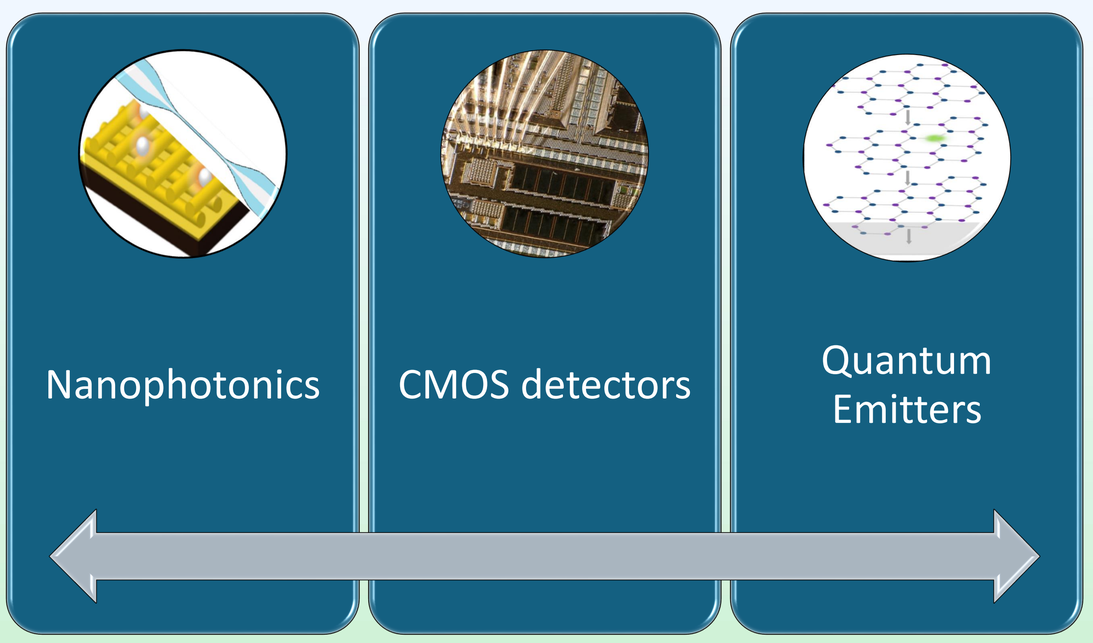
Enhancing Light-Matter Interactions In Integrated Platforms

[1,2]Malaika Waheed, [1]Ambika Shorny, [1]Helmut Hörner, [1]Alexander Götz, [1]Adarsh S. Prasad and [1]Sarah M. Skoff, [2]Christian Koller
[1]Atominstitut, TU Wien, Stadionalle 2, 1020 Wien, Austria
[2] Fachhochschule Wiener Neustadt, University of Applied Sciences, Austria

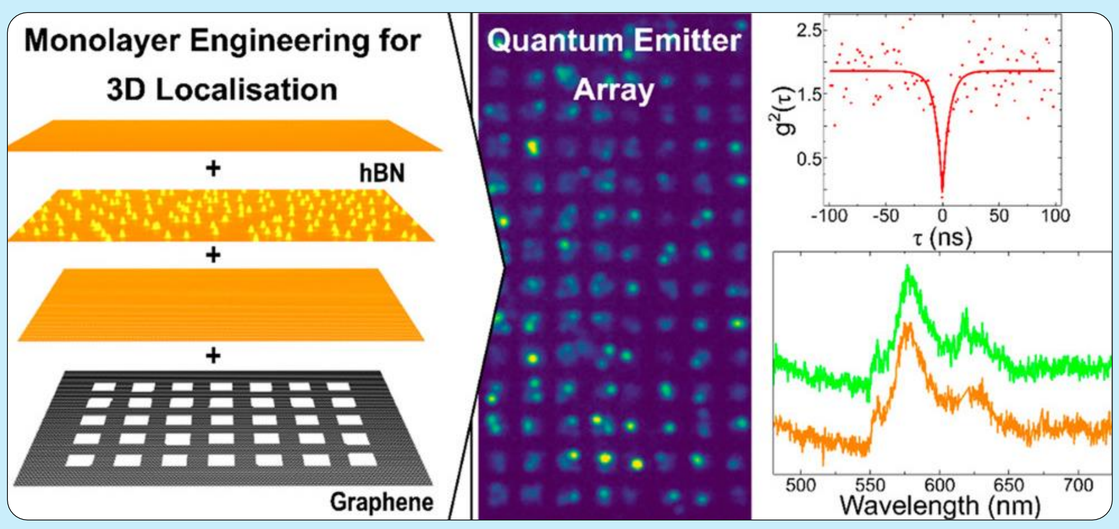
→Nanofabrication advances drive miniaturization & scalability.

→Hexagonal boron nitride (hBN) quantum emitters enable room-temperature indistinguishable photons.

→Potential for chip-based single-photon sources and strong optical non-linearities.



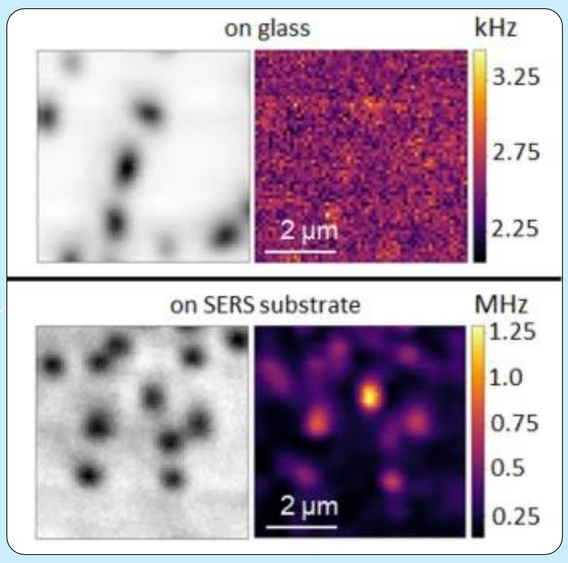
Nanophotonics



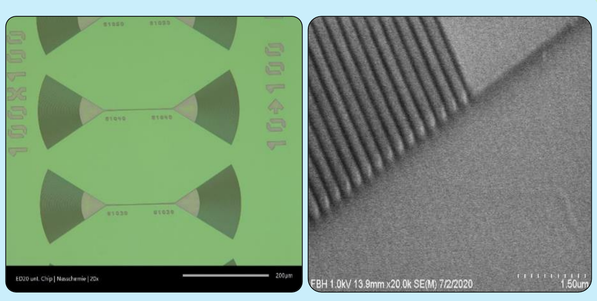
Sample made by the group of Prof. Stephan Hofmann, University of Cambridge

- ✓ Hexagonal boron nitride (hBN) is a promising host material for room-temperature, tuneable solid-state quantum emitters.
- ✓ h-BN is a wide bandgap (~ 5.9 eV) semiconductor material, the so called “white graphene.”
- ✓ It can host single photon emitters for a wide range of wavelengths.

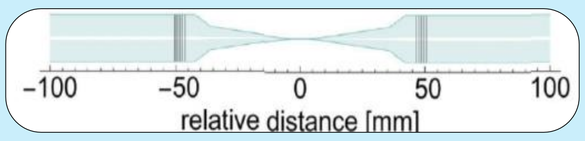
Quantum Emitters



Confocal images taken of 300 nm polystyrene particles on a glass and a SERS substrate (Pico SERS) [1].

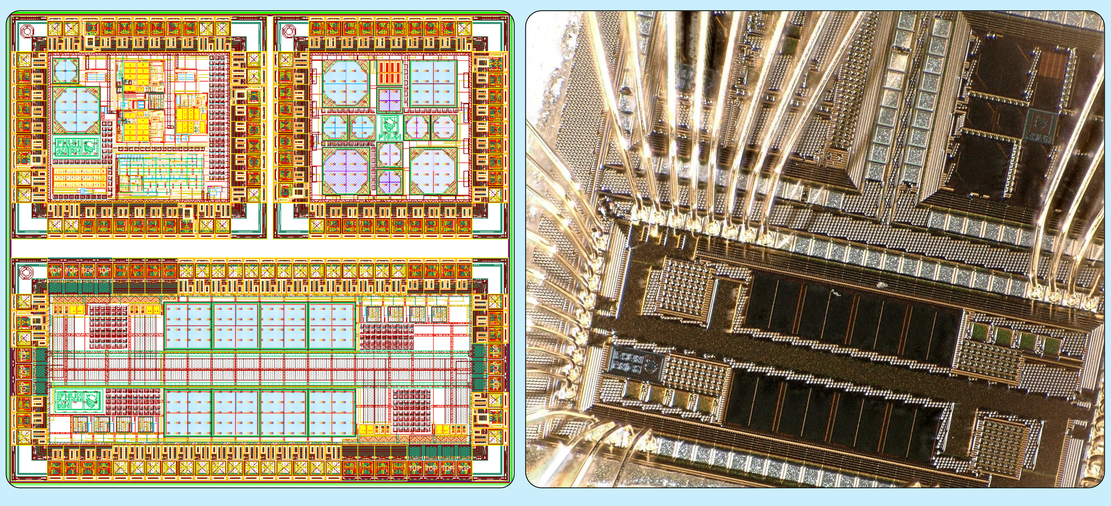


✓ Waveguides made up of silicon nitride on glass.



✓ High-Q resonator based on two fiber Bragg gratings and a nanophotonic waveguide allows for reaching the strong coupling regime.

CMOS detectors



✓ The combination of hBN (along with nanophotonics) with integrated CMOS technology paves the way for a chip-based strong light-matter interaction.

Outlook

- ✓ The integration of hBN with integrated CMOS-compatible platforms presents a promising approach for enhancing light-matter interactions at the nanoscale for quantum technologies.
- ✓ The unique optical and electronic properties of hBN, coupled with nanophotonics, enable efficient photon manipulation, facilitates nonlinear optical effects and single-photon emission.
- ✓ Moreover, the incorporation of avalanche photodiodes allows efficient on-chip single-photon detection, making the systems highly suitable for quantum photonic applications.

References
[1]. Shorny, A., Steiner, F., Hörner, H. *et al.* Imaging and identification of single nanoplastic particles and agglomerates. *Sci Rep* **13**, 10275 (2023). https://doi.org/10.1038/s41598-023-37290-y
[2]. J. C. Stewart et al., “Quantum Emitter Localization in Layer-Engineered Hexagonal Boron Nitride,” ACS Nano, vol. 15, no. 8, pp. 13591–13603, Aug. 2021, doi: https://doi.org/10.1021/acsnano.1c04467.
[3]. Shorny *et al.* Properties of quantum emitters in different hBN sample types particularly suited for nanophotonic integration. arXiv:2210.11099

Finanziert von der Europäischen Union
NextGenerationEU
Bundesministerium Bildung, Wissenschaft und Forschung
FFG Forschung wirkt.
FWF Der Wissenschaftsfonds.