Consiglio Nazionale delle Ricerche
Unità Ufficio Stampa

PRESS RELEASE 41/2025

Diamond “defects” improve the performance of quantum bits

An international project coordinated by the Institute for Photonics and Nanotechnologies of the CNR led to an innovative hybrid laser and ion beam fabrication method in diamond, for high performance quantum bits to power quantum information and sensors. The research, published as a cover article in the journal Nano Letters, involved young researchers funded by the “Marie Skłodowska-Curie” European Doctoral Network programme.

An international research project coordinated by Institute for Photonics and Nanotechnologies of the National Research Council (CNR-IFN) studied defects within diamond which demonstrate great promise as quantum bits, the building blocks for quantum technologies such as quantum computing and sensing.

The scientific discovery was published in the journal Nano Letters, and investigates the nitrogen vacancy defect, an atomic scale impurity in diamond’s carbon lattice: its added value as a quantum bit is its “coherence time,” the length of time the qubit maintains its useful quantum properties. Since the nitrogen vacancy has a particularly long coherence time, it allows for efficient quantum computing and sensitive detection of tiny biomolecules.

“Interconnected quantum bits within diamond will enable the creation of extremely powerful quantum information systems and ultrasensitive nanoscale sensors of magnetic fields for biomedical imaging and other applications that require high-resolution imaging,” explains Shane Eaton, a researcher at CNR-IFN who coordinated the study.

In 2016, the CNR-IFN group led by Dr. Shane Eaton first developed a method to fabricate optical interconnects for these quantum bits within diamond, an essential step for achieving scalable and stable quantum networks and quantum sensors. Then in 2018, the same researchers found that with the same laser fabrication method, they could position these desirable defects on demand, perfectly aligned with the laser-formed optical interconnects.

Today, their next step forward is the development of an innovative nanofabrication method using lasers and ion beams that does not degrade the coherence time of the qubits inside optical interconnects in diamond, showing significant potential for quantum technologies.

“Our latest results build upon our first demonstration that lasers can fabricate photonic interconnects in diamond, crucial building blocks needed for quantum computing and sensing”, says Eaton. “Now that we have proven that laser fabrication does not degrade the important coherence properties of quantum bits, we will focus our attention on creating high-performance quantum technology devices in diamond. The next step is a magnetic field sensor prototype which will allow us to detect single molecules, starting from atoms, studying both their dynamics and structure, a critical aspect for life sciences. For this reason, we are developing a system that could break all records in terms of magnetic field sensitivity, giving much more precise images than those available from nuclear magnetic resonance imaging."

The study was funded by the European project "LasIonDef", coordinated by Eaton, and involved doctoral students from Cardiff University, Wrocław University of Science and Technology, University of Torino, Ulm University, University of Insubria and Politecnico di Milano thanks to the Marie Skłodowska-Curie Doctoral Network: their discoveries will have a profound impact on the upcoming quantum revolution and on the future of computation and medical sensing.

Captions

Fig 1: A hybrid fabrication method developed within LasIonDef project that combines laser and ion beam fabrication to form quantum bits and optical interconnects in diamond for integrated quantum computing and sensors

Fig 2: LasIonDef European project consortium coordinated by Shane Eaton and CNR-IFN: Left to right: Sahnawaz Alam (Wroclaw U), Paolo Olivero (U Torino), Yanzhao Guo (Cardiff U), JP Hadden (Cardiff U), Bilge Yağci (Cardiff U), Sajedeh Shahbazi (U Ulm), Giulio Coccia (CNR), Selene Sachero (U Ulm), Shane Eaton (CNR), Roberta Ramponi (CNR), Elena Nieto Hernández (U Torino), Diana Kafizova (Microfluidics Innovation Center, Paris), Egle Molotokaite (CNR), Ottavia Jedrkiewicz (CNR), Anthony Bennett (Cardiff), Astghik Chalyan (EYEST, Brussels), Michał Gawełczyk (Wroclaw U)

Rome, May 23, 2025

In brief

Who: CNR-IFN, Cardiff University, Wrocław University of Science and Technology, University of Torino, Ulm University

What: **https://pubs.acs.org/doi/10.1021/acs.nanolett.5c00148?ref=PDF**

Cnr Press Office: Gaetano Massimo Macrì, gaetanomassimo.macri@cnr.it; tel. 06.4993700, mobile: 328/1190682; Head of Press Office: Emanuele Guerrini, emanuele.guerrini@cnr.it, mobile: 339.2108895; Secretariat: ufficiostampa@cnr.it, tel. 06.4993.3383.

Consiglio Nazionale delle Ricerche
Unità Ufficio Stampa

Y. Guo, G. Coccia, V. K. Kavatamane, A. N. Giakoumaki, A. N. Vetlugin, R. Ramponi, C. Soci, P. E. Barclay, J. P. Hadden, A. J. Bennett**, S. M. Eaton,** "Enhanced quantum magnetometry with a laser-written integrated photonic diamond" Nano Letters (2025). https://doi.org/10.1021/acs.nanolett.5c00148

For more information: Shane Eaton, CNR-IFN, e-mail: shanemichaeladler.eaton@cnr.it, mobile +39 3200921952;

(contact details for professional use only, not to be disclosed)

Follow us

Il Cnr ti aspetta anche su WhatsApp! Clicca qui per seguire il Canale, oppure inquadra il QRCODE

Cnr Press Office: Gaetano Massimo Macrì, gaetanomassimo.macri@cnr.it; tel. 06.4993700, mobile: 328/1190682; Head of Press Office: Emanuele Guerrini, emanuele.guerrini@cnr.it, mobile: 339.2108895; Secretariat: ufficiostampa@cnr.it, tel. 06.4993.3383.