Nano Technologies for Quantum

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Nanotechnologies are among the main drivers of contemporary scientific and technological innovation and are expected to play a pivotal role in the next industrial revolution. The ability to design, fabricate, and characterize materials and devices at the nanoscale opens unprecedented opportunities across a wide range of application fields, including advanced electronics, photonics, energy, healthcare, sensing, and information technologies. By enabling the manipulation of matter at nanometric dimensions, nanotechnologies make it possible to exploit emerging physical properties that are not accessible at larger scales, fostering the development of high-performance and disruptive solutions.

From a scientific perspective, nanotechnologies are of strategic importance for the advancement of quantum technologies. Many quantum phenomena can only be effectively observed, controlled, and exploited through structures, materials, and devices engineered with nanometer-scale precision. The realization of qubits, quantum sensors, single-photon sources, and platforms for quantum computing and communication relies heavily on advanced nanofabrication and characterization techniques, making nanotechnologies a key enabling factor for progress in the quantum domain.

This strong connection between nanotechnologies and quantum applications is clearly reflected in the research activities carried out at Fondazione Bruno Kessler (FBK), where state-of-the-art fabrication and characterization methods are employed to develop innovative materials and devices for quantum technologies.

In this contribution, representative examples of research activities conducted at FBK will be presented. First, the fabrication of diamond lamellae by means of Plasma Focused Ion Beam (P-FIB) techniques will be discussed, highlighting the preparation of shallow-defect platforms for optical investigations. P-FIB-fabricated diamond lamellae hosting NV centers will be presented as a platform for all-optical nanothermometry. By monitoring the temperature-dependent shift of the NV zero-phonon line (ZPL), local temperature variations can be measured with high spatial resolution, highlighting the potential of quantum defects as nanoscale thermal sensors. Second, optical nanospectroscopy techniques such as Tip-Enhanced Raman Spectroscopy (TERS) will be introduced as powerful tools for chemical, structural, and optical characterization beyond the diffraction limit. By exploiting plasmonic near-field enhancement, TERS enables spectroscopic imaging with spatial resolutions down to a few nanometers. A demonstrative application on multiwalled carbon nanotubes will illustrate nanoscale chemical characterization with a lateral resolution of approximately 10 nm.