PRESS RELEASE

Turning quantum discoveries into real-life products with advanced R&D facilities in Berlin

Quantum computing is hailed everywhere as the technology of the future, but what about quantum sensing and communicating? These capabilities promise to make quantum technologies the seed for a new generation of products in information and communication technology and modern sensor systems. But manufacturers who want to use the great potential and fundamental principles of quantum mechanics need highly specialized facilities and processes. With funding from the EU and the State of Berlin, researchers at Fraunhofer IZM have created a vision of a technology centre to power the development of new glass-based quantum technologies.

Quantum objects measure just a handful of nanometres in scale, but they exhibit some unique behaviour: They do not exist in a certainly knowable position, nor do they move in a definable direction. Quantum particles can be entangled, even when they are far removed from each other. It is these phenomena that have inspired researchers worldwide to develop new quantum technologies with immense potential for applications in a wide range of industries.

The Fraunhofer Society is already playing its part in shaping this revolution with Germany’s first quantum computer, installed at the start of the year. But quantum research is not only about computing, as photonic quantum technologies promise groundbreaking innovations in quantum communications and sensors. In order for these revolutionary inventions to make their way into scalable components and market-ready products, researchers have to find ways to measure quantum states reliably and precisely.

Berlin’s QuantumPackagingLab will open in mid-2022 and is expected to become the go-to place for developing reliable packaging solutions for quantum photonics with its exceptional technical facilities. Researchers at the lab will be pursuing ambitious plans in their quest to close the remaining technology gaps and bring the second quantum revolution into industrial applications. Their endeavours include using glass as a transparent substrate and carrier for photonic circuits or expanding established waveguide technologies into the visible and near-infrared range, the so-called VIS-NIR spectrum. The researchers are using panel-level integration approaches originally designed for electronic circuit boards. To prepare the existing packaging and system integration technologies for this leap into quantum photonics, the Fraunhofer Institute for Reliability and Microintegration IZM is creating a completely new infrastructure

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landscape in no fewer than four separate labs, with five units playing a particularly crucial role:

Scanning Nearfield Optical Microscope (SNOM)

- **How it works:** As the centrepiece of the optical measurement lab, the SNOM uses optical spectroscopy to scan the surfaces of nanophotonic components. To do so, it focuses an incredibly narrow laser beam, with a smaller diameter than a waveguide, in the immediate proximity of the sample. Highly reliable measurements are also possible by using the evanescent field that is created around a surface when a light wave fades.
- **What it brings:** The SNOM gives researchers the ability to characterize nano-photonic components with extreme precision, at a resolution far below the diffraction limit for distortion-free imaging. The plans include the eponymous scanning near-field optical microscope for exploring the evanescent field of glass-embedded waveguides and optical nanofibers to optimize the interaction between light and matter as well as fluorescence microscopes for nanostructures (e.g. individual molecules, nitrogen-vacancy defects in diamonds, quantum dots, or nanocarbons).

Waveguide coupler

- **How it works:** This large automated unit uses an integrated camera and search and optimization algorithms to couple several waveguides with a fibre array. The coupled light can then be detected at the waveguide's output side.
- **What it brings:** For glass-embedded waveguides to become usable in quantum technology, their production process has to be adjusted for the visible and IR light spectrum, with single-mode light guiding and minimal propagation losses. This has already been possible with a custom system built at Fraunhofer IZM, but the researchers hope to make the measuring processes much faster and more precise with the new facilities.

3D Glass Printer

- **How it works:** The 3D glass printer uses ultrashort light impulses to model glass structures. Its surfaces can then be modified by etching. The printer unit is expected to be particularly useful for laser direct writing, that is, the use of a laser to create waveguides and other photonic structures like diffraction gratings directly in the glass. The system will also be able to drill microcavities or weld glass by heating up only the immediate target area to create transparent, but hermetically sealed glass-on-glass joints.
- **What it brings:** The 3D glass printer opens up a world of possibilities: Level or curved optical surfaces can be created directly on the waveguides e.g. to activate quantum emitters. The novel weld joints will be crucial for thermally insulating quantum sensors or for producing miniature spectroscopy cells. The researchers expect a tenfold improvement over conventional technology in the

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roughness, precision, and reproducibility of glass structures created with this system.

Micro Ultra-High Vacuum Bonder

- **How it works:** The new bonder will be used for laser soldering and other hermetic joining processes for glass in a vacuum. The highly focused laser beam is absorbed by the glass solder, heating it up to the melting temperature and creating a joint between two glass surfaces.
- **What it brings:** The micro ultra-high vacuum bonder will be particularly useful for testing new ways to join glass surfaces. The key is to create joints that are hermetically sealed on the microlevel to allow the development of micro vacuum or micro gas cells or other thermally insulated designs.

Ultra-High Vacuum Vapor Deposition Unit
Highly Precise Vacuum Metalizing

- **How it works:** In the ultra-high vacuum vapor deposition system, glass surfaces can be metallized with extremely fine coats of only a few nanometres, applied with a record precision of a single nanometre. This process is used to create semi-transparent metalized mirrors or to turn the metalized surfaces themselves into plasmonic guides.
- **What it brings:** The system is taking the capabilities of conventional sputtering to the quantum technology domain. It can be used to create parallel or confocal gold coats with microscopically tiny cavities along the waveguide. When quantum emitters enter these cavities, the emission patterns change, and light particles are far more likely to be emitted in the direction of the waveguide.

Fraunhofer IZM is looking for research partners to tread new ground in application-driven system integration, especially assembly and packaging technologies, for quantum communication and quantum sensors.

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(Text: Olga Putsykina)

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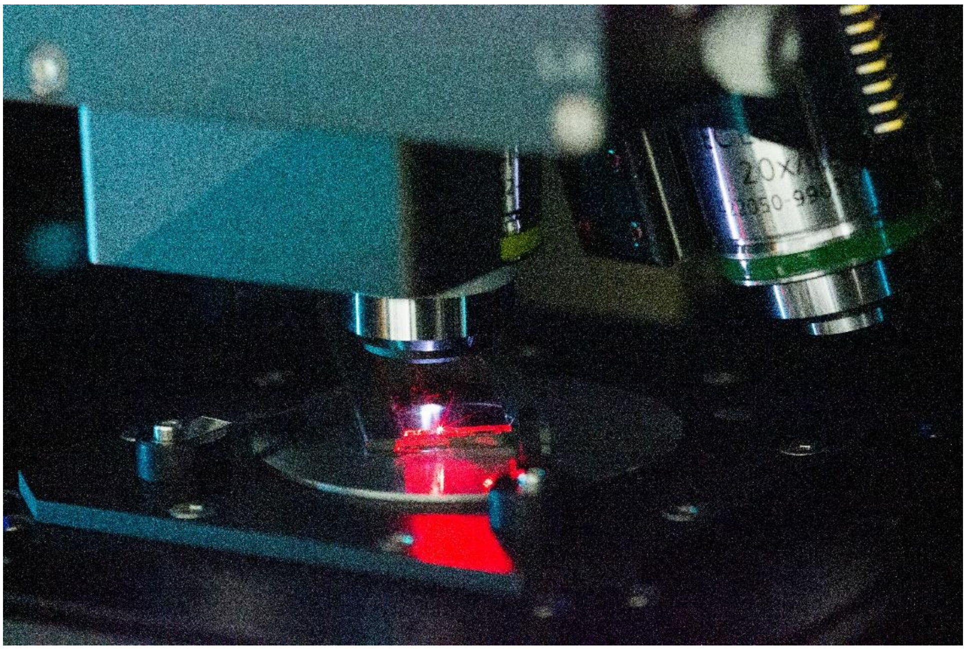

Getting quantum technologies ready for breakthrough: Packaging technologies for quantum photonics developed at the Berlin QuantumPackaging Lab.
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