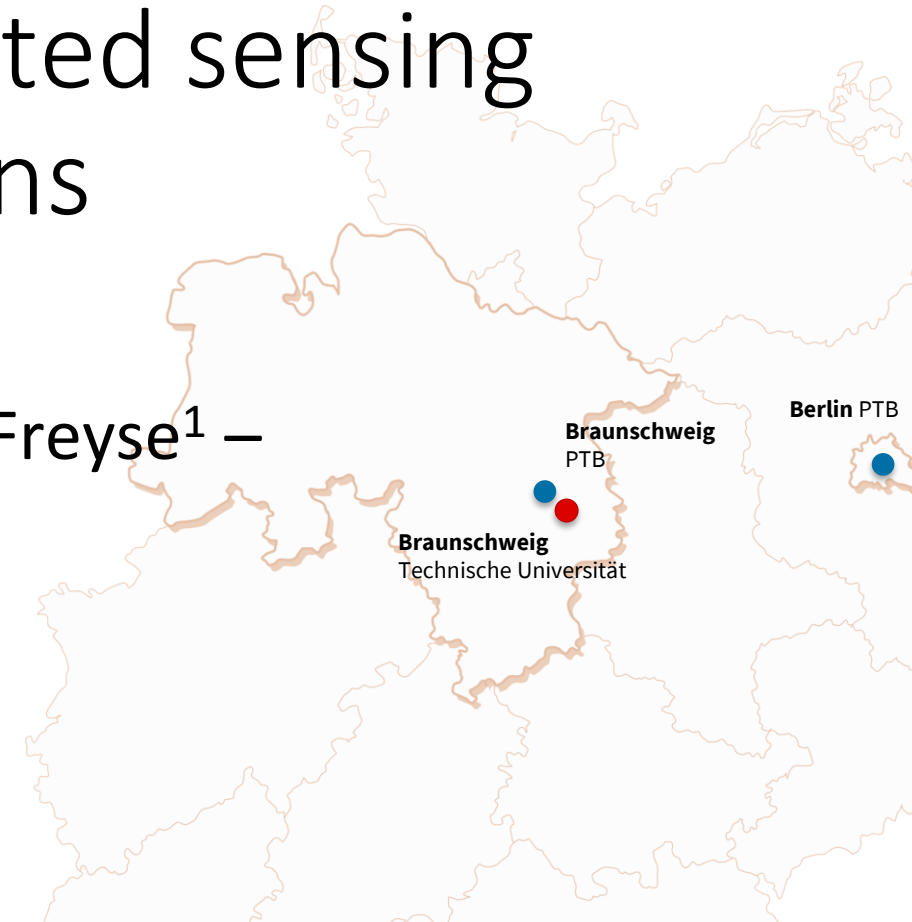


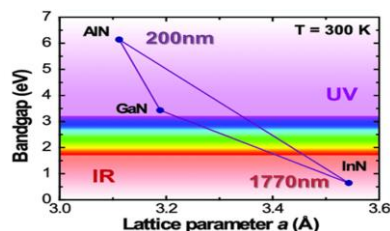
Integrated light for distributed sensing and new metrology solutions

Olav Werhahn¹, J. Daniel Prades², Joanna Freyse¹ –
Physikalisch-Technische Bundesanstalt
GERMANY



Nitrides: The second pillar of microelectronics

Silicon (The CMOS king):
 not the best in anything
 ... but on the price
 ... +70 advantage.



(In,Al,Ga,...)+N

Solid State Lighting



5G/6G Mobile Communication



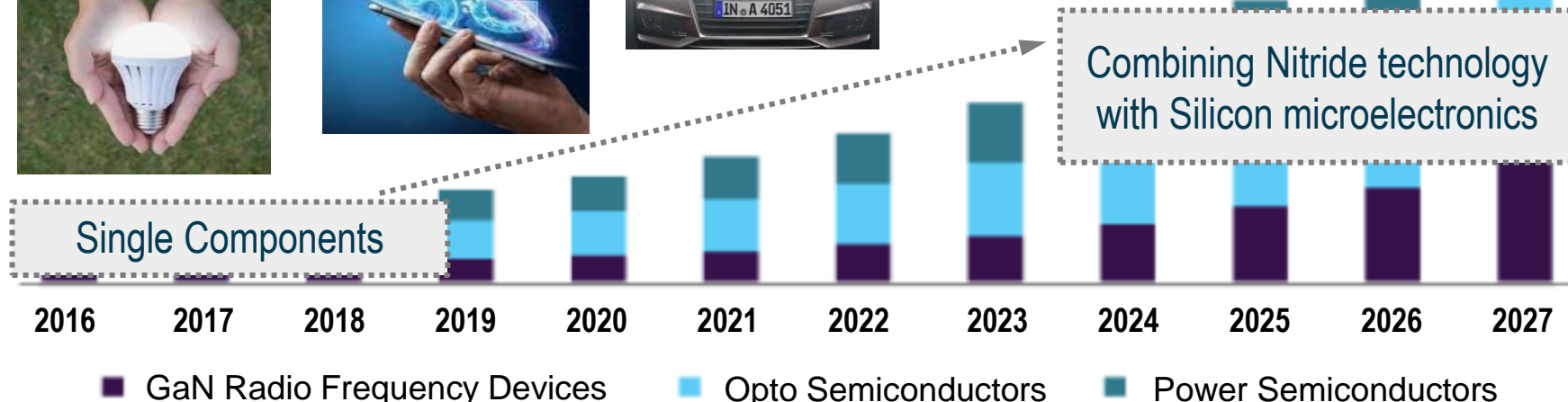
Automotive UV Desinfection



Power Electronics



Sensing Metrology
 Artificial Intelligence
 Quantum Computing



Combining Nitride technology with Silicon microelectronics

Single Components

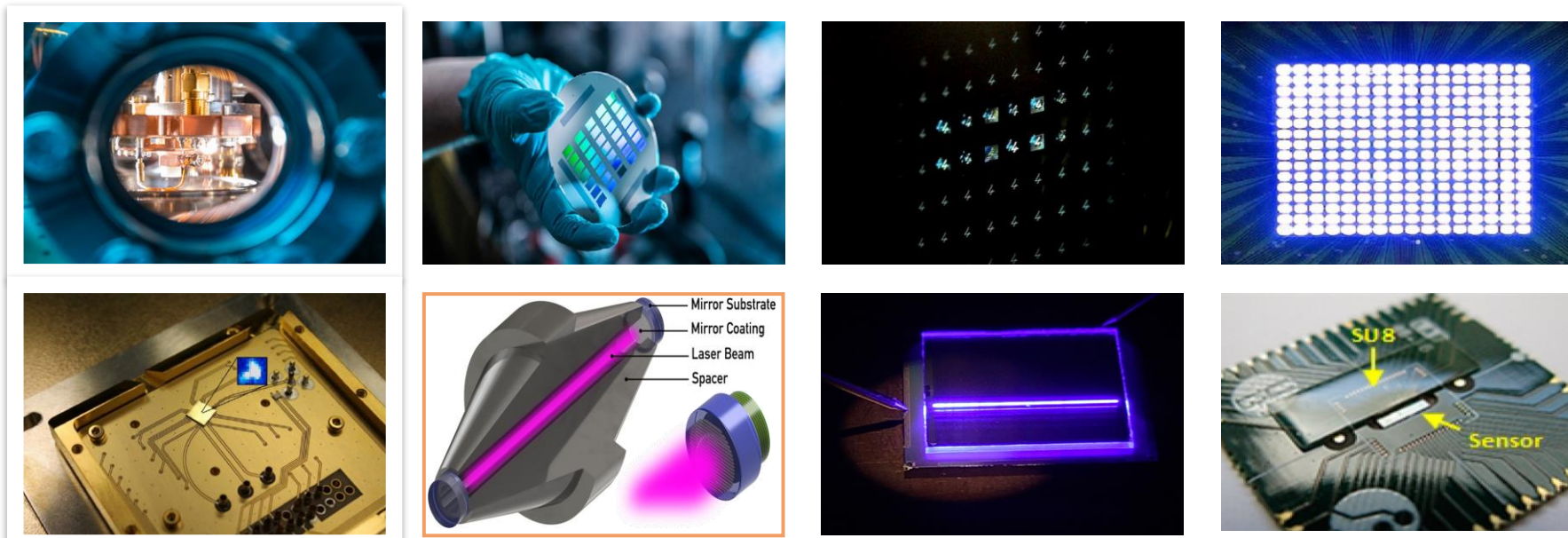
■ GaN Radio Frequency Devices

■ Opto Semiconductors

■ Power Semiconductors

CAGR 20% (2020-27)

Nitrides from Quantum Tech



**Ion-based
Quantum Computing**

**Meta-mirrors
Resonator Cavities**

Integrated Photonics

**MicroLED/VCSEL Arrays
Single-Photon Detectors**

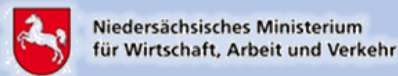
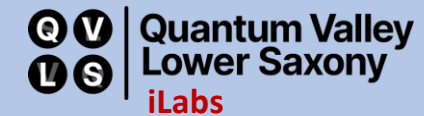
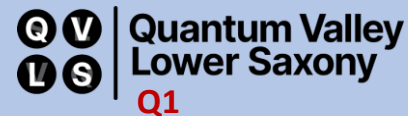
quantum for metrology and computing

50-Qubit Quantum computer

transfer QT to Industry



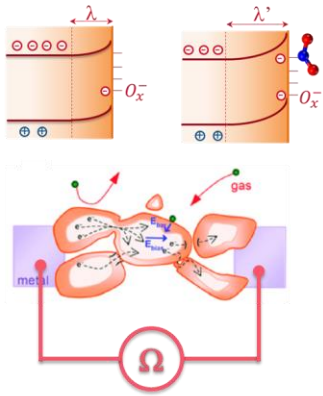
QuantumFrontiers
Cluster of Excellence



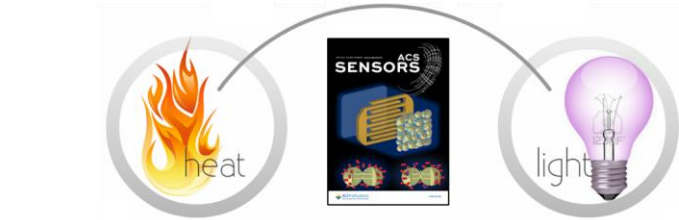
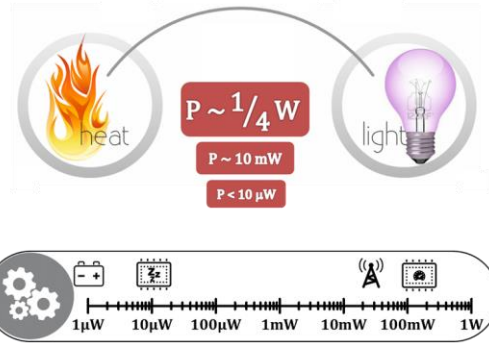
Alexander von HUMBOLDT STIFTUNG J. Daniel Prades daniel.prades@tu-braunschweig.de

Semiconductor Gas Sensing

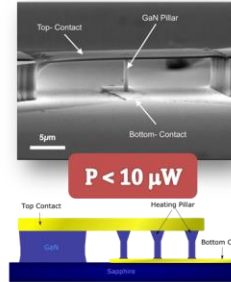
$R(\lambda(gas))$



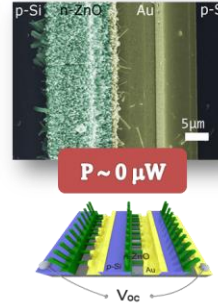
Power Consumption



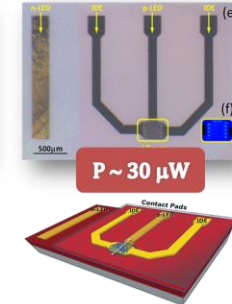
Top Down Self-Heating



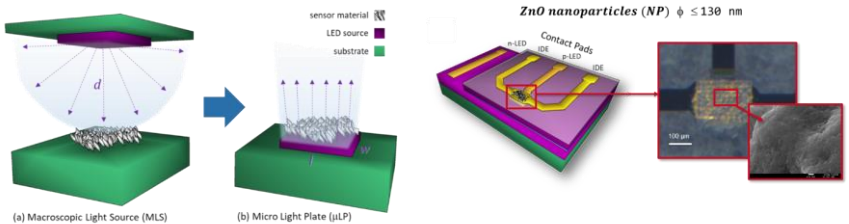
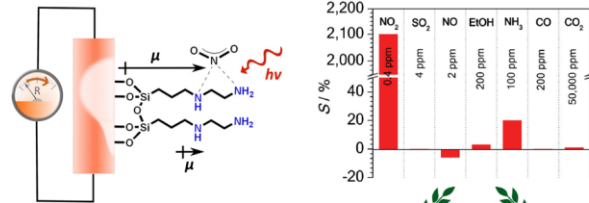
Zero-Power Devices



Micro-Light-Plates

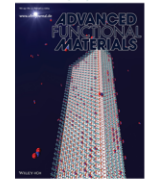
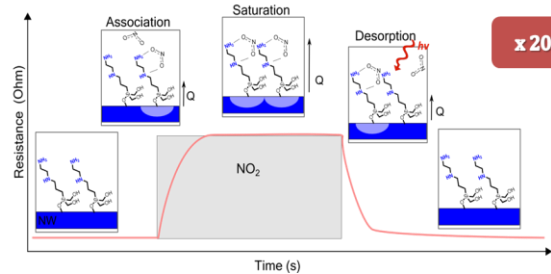
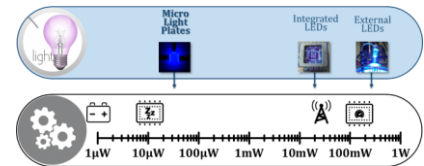


Specificity



Appl. Phys. Lett. 114, 053508 (2019)

Micro LEDs

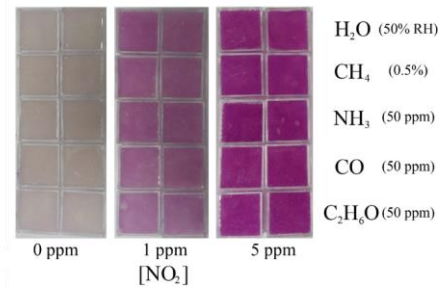
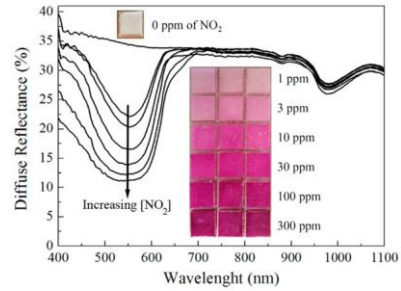


Colorimetric Gas Sensing



Colorimetry

Sens. Actuators B: Chem. 293, 41-44 (2019)



3) Digital ID 2) References

< 0.001€

1) Sensor

Ultra-Low-Cost Sensors

Smartphone color analytics

Our technology enables the digitalization of any color-based test.

ColorSensing tracking true colors

Accurate and automatic quantification of a color/intensity change based assay.



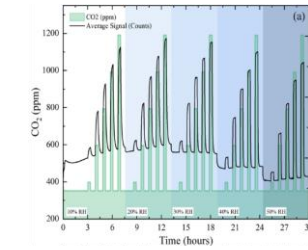
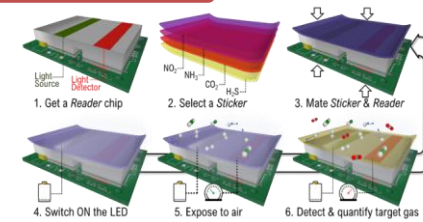
Accurate and automatic reading of a color change based assay for virus detection & quantification

100% quality control for packaged foods

We help manufacturers and retailers cut down waste and ensure safety.



Chip-Colorimetry Patent (2020) EP3320567B1



< 100 μW

Sensor Ink Photodiode LED



J. Daniel Prades daniel.prades@tu-braunschweig.de

MicroLED Arrays

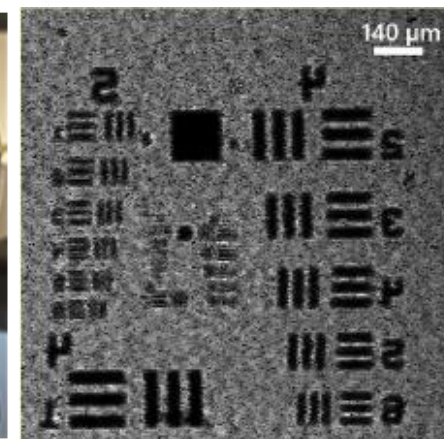
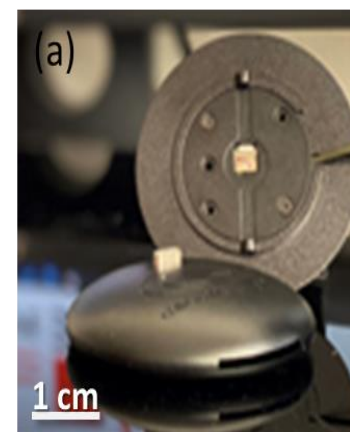
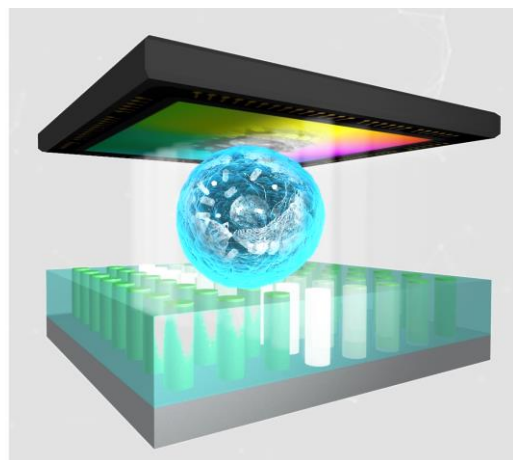
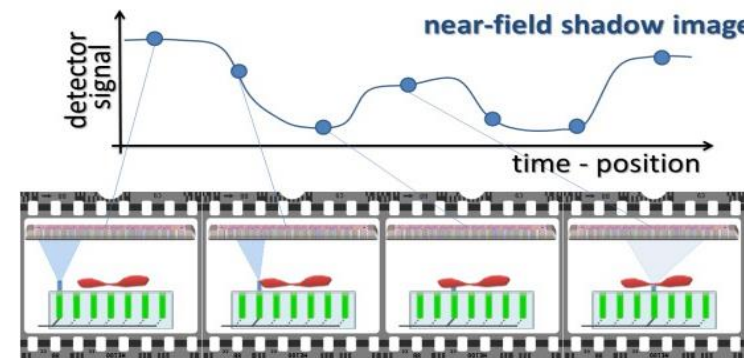
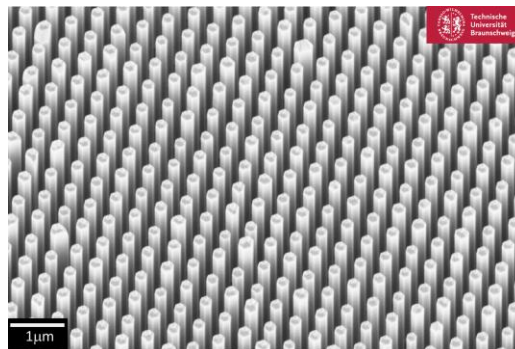
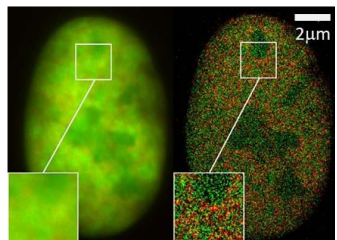
Microscopy On-a-Chip

An optical microscope on a chip ...



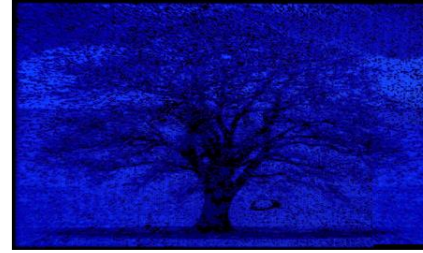
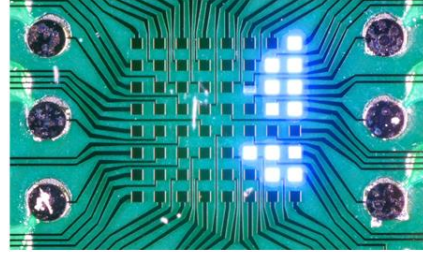
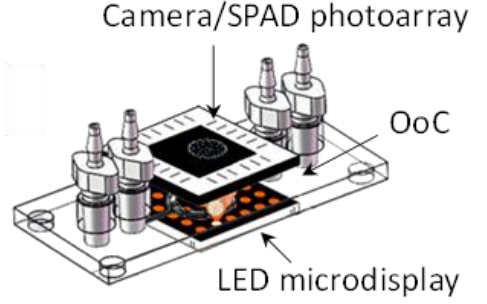
... with superresolution capabilities

$$\text{feature size} < \frac{\lambda}{2}$$

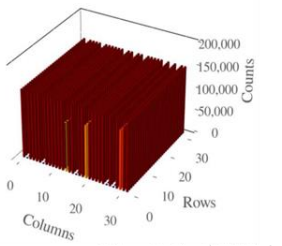
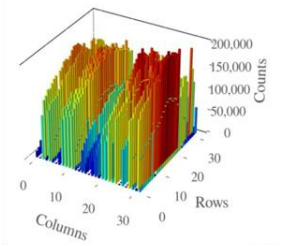
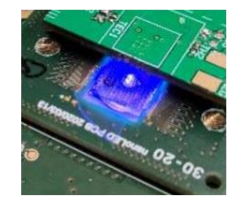
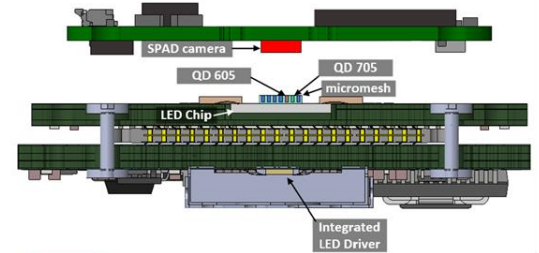
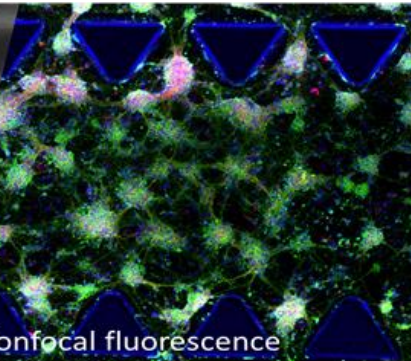
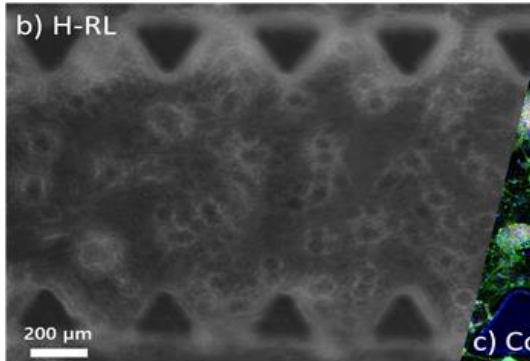


MicroLED Arrays

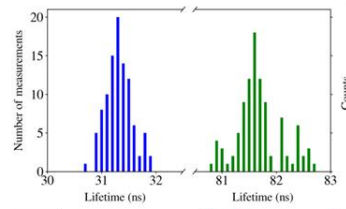
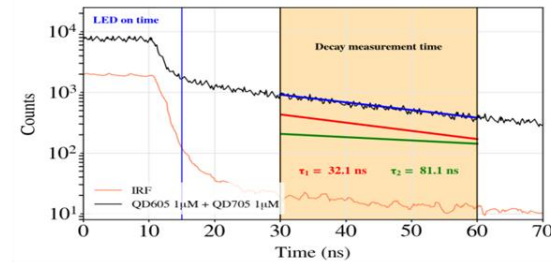
Distributed Microscopy



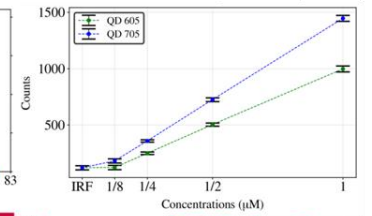
- **High brightness:** $\sim 100 \text{ W/cm}^2$ + micro-lenses
- **High resolution:** 512 x 512 pixels
10 μm pixel size
- **Point precision:** $\pm 5 \text{ nm}$
- **High speed:** 10 kHz frame rate
1 MHz frame pulsing



Fluorescence Array Analyzer

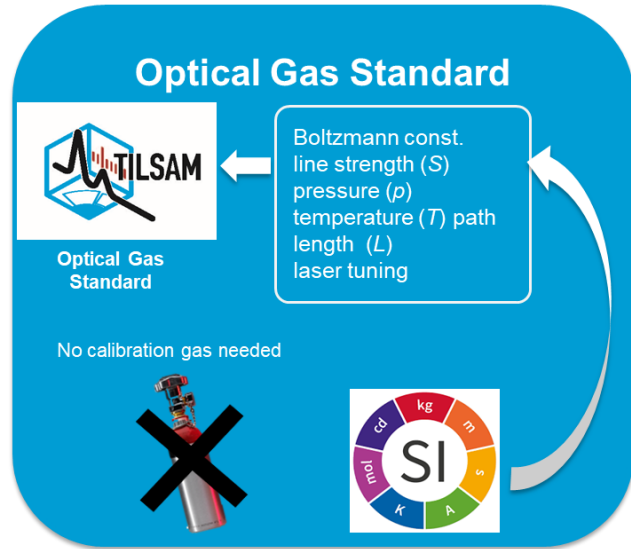


Biosensors 14, 264 (2024)

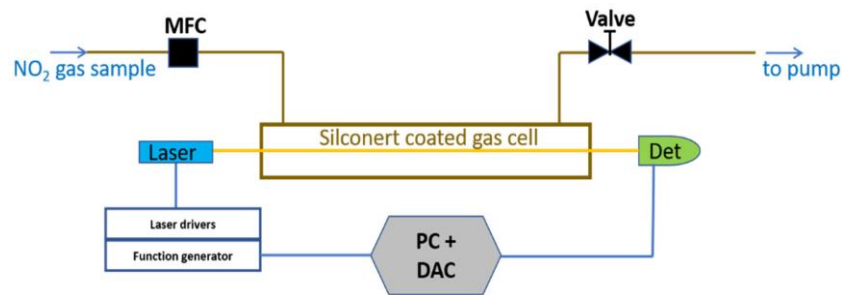


Integration of Optical Gas Standards

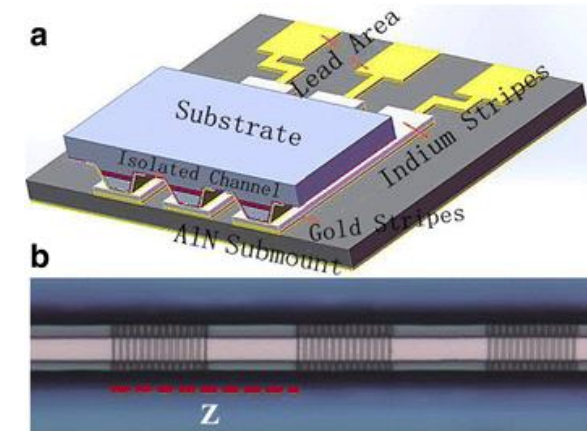
TILSAM: Traceable Infrared Laser Spectrometric Amount fraction Measurement



Advancing optical gas standards by quantum technology tools

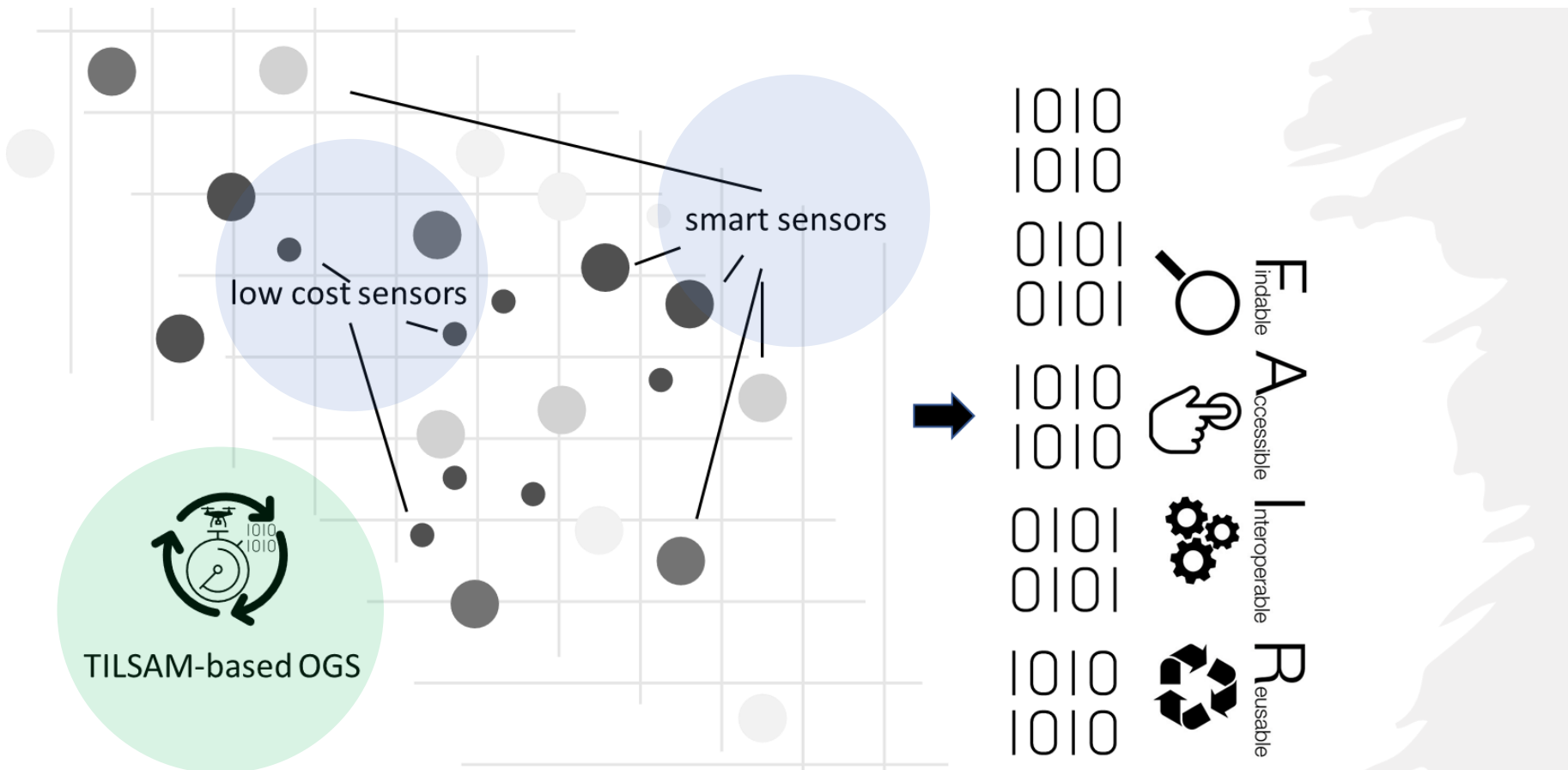


„On-table setup“



„On-chip setup“

Sensor Networks in environmental monitoring, climate and complex systems



Achieving **traceability** in sensor networks requires **new sensor devices** and **innovative calibration approaches**

Conclusions



- We have shown that there is a direction from **table top standards** up to **quantum technology based** standards in gas metrology
- With that we **support** the development of **sensor networks**, e.g. **for air quality**
- BIPM-WMO recommendations 1A.2 related to *Low Cost Sensor Networks*: are followed by this work:
more portable calibration methods

- Olav Werhahn, PTB, olav.werhahn@ptb.de
- J. Daniel Prades, TU-BS, daniel.prades@tu-braunschweig.de
- Joanna Freyse, PTB, joanna.freyse@ptb.de



Thanks for your attention.



Olav Werhahn
Executive Secretary
Innovation Cluster for Environment & Climate
IC-U@ptb.de
+49 531 592-2008

Metrology

Measurements in Science and Technology

