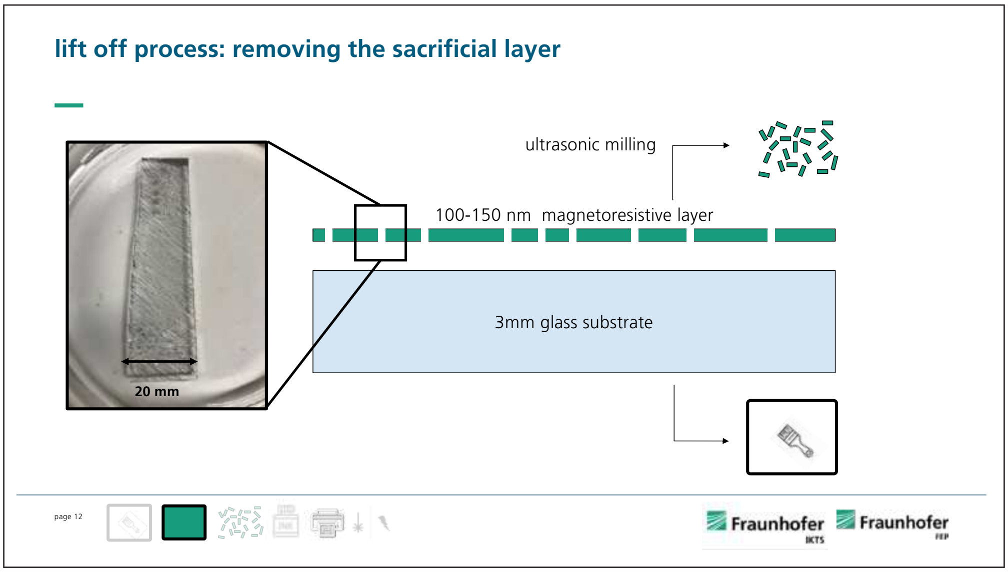
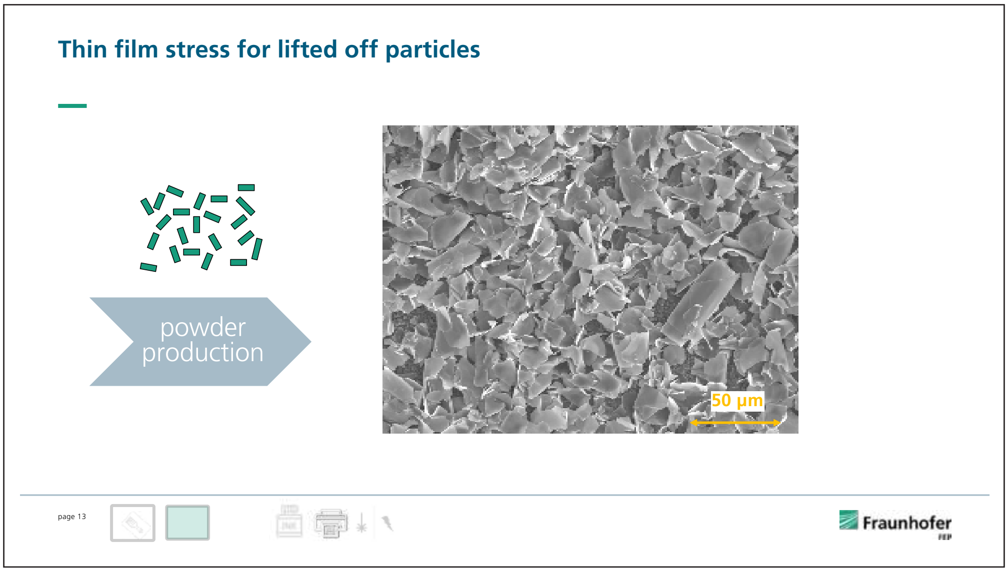
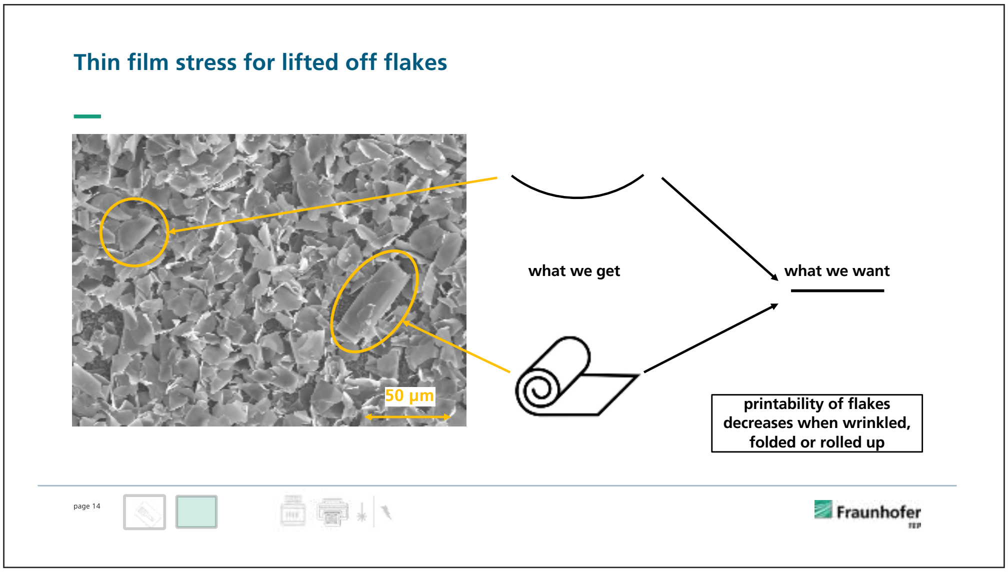
AMG TITANIUM ALLOYS & COATINGS GfE Fraunhofer FEP

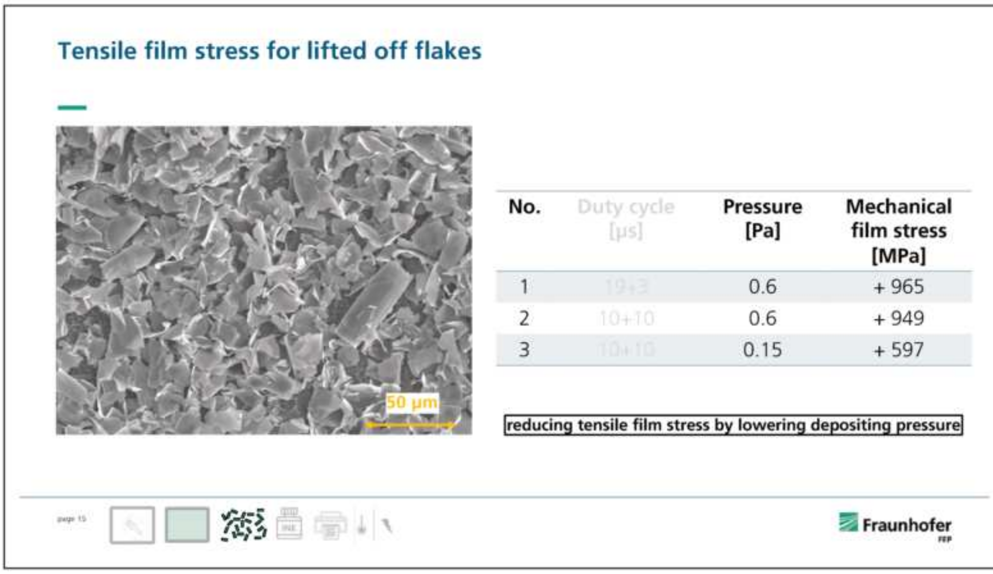

Deposition of a magnetoresistive layer
100-150 nm magnetoresistive layer
5 µm sacrificial layer
3 mm glass substrate
AMR material
Ta-Fe-Ta
R spec. [µΩcm]
bulk 10…15
coating 20…24
Fraunhofer
FEP

SYNTHESIS OF MAGNETIC PARTICLES FOR PRINTABLE INKS AND PASTES BY SPUTTERING FOR SENSOR APPLICATIONS








Tensile film stress for lifted off flakes
50 µm
No. | Duty cycle [µs] | Pressure [Pa] | Mechanical film stress [MPa]
1 | 19+3 | 0.6 | + 965
2 | 10+10 | 0.6 | + 949
3 | 10+10 | 0.15 | + 597
reducing tensile film stress by lowering depositing pressure
Fraunhofer
FEP

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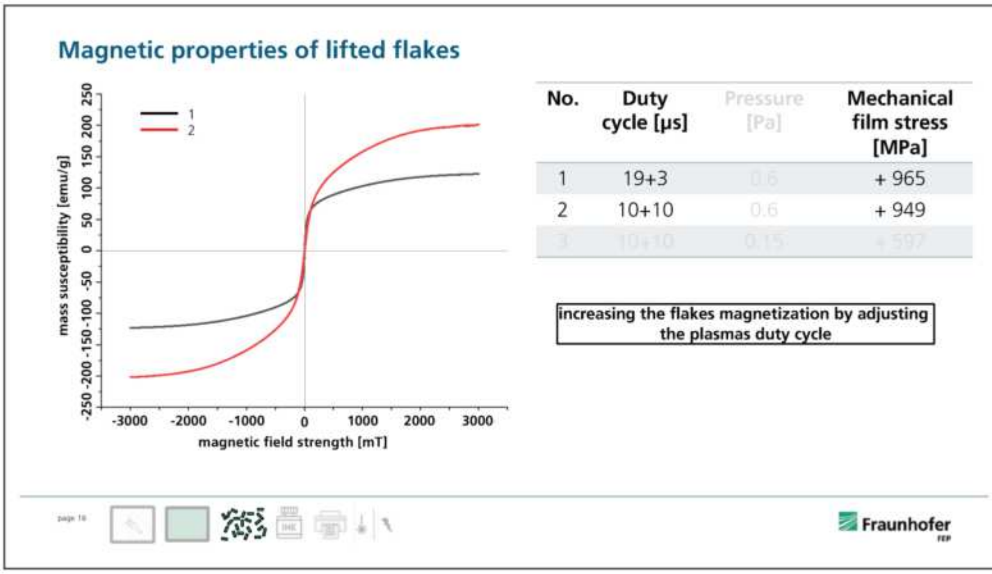


Powder manufacturing productivity

one Run: 40 minutes with three substrates (400 x 400 mm²)

→ 0.4g AMR material

→ **4.7g per day**

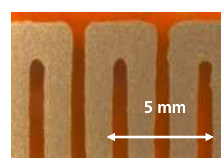
23.4g per week

→ **22 weeks** for **500g** AMR material **<u>under laboratory conditions</u>**

→ enough material for **80 Mio. sensors**

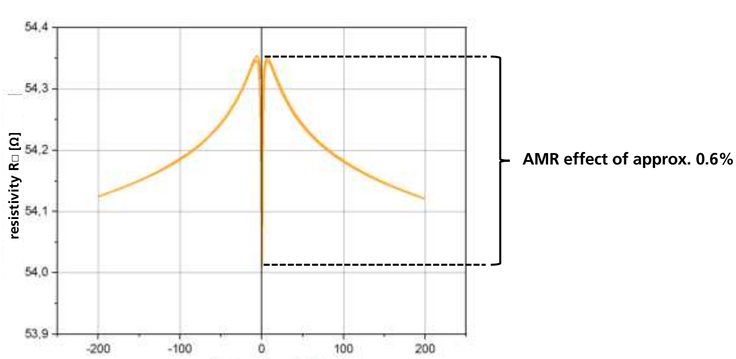
from powder to sensor

- Choice of binding agent
- Control of ink and paste viscosity
- Particle shape



- Choice of printing technology
- Ratio particles/binder after printing
- Thickness and defects of printed structures

AMR properties for Permalloy (NiFe) as ink material



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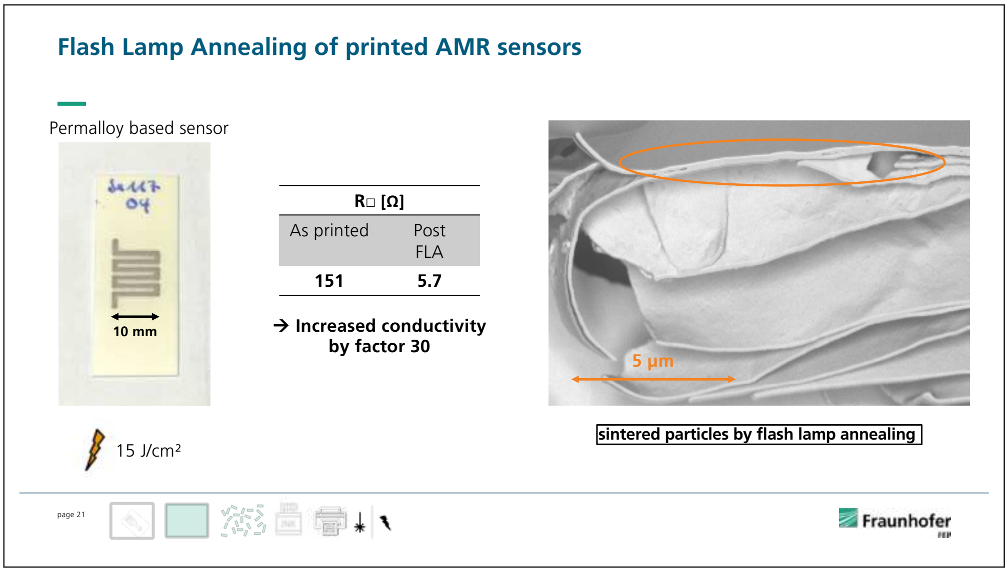

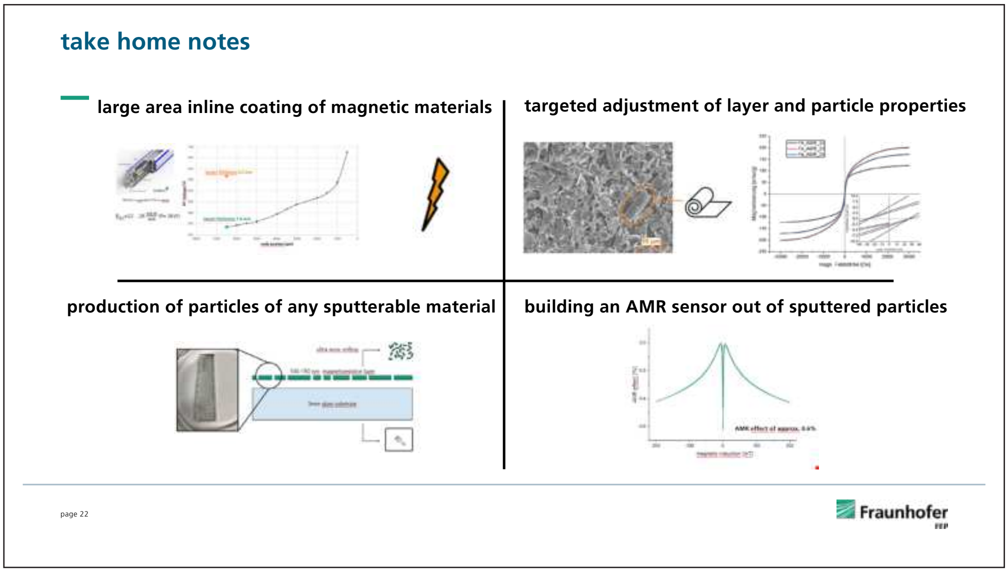

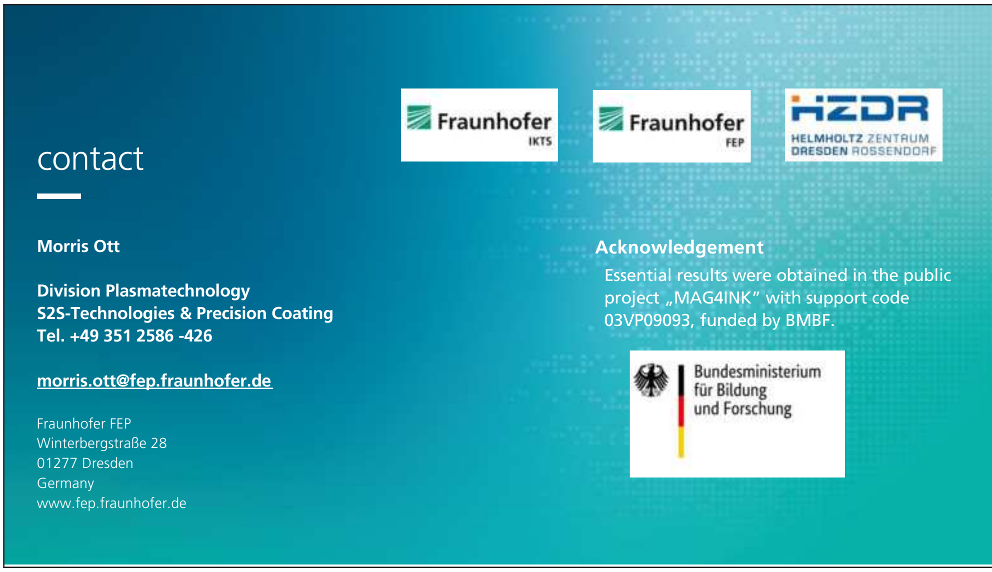

About the Author:
Morris Ott

Morris Ott studied material science at the Technical University in Ilmenau, Germany with specialization to thin film technologies. In 2019 he graduated in the topic of large area, rf-sputtered ITO. Since then, he works as process engineer and project manager at the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP in Dresden. His work is devoted to applied research in fields of thin films, physical vapor deposition, plasma and vacuum technology as well as Flash Lamp Annealing.