EPIC
EUROPEAN PHOTONICS INDUSTRY CONSORTIUM

Fraunhofer IPMS

Fraunhofer Institute for Photonic Microsystems IPMS

EPIC Online Technology Meeting on Photonics for Quantum Industry

Patrick Engelmann
Fraunhofer IPMS, Dresden, Germany

Photonic and Microelectronic Technologies for Quantum Systems

Fraunhofer IPMS

Your Partner for Electronic and Photonic Microsystems

Fraunhofer IPMS is a leading international research and development service provider for electronic and photonic microsystems in the application fields of Smart Industrial Solutions, Bio and Health, Mobility as well as Green and Sustainable Microelectronics.

Quality Management

ISO 9001

www.dekra-seal.com

At a Glance

- > 600 employees
- 4 sites

- € 84 M annual turnover
- € 34 M industrial revenue

- 200 mm wafer fabs for MEMS / MOEMS & microdisplays
- 300 mm wafer fab for micro- and nanoelectronics

Plan 2026

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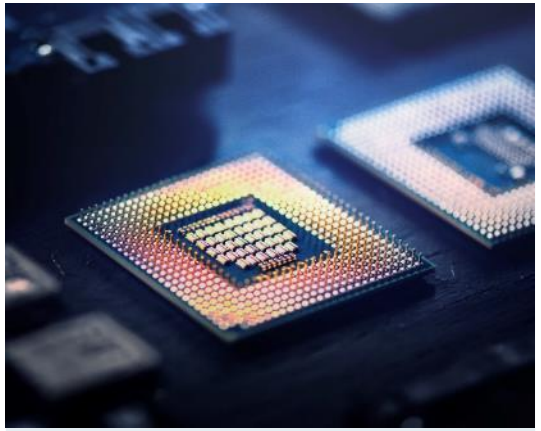
Overview

Quantum Technologies

Quantum Foundry

- Quantum manufacturing “from lab to fab” –scalable quantum manufacturing technologies

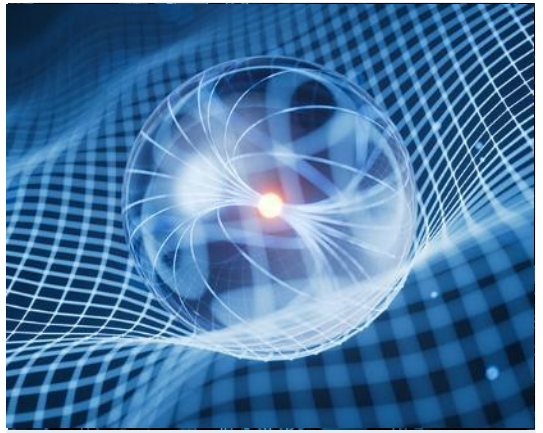


Quantum Computing

- Qubit manufacturing technologies
- New and optimized materials, processes and integration concepts for cryoelectronics

Quantum Communication

- Quantum key distribution (QKD)
- Quantum random number generation (QRNG)



Quantum Sensing

- CMOS-integrated NV technology for the next generation of quantum sensing

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Quantum Foundry

Quantum Manufacturing “From Lab to Fab”

The ability to develop proprietary technologies for industrial-scale quantum technology manufacturing is crucial for technological sovereignty.

Fraunhofer IPMS leverages its expertise in micro- and nanotechnologies, semiconductor processes as well as assembly and interconnect technologies to establish the foundation for scalable quantum technologies.

Our research focuses on:

- Qubit fabrication
- Integration of control and readout systems
- Materials and process development

Our value proposition

- Industry-grade infrastructure
- Long-standing expertise in scalable 300 mm technologies

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Quantum Computing

Made in Germany

Quantum computers have the potential to exceed the limits of conventional computing systems many times over. Fraunhofer IPMS is therefore conducting research together with German and European partners on scalable technologies for semiconductor qubits.

Our research topics at a glance:

- Industry-oriented, CMOS-compatible manufacturing methods
- Qubits and their electronic interfacing (Si/SiGe, Si-MOSFET and superconductors)
- New and optimized materials, processes and integration concepts for cryoelectronics
- Superconducting metallization concepts
- Manufacturing processes for nanostructuring

Our value proposition

- Large scale integration of quantum concepts with silicon technologies
- Industrial standard test bed for start-ups, SMEs and universities
- Link to semiconductor fabs

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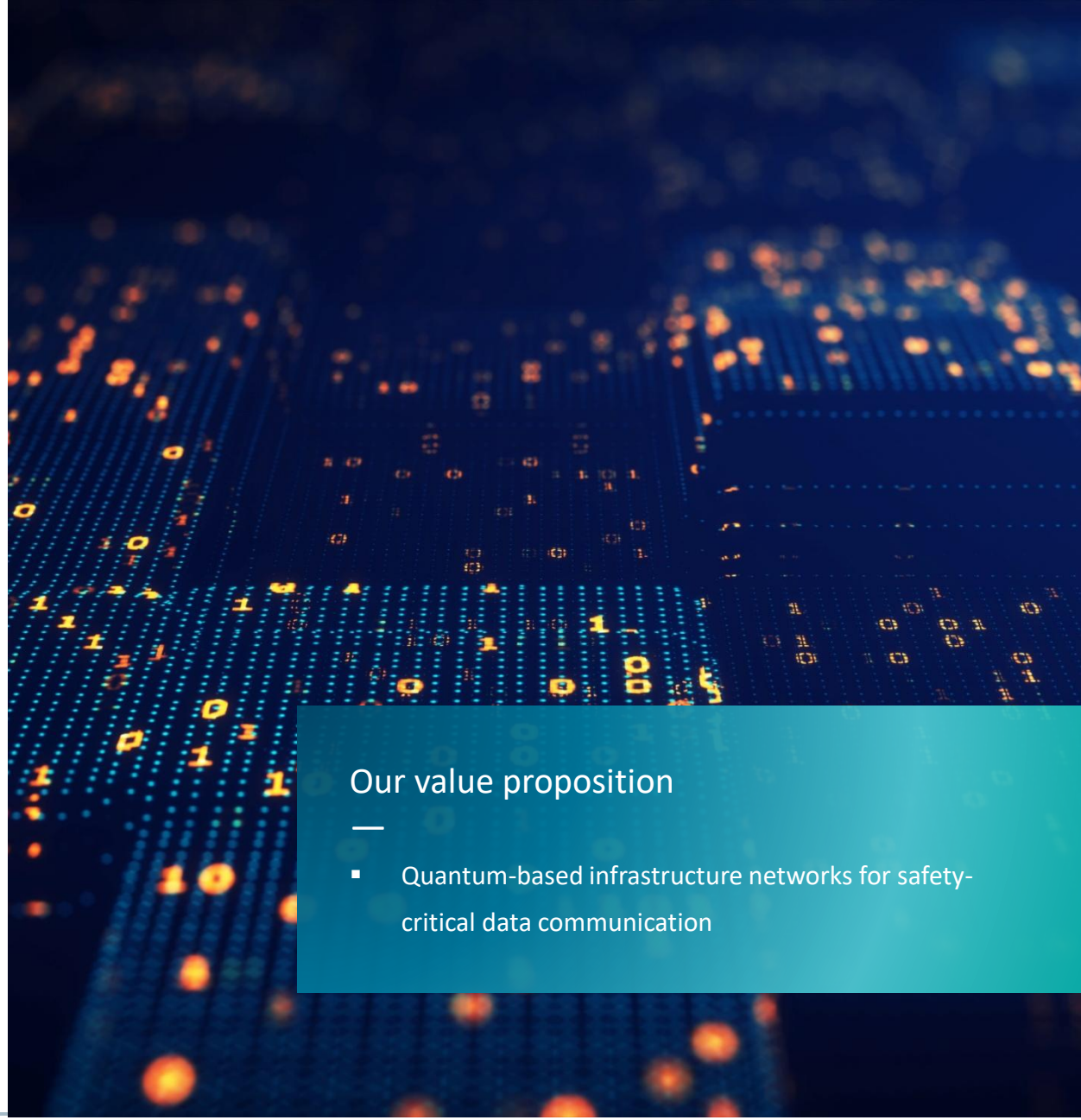
Quantum Communication

Secure Data Communication

In quantum communication and quantum encryption, developments focus on secure and private data communication. Here, classical encryption approaches based on computational complexity are to be replaced by novel quantum key distribution approaches in combination with post-quantum cryptography.

Our research focuses on:

- Adhoc / Mini Quantum Key Distribution (QKD) for mobile applications and secure communication over shorter distances
- QKD protocols
- Quantum Random Number Generators (QRNG) that increase cryptographic security
- Beam steering systems for use in quantum technologies



Our value proposition

- Quantum-based infrastructure networks for safety-critical data communication

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Quantum Sensing

CMOS-integrated NV Technology

With CMOS-integrated NV sensors, Fraunhofer IPMS is developing a platform that enables highly sensitive quantum magnetometry at room temperature while leveraging the scalability, robustness, and energy efficiency of modern microelectronics.

Our research focuses on:

- CMOS backplane from an industrial foundry which is then expanded at Fraunhofer IPMS through wafer-based post-processing into a complete quantum sensor unit
- Full integration of all components – light source, microwave control, photodetection, and readout electronics
- Multi-channel arrays enabling multidimensional, potentially imaging-capable detection of magnetic fields down to the micrometer scale

Our value proposition

- Compact and energy-efficient quantum sensing modules which work at room temperature
- Scalable, CMOS-integrated technology

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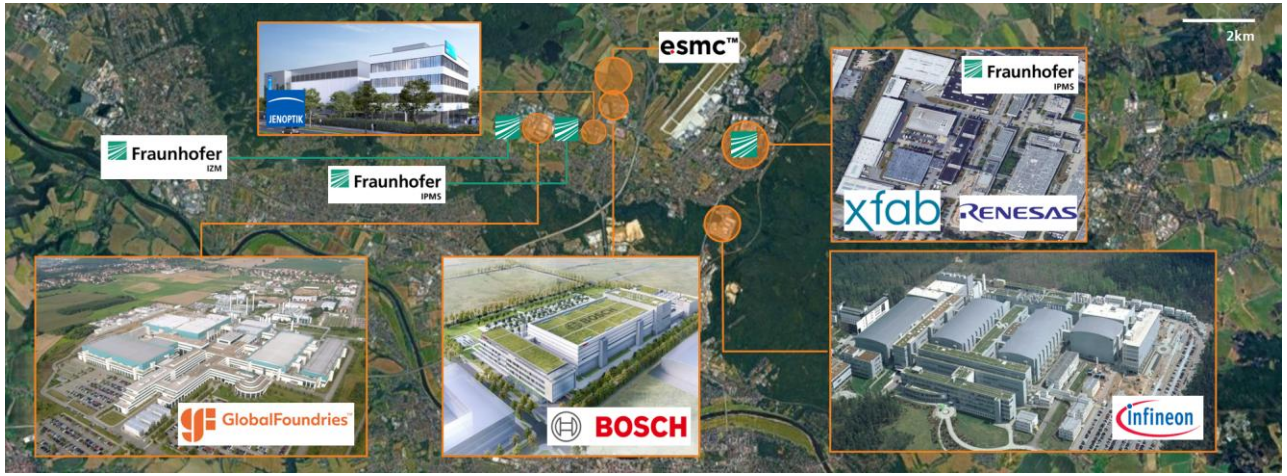
Introduction – OLED-on-Silicon for Quantum Sensing

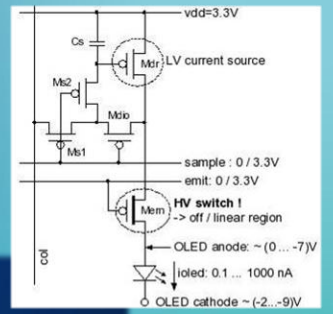
Dr. Uwe Vogel
Division Director Microdisplays & Sensors

Location: Dresden/Germany („Silicon Saxony“)

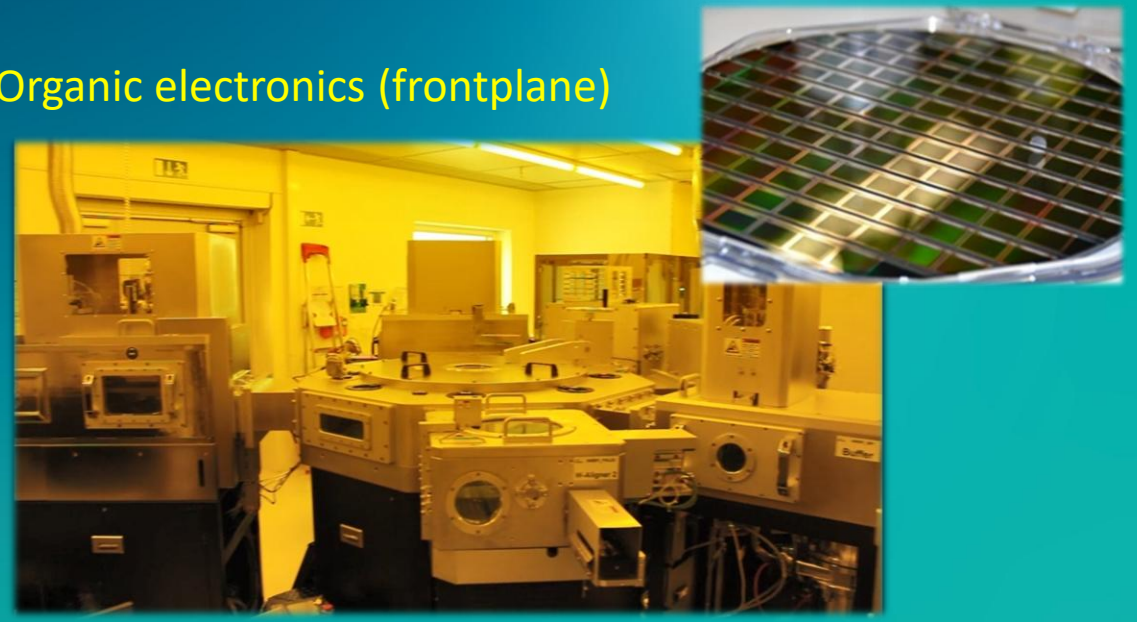


Core competences

IC design (backplane)



Organic electronics (frontplane)



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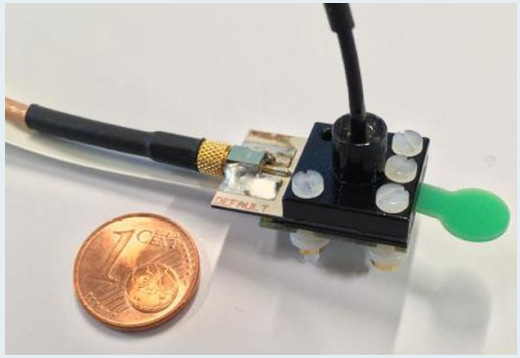
CMOS Integration of Quantum Sensing

Motivation

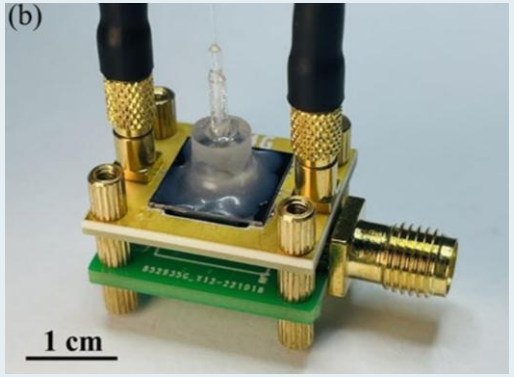
Goal

- **Fully integrated** quantum sensing system based in NV technology **including**
  - **Optical excitation**
  - **Microwave excitation** (MW) including **generation**
  - **Optical detection**
  - **Control** circuitry
  - **Read-out** circuitry

Current state



Stürner, F. M. et al., „Integrated and portable magnetometer based on nitrogen-vacancy ensembles in diamond“, Advanced Quantum Technologies, 2021



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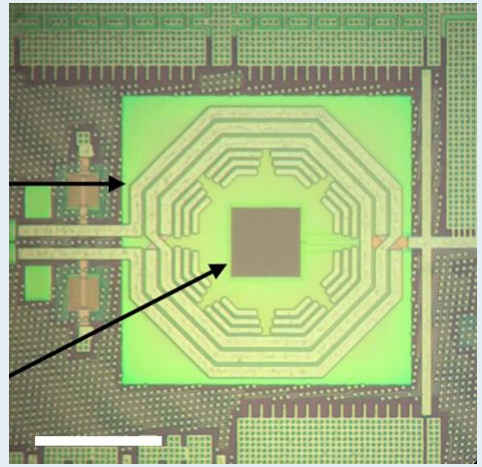

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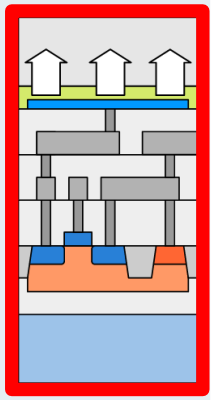
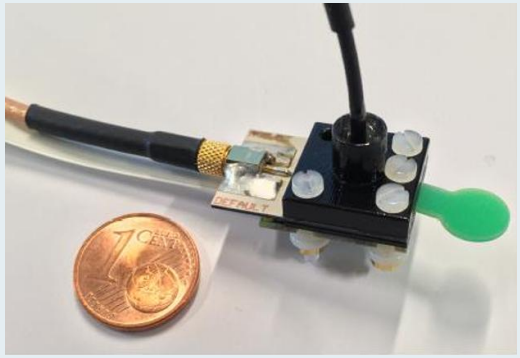


OLED-on-Silicon

Current state



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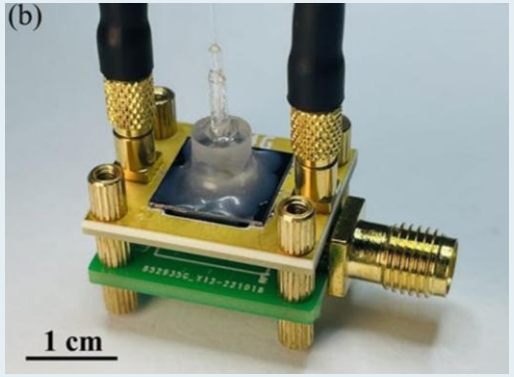

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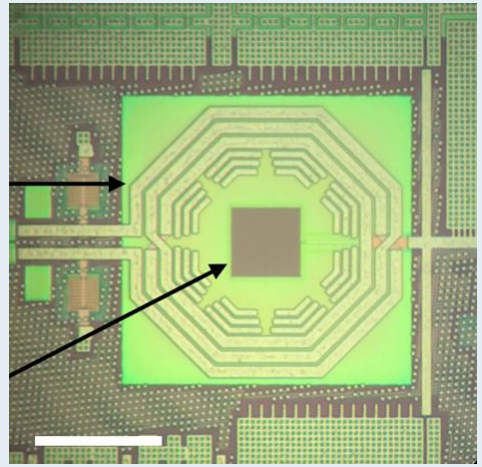

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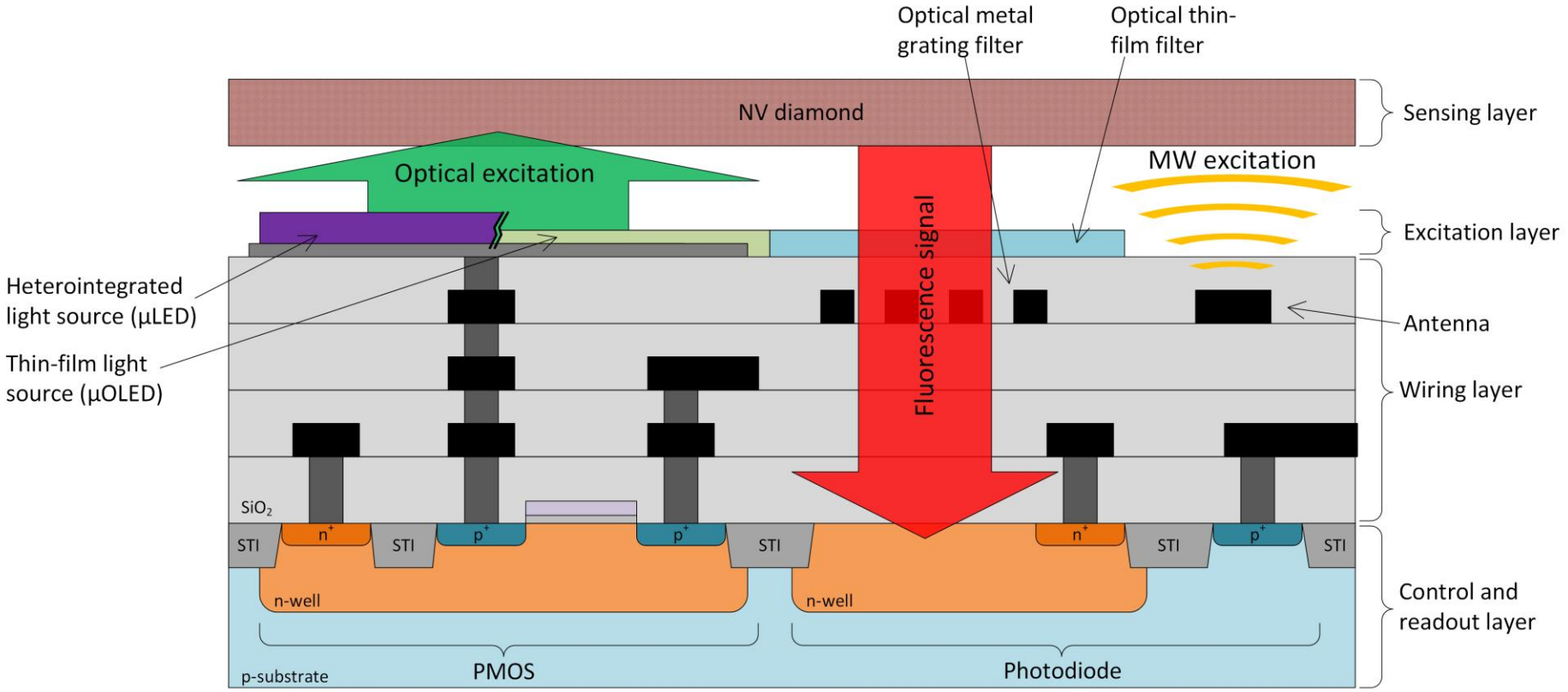
CMOS-integrated optical Quantum Sensing Platform



Advantages

- **Complete system** integration
- **Small** sensor **footprint** (µm range)
- High **fill factor**
- **Array** scalability

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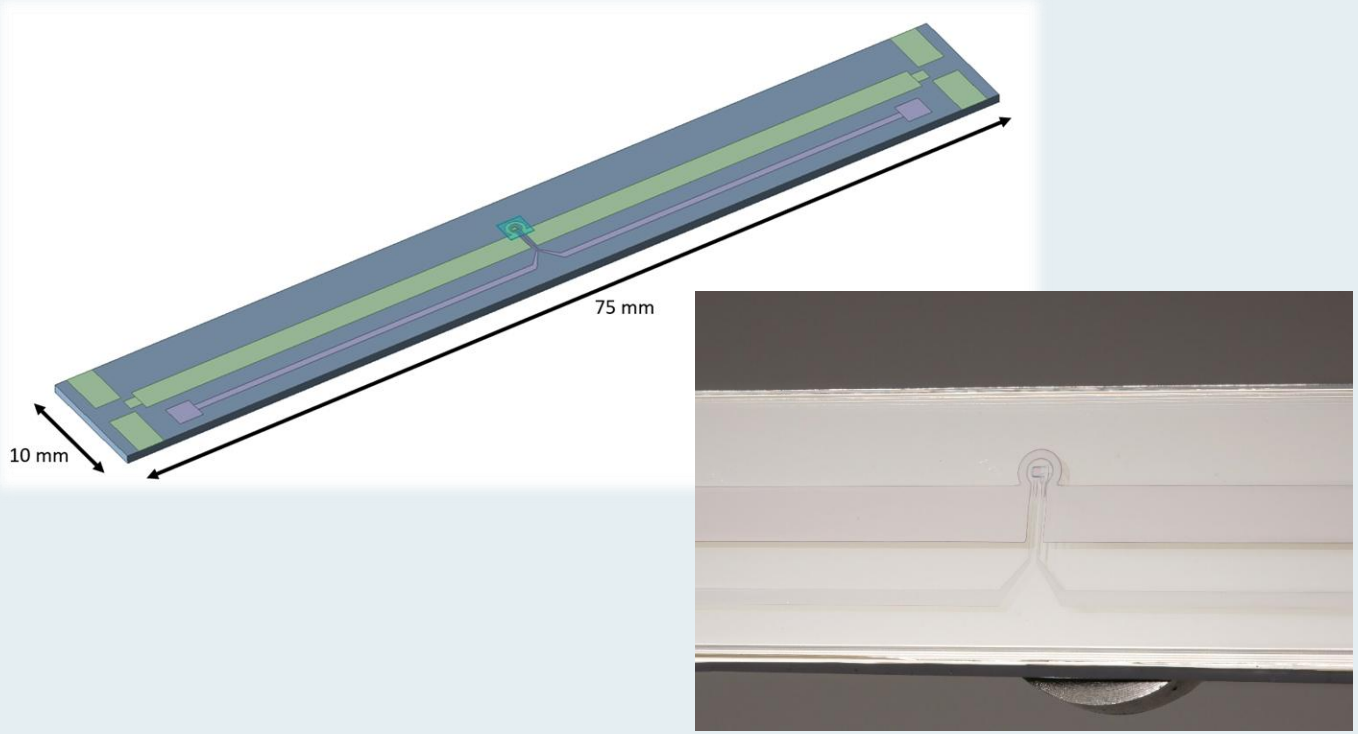
Proof-of-Concept Experiments

CMOS Quantum Sensing Technology Demonstrator

Goal

- Test device for **technology optimization**
  - OLED optimization
  - NV diamond optimization
  - Investigation of material / technology interface between OLED-on-Silicon and NV-diamond technology

Design



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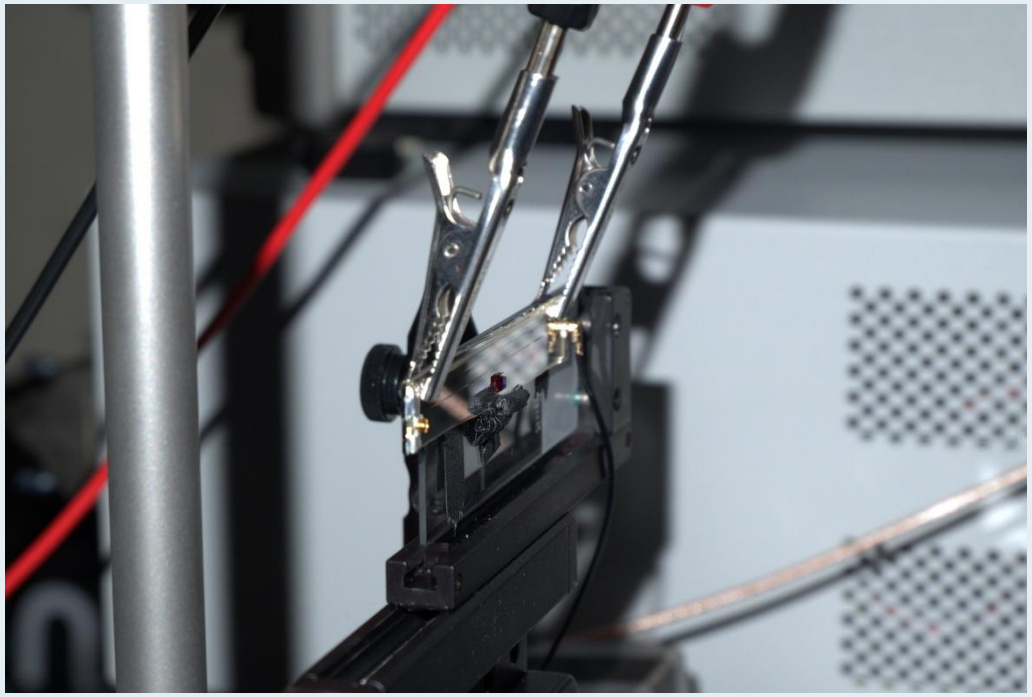
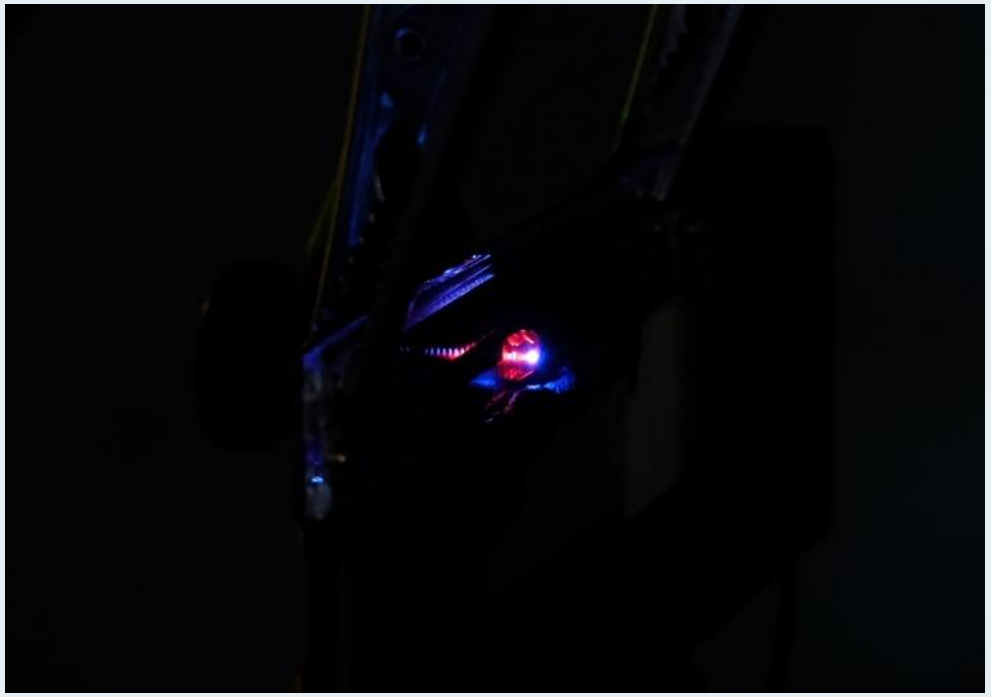
Proof-of-concept experiments

CMOS Quantum Sensing Technology Demonstrator

Test setup



Results



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What are we looking for and how can you work with us?

Cooperation with us is possible in different ways – depending on your goal, your business and your budget

Direct Order Projects

If you have clear objectives and if you want us to develop tailor-made solutions for your company, we recommend a direct order.

At the end of this project, you are the sole recipient of the results of our research.

Publicly Funded Projects

Nationally or internationally funded joint projects with larger research consortia are suitable for overarching topics.

At the end of the project, all results are available to all project partners.

Strategic Partnership

For long-term technology development in a field, we can not only advise you on the technical side and develop a solution for you, but also plan your roadmap with you.

Licensing

We conduct internal preliminary research to develop promising technologies at an early stage.

As a licensee, you can bring the technologies to application in your company.

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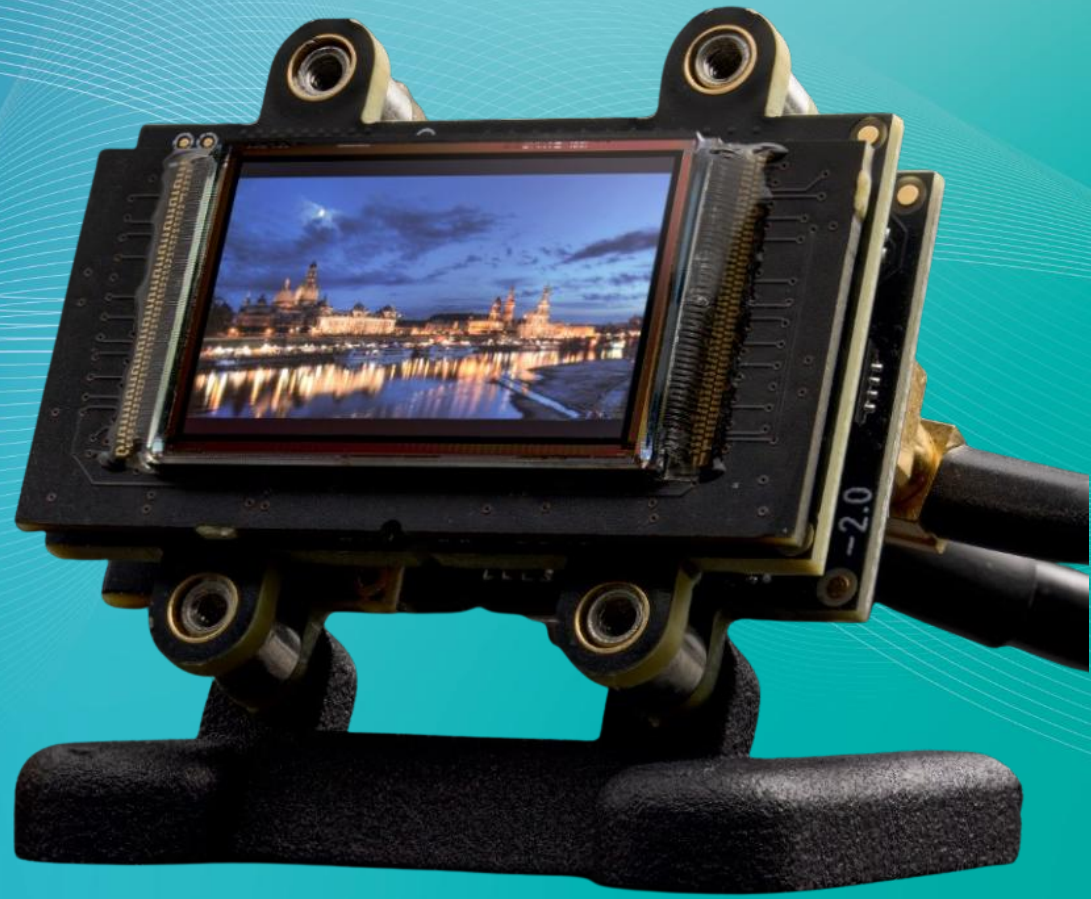
Thank you for your attention!

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