Why Fraunhofer IAF?

Fraunhofer IAF is a world-leading research institute in the field of synthetic diamond growth and processing with expertise encompassing the entire value chain. In a clean room of 1000 m^2 and additional laboratory space covering 3000 m^2, epitaxy and processing equipment along with measurement technologies are available to realize diamond devices for innovative applications in the field of quantum systems and others.

In addition, Fraunhofer IAF has decades of experience in running complex international research projects and collaborating with customers from industry and small and medium-sized enterprises. This enables an equally efficient and flexible cooperation in the application-oriented research and development of innovative quantum technologies as well as in the customized implementation of orders.

What we offer:

Fraunhofer IAF offers customized synthetic diamond for various applications in quantum technology and other fields:

- Homoepitaxial and heteroepitaxial growth of ultra-pure single crystal and poly-crystalline diamond substrates as well as thin films tailored to quantum devices, electronic or photonic devices
- Creation of microstructures containing color centers as atomic scale sensors for quantum sensing
- Generation of NV centers as ensembles in layers for quantum sensing or few centers for spin qubits in quantum computing

If you want to learn more about our range of services please feel free to contact us.

Fraunhofer IAF

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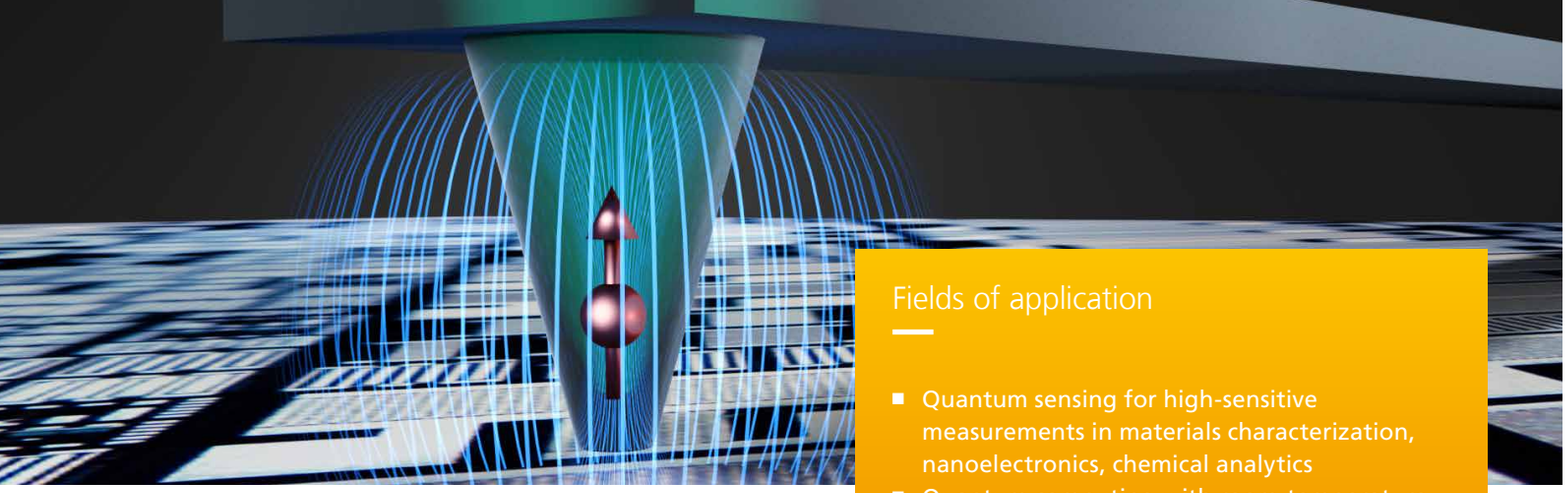
Synthetic diamond for quantum technologies and more

Diamond synthesis



Tailored diamonds

Fraunhofer IAF offers homoepitaxial and heteroepitaxial growth of single crystal and poly-crystalline diamond substrates on wafer scale as well as thin films from robust and well-controlled processes. The quantum properties of these materials can be further pushed to their limits by optimizing the isotopic ratio within the diamond.

Advantages of synthetic diamond

Due to the incredibly rigid structure of diamond, the quantum effects of color centers incorporated within the crystal can be observed and harnessed close to room temperature in contrast to, e.g., superconducting circuits that form the qubits in state-of-the-art quantum computers operating under cryogenic conditions. In addition, diamond is a promising semiconductor material.

Diamond properties

- Refractive index: 2.4
- Optical window: 300 nm to 2.5 µm and 7 to > 100 µm
- Density: 3.51 g/cm³
- Thermal conductivity: 2,600 W/mK
- Hardness: 10,000 HV

Fields of application

- Quantum sensing for high-sensitive measurements in materials characterization, nanoelectronics, chemical analytics
- Quantum computing with room-temperature quantum processors based on color centers in diamond
- High-power electronics
- Electrodes
- Photonic devices

Diamond synthesis equipment

For diamond synthesis, Fraunhofer IAF runs in total 10 microwave plasma reactors:

- 7 reactors covering a 80 mm diameter area
- 3 reactors covering a 150 mm diameter area

The reactors are equipped with purified gases to obtain contamination-free diamond and dopant gases as well as isotopically-enriched gases to alter the diamond properties or include color centers during growth.

Doping of diamond

Fraunhofer IAF provides different dopants for diamond, each tailored to their application:

- Nitrogen for nitrogen vacancy (NV) generation
- Boron for p-type diamond
- Phosphorous for n-type diamond

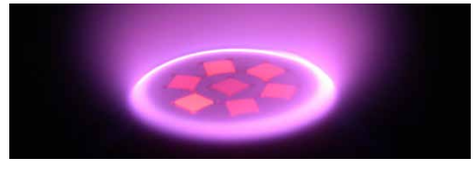
Processing of diamond

For further customized processing of synthetic diamond, Fraunhofer IAF offers different technologies for the structuring of wafers and diamond crystals:

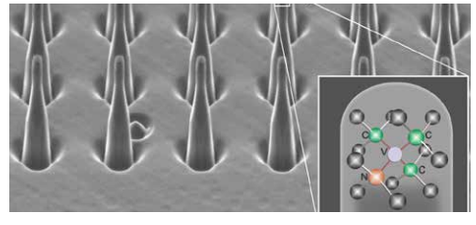
- Electron-beam lithography
- Laser lithography and cutting
- Reactive ion etching
- Metallization
- Polishing

Diamond as a platform for atomic scale sensors

The NV center is a point defect in diamond which exhibits an optically accessible spin system under ambient conditions. Owing to its minute size, the NV center can be used to measure magnetic fields on the nanometer scale. Films with NV ensembles are versatile sensing layers with optical readout for larger areas.



Diamond growth via chemical vapor deposition (CVD)



Microstructures fabricated at Fraunhofer IAF containing an atomic scale sensor, the NV center

For measurements of magnetic fields, NVs are positioned in tip-shaped microstructures that are scanned over the sample of interest.