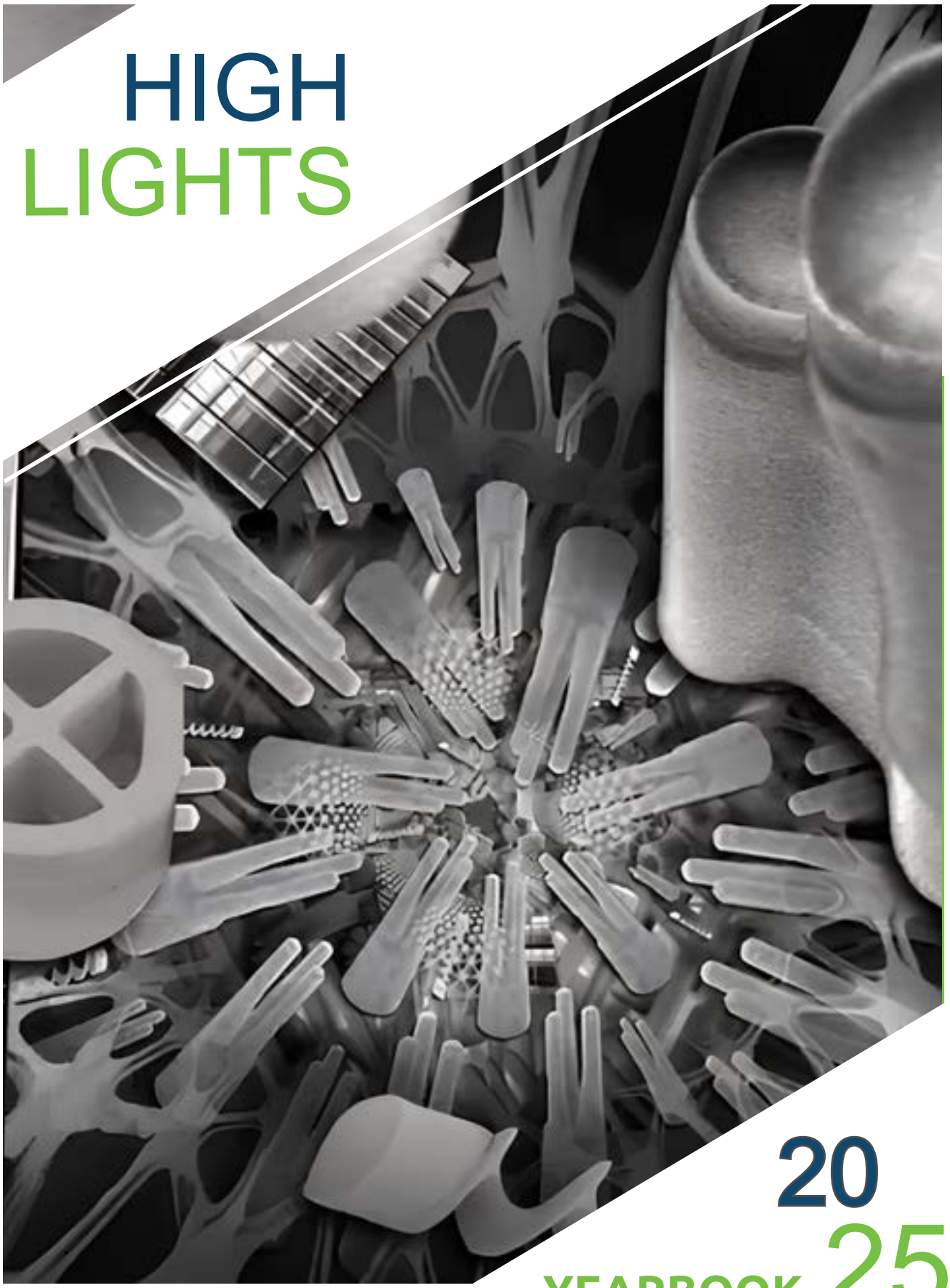
Centre
DE Nanosciences
& DE Nanotechnologies

C2N

HIGH LIGHTS



20 25

YEARBOOK

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Université Paris Cité

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C2N / Luke Conroy (Arts and Sciences project)

C2N - Février 2026

SUMMARY

HIGHLIGHTS 2025

FOREWORD

A DECADE OF EXCELLENCE, A COLLECTIVE TRAJECTORY, A SUSTAINABLE AMBITION

In 2025, C2N continued its commitment to research excellence, both fundamental and applied, in a spirit of responsible innovation and within a dynamic of consolidation and forward projection. More than a succession of highlights, the year 2025 reflects a collective journey and a trajectory that is now firmly established. Over the years, C2N has asserted itself as a reference laboratory, capable of combining scientific excellence with technological mastery, international openness with societal responsibility, thanks to the recognition and promotion of the commitment and expertise of each and every one of you.

This maturity is built on long-term structural choices: a clearly defined scientific ambition; rigorous management of infrastructures, platforms, and scientific, technical and administrative expertise; a close articulation between research, innovation and partnerships; and the integration of management tools enabling our activities to be aligned with a more sustainable trajectory. This year also marks a structuring milestone in our environmental responsibility with the completion of our first carbon footprint assessment.

These orientations have enabled the laboratory to strengthen its visibility, its attractiveness, and its role at the heart of Paris-Saclay, and more broadly within national and international ecosystems, across numerous fields: nanoelectronics, photonics, quantum technologies, energy, artificial intelligence, health, and new materials.

C2N in 2025 is also, as always, defined by its vitality and collective strength, which we have chosen to highlight through new video formats, including the series “Itinérances,” showcasing the journeys of our doctoral candidates, as well as the series “Paroles d’experts” and the “C2N Encounters.” Promoting the career paths, expertise and diversity of professions that make up C2N is not merely a matter of communication, but a key lever for performance and transformation, illustrating the alliance between the commitment of our support services and technological platforms and our scientific excellence. Training, supporting, recognizing and empowering all those who conduct or support research is an essential foundation for preparing the future. In a scientific, technological and societal context undergoing profound transformation, C2N continues to pursue a clear trajectory: developing research excellence that is open to society, particularly to young people (middle school pupils, high school students and university students)attentive to its impacts, and capable of providing concrete responses to major contemporary challenges. This ambition is part of a long-term vision and rests today on robust foundations.

Finally, this 2025 edition holds a particularly personal significance for me. As I prepare to step down from my role as Director after ten intense and exciting years, since the finalization of the C2N project in 2015 and the founding of the laboratory in 2016, I look back with pride at the path we have travelled together. C2N has become the reference laboratory it is today at the local, national and international levels, thanks to the dedication and commitment of all its teams: researchers, faculty members, engineers, technicians, administrative staff, doctoral candidates and postdoctoral researchers.

I would like to warmly thank the Secretary General, my counterpart within the C2N Executive Management over the past six years, for her dedication, dynamism and efficiency, as well as the Executive Board and all staff members for their trust and high standards. My thanks also go to the communication team and to the various contributors to this report. I am convinced that the vitality and excellence of C2N are now firmly anchored at the heart of the scientific and technological challenges of tomorrow.

Giancarlo Faini
Director of C2N
December 2025

C2N KEY FIGURES*

54 RESEARCHERS

66 ENGINEERS TECHNICIANS

45 ASSOCIATE PROFESSORS

131 PHD STUDENTS

43 POST DOCS

30 FIXED-TERM CONTRACTS FOR ENGINEERS AND TECHNICIANS

STAFF MEMBERS **392**

NATIONALITIES **46**

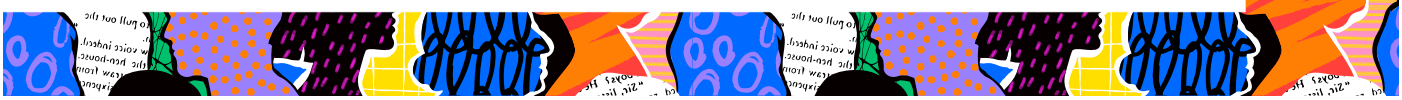
WOMEN	MEN
33%	**67%**

25 THESIS DEFENDED

2 HABILITATIONS A DIRIGER DES RECHERCHES (HDR)

16 SEMINARIES

About 200 PUBLICATIONS



**KEY FIGURES AS OF 31 DECEMBER 2025*

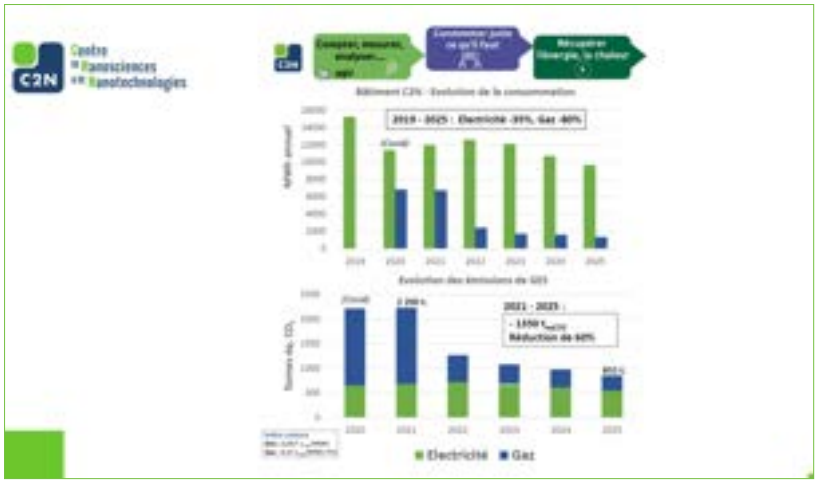
SUSTAINABLE DEVELOPMENT AND RESPONSIBLE RESEARCH : C2N'S 2025 REPORT ON MEASURING AND REDUCING ITS CARBON FOOTPRINT

In 2025, the C2N reached a new milestone with the calculation of its overall carbon footprint, as well as that of its technology facility, marking a first within the RENATECH network [1]. Conducted by the unit's "carbon footprint" team and its sustainable development (SD) coordinators, this assessment was first presented to the laboratory in the summer of 2025, and later discussed at the general assembly at the end of 2025 in order to identify possible action levers, with implementation perspectives starting in 2026 for the areas of Procurement, Travel, and Energy.

At the same time, with the support of the Technical and Logistics Department (STL) of the DR04 regional delegation, the laboratory successfully carried out an energy efficiency improvement project as part of the "Quickwin" component (rapid energy-saving measures) of the French government's 2024 Environmental Transition call for projects (Programme 348), with support from the CNRS. Implemented on site between January and October 2025, the works, defined and jointly monitored by the DR04 and the involved C2N staff, have already led to measurable reductions in the laboratory's energy consumption. These results will be further analysed in 2026.

C2N's commitment to environmental transition also resulted in the selection of two projects led by the unit's sustainable development officers, aimed at increasing the energy efficiency of its research facilities: the CALOMINI project, selected in December 2025 under the PREMAT call for projects of the Sci-Ty consortium (France 2030 – Sustainable Cities and Smart Buildings priority area), and a project focused on real-time particulate monitoring for more energy-efficient cleanroom air conditioning, selected in July 2025 under the CNRS-MTAP Environmental Transition call for projects.

With the aim of sharing and disseminating feedback and best practices, the actions undertaken by C2N in recent years to promote greater resource efficiency have been the subject of several scientific and institutional communications.



OPTICELL PROJECT : TOWARD A NEW GENERATION OF RETINAL TISSUE

Among the very first projects selected as part of the PEPR (Priority Research Program and Equipment) call for projects in Biotherapies and Bioproduction of Innovative Therapies, the OptiCELL project – Bioengineered stem cell-derived retinal cells and tissue for cell therapy – aims to develop a new generation of bioengineered retinal tissue for applications in regenerative medicine.

Degenerative retinal diseases ultimately lead to irreversible vision loss. Stem cell-based therapy represents a highly promising therapeutic approach to address these conditions. The goal of OptiCELL is to design transplantable retinal tissues composed of microstructured and functionalized biocompatible polymer membranes, onto which photoreceptor cells and retinal pigment epithelium cells will be seeded.

Led by the Vision Institute, the project brings together three partners : I-Stem, Artemis (Télécom SudParis), and the Center for Nanoscience and Nanotechnology (C2N). At C2N, the work focuses on developing microfabrication processes to microstructure and functionalize membranes made of biocompatible polymers or new biodegradable materials, with the goal of reconstructing retinal tissues from human pluripotent stem cells.

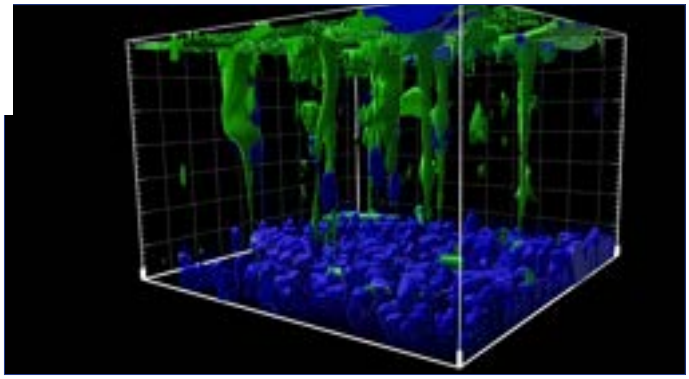


Figure : Confocal microscopy observation of the assembly of photoreceptors and RPE within the scaffold

MONITORING CANCER PROGRESSION WITHOUT INVASIVE INTERVENTION IS NOW POSSIBLE

A study published in Science Advances demonstrates the effectiveness of an innovative technology combining electrical impedance spectroscopy and artificial intelligence. The result of a collaboration between Sensome, École Polytechnique and the Centre for Nanoscience and Nanotechnology, this breakthrough opens up new perspectives for diagnosis and therapeutic monitoring.

MICROFLUIDICS-BASED ELECTROCHEMICAL DETECTION OF ANTIMICROBIAL-RESISTANT DNA SEQUENCE IN LYSED ESCHERICHIA COLI MEDIUM : TOWARDS EARLY DIAGNOSIS OF SEPSIS

Facing the emergence of multi-drug-resistant bacteria, rapid and sensitive detection of the antimicrobial resistant genes in such organisms is crucial for appropriate and timely treatment management. In this work, a team from C2N has fabricated a microfluidic DNA biosensor immobilized with 6-mercaptohexanol and probe DNA sequence, aimed for the detection of antibiotic-resistant genes in Escherichia coli (E. coli). As proof-of-concept, the team has demonstrated the successful electrochemical detection of the target DNA sequence down to 10 fM in the presence of diluted lysed E. coli cells, by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). A new approach was used to analyze the CV and EIS plots based on the influence of non-linear mass transport phenomenon more representative of the surface modification under flow conditions in microchannel. The custom fitting of the model allows us to estimate the apparent charge transfer resistance and thus evaluate the surface coverage and surface molecular immobilization on the electrode. This approach represents a major advance not only for the early detection of sepsis but can be applied to a wide range of bioelectrochemical detection applications in complex sample matrices.

Further reading

Hiu Mun Man, Choayb Omar, Martina Freisa, David Bouville, Téo Baptiste, Anne-Marie Haghiri-Gosnet, Hervé Jacquier, Isabelle Le Potier and Jean Gamby
Microfluidics-based electrochemical detection of antimicrobial-resistant DNA sequence in lysed escherichia coli medium.
ACS Electrochem. 2025, 1, 6, 886–896.
DOI https://doi.org/10.1021/acselectrochem.4c00203

A NEW AI MEMORY CAPABLE OF LEARNING AND DECIDING ON-CHIP

A French team led by CEA-Leti, with participation from C2N and several other laboratories, has developed a hybrid memory technology that allows artificial neural networks to learn and make decisions directly on-chip.

The new system combines ferroelectric capacitors and memristors in a single CMOS-compatible stack. The memristors are suited for inference, while the FeCAPs enable precise updates for learning. The hybrid device switches between these modes, allowing efficient learning without relying on the cloud. This innovation could benefit autonomous vehicles, medical sensors, and industrial systems by enabling them to adapt in real time to incoming data. The work is presented in Nature Electronics and was supported by the European Research Council and the PEPR Electronics program, as part of the France 2030 initiative.

Further reading

A ferroelectric–memristor memory for both training and inference
Michele Martemucci, François Rummens, Yannick Malot, Tifenn Hirtzlin, Olivier Guille, Simon Martin, Catherine Carabasse, Adrien F. Vincent, Sylvain Saïghi, Laurent Grenouillet, Damien Querlioz & Elisa Vianello
Nature Electronics (2025)
https://doi.org/10.1038/s41928-025-01454-7

BAYESIAN CONTINUAL LEARNING AND FORGETTING IN NEURAL NETWORKS

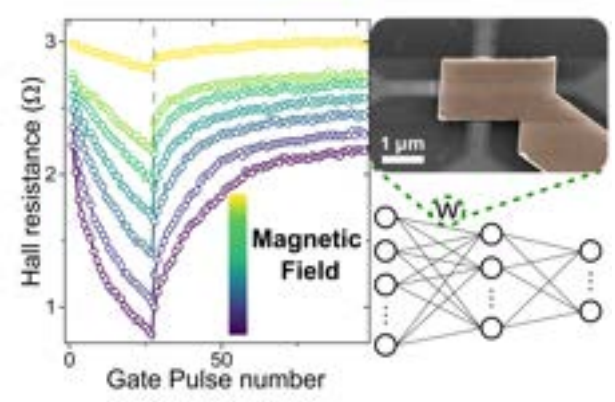
Biological synapses effortlessly balance memory retention and flexibility, yet artificial neural networks still struggle with the extremes of catastrophic forgetting and catastrophic remembering. Here, we introduce Metaplasticity from Synaptic Uncertainty (MESU), a Bayesian update rule that scales each parameter's learning by its uncertainty, enabling a principled combination of learning and forgetting without explicit task boundaries. MESU also provides epistemic uncertainty estimates for robust out-of-distribution detection; the main computational cost is weight sampling to compute predictive statistics. Across image-classification benchmarks, MESU mitigates forgetting while maintaining plasticity. On 200 sequential Permuted-MNIST tasks, it surpasses established synaptic-consolidation methods in final accuracy, ability to learn late tasks, and out-of-distribution data detection. In task-incremental CIFAR-100, MESU consistently outperforms conventional training techniques due to its boundary-free streaming formulation. Theoretically, MESU connects metaplasticity, Bayesian inference, and Hessian-based regularization. Together, these results provide a biologically inspired route to robust, perpetual learning.

Further reading

Bonnet D., Cottart K., Hirtzlin T., Januel T., Dalgaty T., Vianello E. and Querlioz D.
Bayesian continual learning and forgetting in neural networks. Nature Communications, 16 (1), p.9614, 2025
https://doi.org/10.1038/s41467-025-64601-w

DYNAMIC CONTROL OF WEIGHT-UPDATE LINEARITY IN MAGNETO-IONIC SYNAPSES

Multifunctional hardware technologies for neuromorphic computing are essential for replicating the complexity of biological neural systems, thereby improving the performance of artificial synapses and neurons. Integrating ionic and spintronic technologies offers new degrees of freedom to modulate synaptic potentiation and depression, introducing novel magnetic functionalities alongside the established ionic analogue behavior. We demonstrate that magneto-ionic devices can perform as synaptic elements with dynamically tunable depression linearity controlled by an external magnetic field, a functionality reminiscent of neuromodulation in biological systems. By applying magnetic fields we significantly reduce the nonlinearity of synaptic depression, transitioning from an exponential dependence to a linear response at higher fields. Neural network simulations reveal that this magnetically induced linearity enhancement improves learning accuracy across a wide range of learning rates, which is retained after the magnetic field is removed. These findings highlight the versatility and promise of magneto-ionic devices for developing tunable synaptic elements for neuromorphic hardware.



Further reading

Dynamic Control of Weight-Update Linearity in Magneto-Ionic Synapses
Nano Lett. 2025, 25, 4, 1443–1450
Guillaume Bernard, Kellian Cottart, Maria-Andromachi Syskaki, Victor Porée, Andrea Resta, Alessandro Nicolaou, Alan Durnez, Shimpei Ono, Ariam Mora Hernandez, Juergen Langer, Damien Querlioz, Liza Herrera Diez
https://doi.org/10.1021/acs.nanolett.4c05247

Figure : The magnetic-field–driven tunability of synaptic weight-update linearity in a magneto-ionic device provides a means to modulate synaptic learning capabilities in artificial neural networks.

EXCITING NANOMAGNETS WITH ROLLING FIELDS

Most traditional applications of nanomagnetism rely on the coupling of magnetization with electromagnetic fields, either in the form of a slowly varying magnetic field for sensor-type applications, or in the form of microwave photons for information storage and manipulation. Magnetization also couples with the electron bath and with the phonon bath. The latter interaction has so far been scarcely exploited. Indeed, only a fraction of magnetic materials exhibit significant "magnetostriction" (direct coupling between the crystal lattice and the orientation of magnetization via spin-orbit coupling), and most of these magnetostrictive materials are not suitable for energetically efficient manipulation of their magnetization.

It has recently been demonstrated that, since the dipolar field of magnets depends on their shape, any magnet whose surface is dynamically deformed should experience a torque on its magnetization. In collaboration with CEA SPEC in Saclay and within the framework of the ANR MAXSAW project, a team from C2N demonstrated the existence of this "magneto-rotation" coupling and showed its ability to efficiently excite the magnetization of a magnetic nanocylinder in the microwave regime using a surface acoustic wave.

Further reading

Experimental Observation of Vortex Gyration Excited by Surface Acoustic Waves
R. Lopes Seeger, F. Millo, G. Soares, J.-V. Kim, A. Solignac, G. de Loubens and T. Devolder
Phys. Rev. Lett. 134, 176704 (2025).
https://doi.org/10.1103/PhysRevLett.134.176704

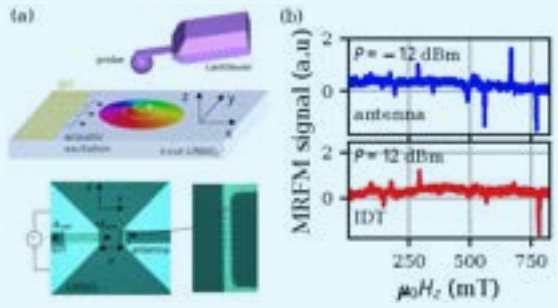
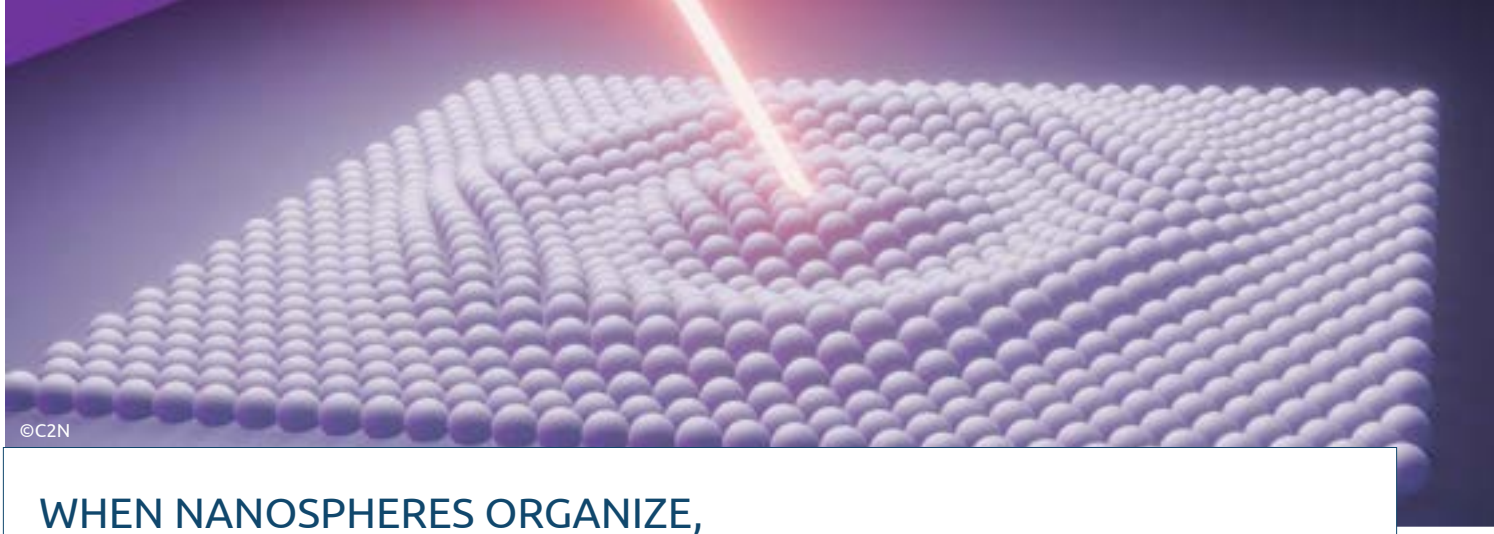


Figure caption : (a) Sketch of the magnetic resonance force microscopy experiment to detect the vortex gyration induced by surface acoustic waves. An IDT excites SAWs on a piezoelectric substrate propagating towards a disk in the vortex state (the colors encode the in-plane magnetization orientation). The setup includes a top antenna for the benchmarking with inductive excitation/detection, shown in the optical image. The inset is an enlarged view of the antenna's constriction with several CoFeB microdisks. (b) Spectroscopy of the magnetic excitations achievable either using traditional antenna (top panel) or using the rolling field of the SAW (bottom panel) at 0.86 GHz, versus applied field. Most modes that are excitable by magnetic fields appear to be also excitation by the magneto-rotation torques.



WHEN NANOSPHERES ORGANIZE, SOUNDRESHAPES

Researchers from C2N and the Instituto de Ciencia de Materiales de Madrid have developed a cost-effective approach to block sound waves oscillating at billions of vibrations per second. By allowing tiny polystyrene spheres to self-assemble, they created a network capable of trapping and controlling hypersound, paving the way for faster and more efficient nanoscale devices.

Further reading

A self-assembled two-dimensional hypersonic phononic insulator
Pedro Moronta, Sandeep Sathyan , Edson R. Cardozo de Oliveira , Rafael J. Jiménez-Riobóo, Norberto Daniel Lanzillotti-Kimura, Pedro D. García and Cefe López
Nanophotonics 2025; 14(22) : 3569–3577
https://doi.org/10.1515/nanoph-2025-0141

FERROMAGNETIC SUPERLATTICES FOR NANOSCALE HYPERSOUND CONTROL

Teams at C2N, working within an international collaboration, have developed Co/Pt multilayers combining magnetism and ultra-high-frequency acoustic vibrations — paving the way for future magnetoacoustic and quantum technologies.

Scientists in France and Argentina have demonstrated that cobalt–platinum (Co/Pt) superlattices, known for their robust magnetic properties, can sustain sound vibrations close to the terahertz frequency range, nearly a trillion times per second. Their findings open a new route toward integrating sound, magnetism, and ultrafast dynamics in nanoscale devices.

Acoustic vibrations at gigahertz to terahertz frequencies—known as hypersound—play a central role in nanoscale control of energy, heat, and spin. Yet achieving such vibrations in magnetic materials has been a long-standing challenge. The new study, published in Journal of Physics D: Applied Physics (2025), shows that metallic Co/Pt multilayers does not only exhibit perpendicular magnetic anisotropy, but also supports hypersound up to 900 GHz, key property for next-generation spintronic and magnetoacoustic systems.

Further reading

Structural and nanoacoustic characterization of Co/Pt ferromagnetic superlattices
J. Phys. D: Appl. Phys. 58 (2025) 455301 (10pp)
E. R. Cardozo de Oliveira, C. Xiang, C. Borrazás, S. Sandeep, J.E. Gómez, M. Vasquez Mansilla, N. Findling, L. Largeau, N. D. Lanzillotti-Kimura and M Granada
https://doi.org/10.1088/1361-6463/ae148a

TOWARDS A COMPLETE PHOTONIC INTEGRATED PLATFORM FOR MID-IR SPECTROSCOPY

The development of compact systems operating in the mid-infrared wavelength range is of high interest for spectroscopic and sensing applications. Interestingly, graded index Silicon Germanium (SiGe) photonic circuits possessed unique properties for the development of a complete photonic integrated platform in this wavelength range, which are their transparency in a wide spectral range together with the strong non linear index and ability to fine tune both the electronic bandgap and refractive index of SiGe alloys.
In the last year major achievements have been obtained across different fundamental building blocks :

- High speed optical modulators based on carrier depletion in SiGe photonic circuits have been demonstrated. By using the free-carrier plasma absorption effect, the device achieves an extinction ratio of up to 1.9 dB at a wavelength of 9 µm. High-speed operation up to 7 GHz is obtained, while the optical bandwidth is estimated to be around 3 GHz.
- As the development of on-chip spectroscopic systems require broadband mid-infrared sources, supercontinuum generation has been improved, targeting a reduction of the required input power. Octave spanning supercontinuum generation at a record-low peak power of 311 W in this wavelength range has thus been demonstrated.
- Compact integrated resonators have also been demonstrated. Two designs have been developed and compared based on racetrack with Euler bends and wrapped ring resonators. In each case the ring radius is 100 µm. Q factors above 40,000, with over 10 dB of extinction ratio have been demonstrated at 7.5 m wavelength.

Interestingly, each of these results represent a significant step forward in the performance of mid-IR integrated photonics, paving the way for high-performance on-chip spectroscopic systems.

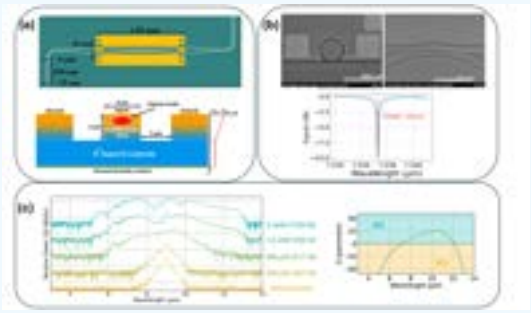


Figure : (a) Integrated electro optical modulator : a Schottky diode is embedded in a SiGe waveguide, and free carrier absorption is used to achieve high speed optical modulation (b) : Compact ring resonator. A thermal phase modulator is used to retrieve the resonance linewidth (c) : Supercontinuum generation within SiGe waveguide. Dispersion engineering allow a flat – more than one octave– super continuum generation.

POLARIZATION INDEPENDENT SILICON MICRO ANTENNA BASED ON A SUBWAVELENGTH METAMATERIAL

Optical antennas are key components of an optical phased array system, enabling light coupling between the chip and the free space. In such systems, surface gratings are commonly used as antenna elements, which however suffer from a strong polarization sensitivity of their scattering angle and efficiency. A C2N team proposes a versatile approach to realize micro antennas based on surface gratings with a polarization insensitive behavior exploiting a subwavelength metamaterial in the silicon-on- insulator platform. In the experimental demonstration, the antenna successfully achieves the same diffraction angle of 10° for both TE and TM polarizations and an estimated scattering efficiency of -4 dB despite a very compact footprint of 6.4 µm x 2.9 µm. The difference in diffraction efficiency between the two polarizations remains smaller than 1 dB over a bandwidth of 31 nm.

Further reading

Polarization independent silicon micro antenna based on a subwavelength metamaterial
Sarra Salhi, Xiaochen Xin, Daniel Benedikovič, Carlos Alonso-Ramos, Laurent Vivien, Delphine Marris-Morini, Eric Cassan, Winnie N. Ye & Daniele Melati
Scientific Reports volume 15, Article number : 13276 (2025)

Figure : Scanning electron microscopy top view picture of the fabricated grating antenna

GENERATING RECONFIGURABLE ENTANGLED PHOTONIC STATES WITH A SINGLE QUANTUM LIGHT SOURCE

This form of quantum computing relies on the creation of a network of entangled photons (known as a graph state) on which computations are carried out through local measurements. Until now, generating such states reliably and at scale has posed a significant experimental challenge.
By precisely controlling the spin of a single electron trapped in a quantum dot using optical pulses, we have shown that a single semiconductor quantum dot embedded in an optical cavity can deterministically generate a photonic graph state known as a "caterpillar graph." This structure is particularly well suited for implementing fault-tolerant quantum computation.

In the long term, this method could serve as a fundamental building block for photonic quantum computer architectures and pave the way for practical applications such as the simulation of complex physical systems and secure quantum communication. Future research will focus on extending the length of the generated photon chain, implementing error correction protocols, and integrating our system with on-chip photonic circuits to enable scalability.

These works are carried out in collaboration with the company Quandela through the QDlight joint laboratory.

Further reading

Deterministic and reconfigurable graph state generation with a single solid-state quantum emitter, H. Huet, P. R. Ramesh, S. C. Wein, N. Coste, P. Hilaire, N. Somaschi, M. Morassi, A. Lemaître, I. Sagnes, M. F. Doty, O. Krebs, L. Lanco, D. A. Fioretto, P. Senellart.
Nature Communication 16, 4337.
DOI : https://doi.org/10.1038/s41467-025-59693-3

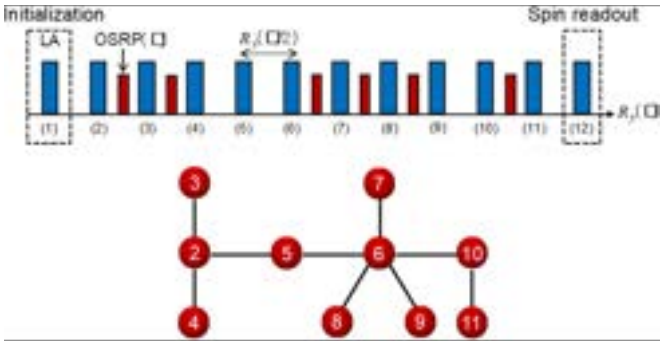


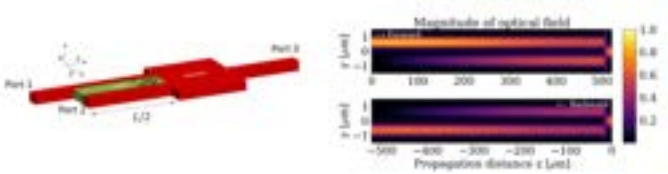
Figure : Near-future example of all-photonic arbitrary caterpillar graph state generation. Pulse sequence combining excitation pulses (LA) and spin control pulses (OSRP) for the generation of all-photonic arbitrary caterpillar graph state that can be generated with our protocol. Each photon emitted following a R_y(π/2) spin gate will be encoded in a new node of the caterpillar graph state, whereas photons emitted after a OSRP pulse will be redundantly encoded with the previous one, within the same node.

THE QUANTUM ERA : C2N, A KEY PLAYER IN FUTURE TECHNOLOGIES

C2N is one of the major and innovative players in the field of quantum technologies. In their appearances on France Culture, two researchers from C2N, Pascale Senellart and Loïc Lanco, present their work on quantum dots, single photons, and photonic circuits, thus paving the way for quantum computing and more secure networks.

INTEGRATED TE OPTICAL ISOLATOR BASED ON MAGNETO-OPTICAL PERTURBATION IN COUPLED WAVEGUIDESELECTROMAGNETIC INDUCED TRANSPARENCY RESONANCE

A team at C2N has proposed a new operating principle for a TE optical isolator, based on the beating of guided modes whose coupling is non-reciprocally disrupted by the transverse magneto-optical Kerr effect (TMOKE). This approach combines evanescently coupled silicon waveguides with the magneto-optical effect of a hybrid material. This new concept is promising for the realisation of a high-performance TE optical isolator, as it does not depend on optical resonances and is free from the constraints associated with interferometers. Based on data from garnet-based magneto-optical materials, the simulated device has a length of 500 µm and its 20 dB isolation bandwidth reaches 35 nm. With its wide bandwidth and high isolation, this device opens up possibilities for the realisation and miniaturisation of complex photonic circuits for optical communications, all-optical signal processing, optical sensors, etc.



Further reading

Integrated TE optical isolator based on magneto-optical perturbation in coupled waveguides.
Kimhong Chao, Vy Yam, Laurent Vivien, and Béatrice Dagens
Scientific Reports 15, no. 1 (2025) : 20381.
https://doi.org/10.1038/s41598-025-08507-z

Figure 1 : left : Schematic of the optical isolator, a combination of a TMOKE coupled-waveguide system and a 1×2 multimode interferometer (MMI). The forward input is Port 1, and the output is Port 3. When a signal is back reflected through Port3, it can be collected at Port2: the device operates as an isolator and also as a semi-circulator. L is the coupling length of the coupled waveguides system, and the gap including the magneto-optical material is chosen to optimize the isolation ratio. Right: FDTD simulation of the TE mode propagation in forward and backward directions.

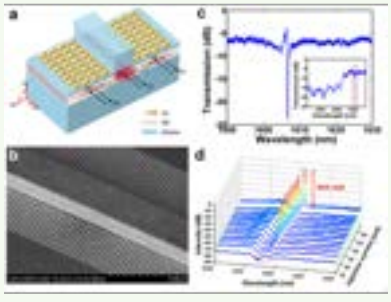
ELECTRICALLY INJECTED METAMATERIAL GRATING DFB LASER FOR TELECOM APPLICATIONS EXPLOITING AN ULTRA-HIGH Q ELECTROMAGNETIC INDUCED TRANSPARENCY RESONANCE

Researchers at the Centre de Nanosciences et de Nanotechnologies (C2N), in collaboration with Laboratoire Charles Fabry (LCF) and Telecom SudParis proposed to use a 2D metamaterial Bragg grating assisted waveguide to achieve Electromagnetically-Induced-Transparency (EIT) resonance with an ultra-high Q~5000 and contrast >20dB. This concept was further applied to the demonstration of single frequency emission electrically injected distributed feedback (DFB) lasers in the NIR telecom domain. The ability of metamaterials to shape lasing properties with EIT - based low losses light propagation opens promising perspectives that such types of lasers may present increased robustness with respect to parasitic optical return which constitutes one of the major impairments of DFB lasers in telecommunications applications.

Further reading

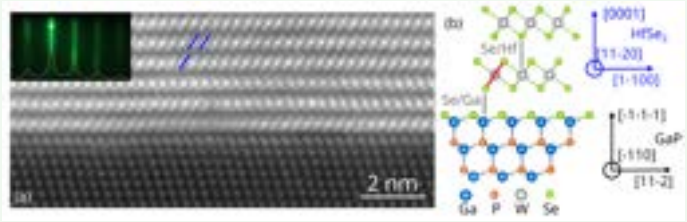
Electrically injected metamaterial grating DFB laser exploiting an ultra-high Q electromagnetic Induced Transparency resonance for spectral selection.
N. Dubrovina, Y. Liang, Q. Gaimard, V. Brac de la Perrière, K. Merghem, H. Benisty, A. de Lustrac, A. Ramdane, A. Lupu
Advanced Functional Materials, 2024, 34 (45), 2405912.
https://doi.org/10.1002/adfm.202405912

Figure 1 : (a) Sketch of the dielectric ridge waveguide assisted by MM Bragg grating. The arrows S1 and S2 represent the two counter-propagating modes of the ridge waveguide. The arrows S3 and S4 represent the fundamental plasmonic supermode of the MM grating. Their profiles (blue/red/brown) are visible on the different cuts., (b) SEM view of gold cut-wires MMG and III-V passive semiconductor waveguide. (c)Transmission spectrum of a 2 µm wide and 3.2 mm long MMG ridge waveguide in the EIT region. The inset shows the spectral response at extended wavelength range. The red box indicates the EIT region. (d) Emission spectra of 1.68 mm long laser waveguide structures at different injection currents.



SURFACE PASSIVATION OF A III–V SUBSTRATE : TOWARD THE GROWTH OF 2D/3D HETEROSTRUCTURES

In recent years, several well-established 3D substrates have been considered for the van der Waals epitaxy of 2D-transition metal dichalcogenides, yet require a proper surface passivation treatment. In the framework of a collaboration between IEMN and C2N, the structural and electronic properties of well-ordered Se-terminated GaP(111)B surfaces by molecular beam epitaxy are studied. The key role of combining atomic hydrogen and cracked phosphine to prepare a smooth P-rich surface with a (2×2) reconstruction on n- and p-doped GaP(111) B is highlighted. The evolution of the surface electronic properties after exposure to a selenium flux is then investigated. The GaP(111)B surface exhibits a systematic change in reconstruction from a (2×2) to a (1×1) pattern, accompanied by a modification of the chemical environment mainly in the outermost P-terminated layer. The absence of GaSe layer formation is evidenced through photodiffraction experiments, while the band structure of the Se-passivated surface is shown to originate from that of GaP(111)B. An effective partial electronic passivation of the surface is further revealed by the evolution of the band bending and surface dipole measured with ultraviolet photoemission spectroscopy. This realization of a Se-terminated GaP(111)B substrate opens new perspectives for the development of 2D/3D heterostructures of strong interest for nanoelectronic and optoelectronic applications.



Further reading

Electronic properties of the selenium passivated GaP(111)B surface : towards growth of large scale quasi-van der Waals 2D/3D heterostructure

Niels Chapuis, Corentin Sthioul, Aymen Mahmoudi, Meryem Bouaziz, Christophe Coinon, Louis Thomas, Davide Romanin, Gilles Patriarche, Fabrice Oehler, Abdelkarim Ouerghi and Xavier Wallart

Physical Review Material 9, 074002 (2025)

DOI : https://doi.org/10.1103/pv8b-89gg

Figure : example of quasi van der Waals epitaxy on a Se-passivated GaP(111)B surface . (1×1) RHEED pattern and HAADF-STEM image of a HfSe2/Se-GaP(111)B heterostructure grown with MBE (a) and the associated side view schematic created with VESTA (b).

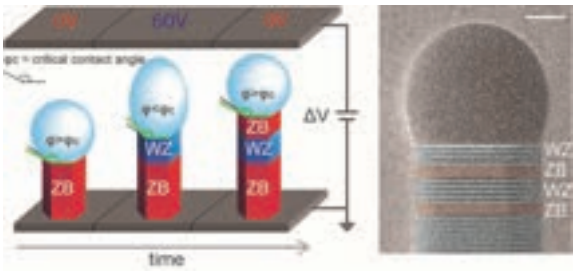
ELECTRIC-FIELD-ASSISTED PHASE SWITCHING FOR CRYSTAL PHASE QUANTUM DOT FABRICATION IN GAAS NANOWIRES

Researchers at C2N and the National University of Singapore have demonstrated a new way to control the crystal structure of semiconductor nanowires using an electric field, paving the way for the on-demand fabrication of crystal-phase quantum dots.

Controlling different crystal phases within nanowires presents both a challenge and an opportunity. While unwanted phase mixing can degrade device quality, deliberately controlling these phases can be used to create new quantum structures known as crystal-phase quantum dots (CPQDs).

In a study published in ACS Nano, the team shows that applying an electric field during the vapour–liquid–solid growth of GaAs nanowires enables precise switching between two crystal structures—zinc blende (ZB) and wurtzite (WZ). This switching occurs with monolayer precision, making it possible to fabricate CPQDs with unprecedented control.

This breakthrough was made possible by custom micro-engineered silicon platforms operated inside the in-situ transmission electron microscope, NanoMAX.



Further reading

Electric-field-assisted phase switching for crystal phase quantum dot fabrication in GaAs nanowires

Qiang Yu, Khakimjon Saidov, Ivan Erofeev, Khalil Hassebi, Chen Wei, Charles Renard, Laetitia Vincent, Frank Glas, Utkur Mirsaidov, Federico Panciera

ACS Nano, DOI : https://doi.org/10.1021/acsnano.5c15434

Figure 1: Crystal phase changes induced by an E-field. (left) Schematic view of the experimental setup showing that applying an E-field during growth induces the crystal phase switching in GaAs nanowires. The E-field dynamically deforms the catalyst droplet, modulating its contact angle beyond a critical threshold to trigger zinc blende (ZB)–wurtzite (WZ) transitions with monolayer precision. (right) Example of crystal phase quantum dots fabricated by the E-field method. The scale bar is 5 nm.

THE C2N TECHNOLOGICAL FACILITIES

The C2N Technological Facilities are hosted in a **clean room of 2 900 sqm**, dedicated to micro and nanofabrication processes, epitaxy and characterization of materials. Some areas are also devoted to education and continuous training in micro-nanotechnologies, and **250 sqm are dedicated to start-up or SME activities**. More than **50 M€ are invested in state-of-the-art equipments for micro-nanotechnologies** and **40 engineers and technicians work in 3 platforms : PIMENT, POEM and PANAM**. The C2N cleanroom is an essential tool for research carried out in the laboratory. It is also part of the French network (RENATECH) coordinated by the CNRS to support research and innovation in the field of micro-nanotechnologies at the national level. Today, more than two hundred academic and industrial projects are supported by our facilities. Among these projects, 25% are from external laboratories.

To access our facilities
To send a request

- via the RENATECH website

- contact directly the Technological Facility staff by e-mail : renatech@c2n.upsaclay.fr

OUR TECHNICAL PROFESSIONS AT THE HEART OF RESEARCH

PAROLES D'EXPERT.E. THE NEW C2N VIDEO SERIES

Our new video series takes you behind the scenes to meet the staff of our nanotechnology center, at the heart of the technical professions that support research and innovation. Faces, expertise, and above all, unwavering commitment.

(From top to bottom)
Abdelmounaim HAROURI
Expertise : optical and alternative lithography
Feriel Laourine
Expertise : dry etching
Frédéric Mahut
Expertise : scanning electron microscopy and microanalysis
Teo Baptiste
Expertise : metal deposition

Discover this series on our YouTube channel

THE ULTIMATEPV PROJECT, LAUREATE OF AN ERC SYNERGY GRANT

Stéphane Collin (CNRS, France), Stefan Glunz (University of Freiburg and Fraunhofer ISE, Germany) and Christophe Ballif (EPFL/CSEM, Switzerland) have been awarded the prestigious ERC Synergy Grant 2025. Their UltiMatePV project aims to rethink the modern solar cell and develop a new generation of photovoltaic technologies that are more resource-efficient and offer higher conversion efficiencies.

The French team will bring together researchers from C2N (Stéphane Collin, Amaury Delamarre) and IPVF (Jean Francois Guillemoles, Daniel Suchet).

With this 16th ERC grant awarded to C2N researchers, the laboratory reaffirms its status as a leading international center in nanoscience and nanotechnology, showcasing the vitality and excellence of its teams.

FOR FURTHER INFORMATION

ULTRATHIN SOLAR CELLS : TOWARD THE PHOTOVOLTAICS OF TOMORROW

Flexible solar cells that are a thousand times thinner than commercial silicon cells — yet offer the same efficiency : this is the achievement of two CNRS researchers, including Stéphane Collin, a CNRS researcher at C2N, who have developed a trap to “capture” light. The result opens the door to applications in mobile devices that could change our daily lives, as they explain in this report.

Watch the CNRS report on our YouTube channel

PHOTOVOLTAICS EXPLAINED IN A COMIC

This comic aims to make scientific knowledge about photovoltaics accessible to everyone, through a format that is both engaging and rigorous. It is the result of a collaboration between a collective of CNRS researchers and a scientific illustrator, Marie-Charlotte Bellinghery – MACHA, bringing together scientific expertise and creative talent. C2N is very proud to have contributed to this collaborative work through the involvement of Amaury Delamarre and Stéphane Collin, alongside several partners committed to a clear and well-sourced dissemination of knowledge on solar energy.
This comic draws inspiration from the SolairePV guide, a document designed to provide clear, accessible answers based on peer-reviewed scientific work, with the aim of informing public debate on photovoltaic solar energy.

PARTNERSHIPS, COLLABORATIONS AND SCIENTIFIC TRAINING

C2N AND THE UNIVERSITY OF CHILE IN SANTIAGO COLLABORATE WITHIN THE INTERNATIONAL POSEIDON PROJECT

The C2N and the University of Chile in Santiago are working together through an International collaboration called Poseidon, an International Emerging Action project (IEA – 2024-2025) funded by the CNRS. The project explores how solitonic-type structures propagate in discrete lattices of nonlinear photonic cells. The work combines theory, numerical simulations and experimental work carried out in liquid crystal light valves in Santiago and coupled semiconductor excitable micropillar lasers in Palaiseau. At the heart of the project is the goal of understanding and controlling how light pulses can carry information in one direction only — a phenomenon known as non-reciprocal or unidirectional transport. Such control could open the door to ultrafast, on-chip, and brain-inspired computing technologies.

A DECADE OF SCIENTIFIC COLLABORATION IN MOLECULAR ELECTRONICS

The C2N is currently contributing to a long-standing international collaboration through the theoretical modeling expertise of Dr. Yannick Dappe, who recently joined the laboratory.

For over a decade, Dr. Yannick Dappe has played a key role in a high-level trilateral collaboration with Prof. Li Yang (XJTLU, China) and Prof. Richard Nichols (University of Liverpool, UK), thanks to his expertise in theoretical modeling. Together, these researchers are pushing the boundaries of molecular electronics by combining modeling, cutting-edge experimental techniques, and innovative nanoscale devices.

OPTICS IN THE CITY OF LIGHT : C2N PROUD TO HOST TOMORROW'S SCIENTIFIC TALENTS

The C2N is very proud to have been one of the host laboratories for the program Optics in the City of Light – Research Experience for Undergraduates (REU), which offers U.S. undergraduate students the opportunity to gain hands-on experience in cutting-edge research within laboratories of the Paris region.

Among them was Hannah Lias, a student at the South Dakota School of Mines and Technology. For two months, under the supervision of Sophie Bouchoule and Jules Duraz, Hannah worked at C2N on an exciting project : the design and fabrication of thin-film micro-LEDs for integration into an ultra-flexible electronic circuit. The goal of this work, carried out at C2N in collaboration with UMI Georgia Tech-Europe and the Institut de l'Audition, is to develop a prototype of an ultra-compact and flexible optical cochlear implant. This device aims to study direct light-based stimulation of hearing, an approach that could ultimately significantly improve the performance of hearing implants.

PARTNERSHIPS AND TECHNOLOGY TRANSFER AT C2N

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FOCUSED ION BEAMS : AT THE HEART OF TECHNOLOGICAL AND SCIENTIFIC INNOVATION


@Frédérique Plas

In an interview with Parlementaires de France Magazine, Jacques Gierak, coordinator of the «Ion Sources & Instrumentation» platform at C2N, discusses major breakthroughs made possible by focused ion beams. From nano-engineering to the creation of deeptech start-ups, this cutting-edge technology is opening up new prospects for both industry and research.

LUMISYNC : DATA SYNCHRONIZATION AT THE SPEED OF LIGHT

The start-up LumiSync is developing the world's first on-chip 100% photonic oscillator based on a unique technological and instrumental savoir-faire developed for several years at C2N with the strong support of its state-of-the-art cleanroom facilities. The ultra-stable microwave oscillations produced by this nano-component enable data synchronization at the speed of light, unlocking the full potential of next-gen AI, HPC and optical computing, as well as new telecom and aerospace use-cases.

Founded by Giuseppe Modica (CTO) and Rémy Braive (CSO), researchers at C2N, along with Alexis Jonville (CEO), LumiSync has benefited from CNRS 'pré-maturation' funding and CNRS INNOVATION support.

Lumi-Sync is the 7th start-up to emerge from the research conducted at C2N.

THE C2N AT THE HEART OF THE CNRS *UN TEMPS D'AVANCE* PROGRAMME

C2N had the honor of being selected by CNRS for its «Un temps d'avance» program, an initiative designed for public and private decision-makers, including elected officials, industry leaders, and journalists.

The program offers an immersive look into public research to foster a better understanding of its role, its operations, and its contribution to major contemporary challenges.

Finally, the day was marked by the pleasure of once again welcoming Physics Nobel Laureate Alain Aspect to C2N.

THE C2N, A KEY PLAYER IN INNOVATION MAY 20–21 AT PARIS-SACLAY SPRING

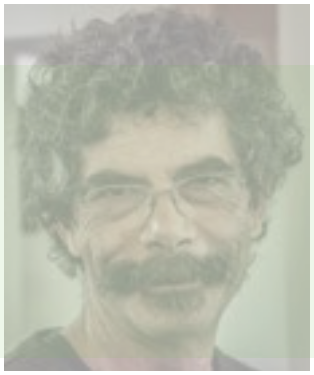
The CNRS invited innovation stakeholders on May 20 and 21 to discover how fundamental research was fueling the technological breakthroughs of tomorrow. Companies seeking scientific expertise or technological levers could meet C2N experts at the CNRS booth at Paris-Saclay SPRING and discover cutting-edge technologies emerging from research in nanoscience and nanotechnology.

EVENTS

40 ANS DES BOÎTES QUANTIQUES ÉPITAXIÉES

HOMMAGE À JEAN-YVES MARZIN

23 - 24 JANVIER 2025
CENTRE DE NANOSCIENCES ET DE NANOTECHNOLOGIES



40 years of epitaxial quantum dots : a look back at a major scientific and technological anniversary dedicated to Jean-Yves Marzin

In 1985, the article titled Growth by molecular beam epitaxy and characterization of InAs/GaAs strained-layer superlattice was published. This foundational act in international research on epitaxial quantum dots marked the beginning of 40 years of fruitful research, intertwining various disciplines : materials physics, advanced characterization methods, nanotechnology, optics, and quantum technologies. These works, blending fundamental aspects with diverse applied developments, led to major scientific breakthroughs and significant success for both the French and international scientific communities.

To preserve these moments and the scientific legacy they represent, a documentary has been produced. Based on interviews with the key figures of this anniversary, the film retraces the epic story of the discovery of quantum dots and explores the breadth of their applications. This documentary was created at the initiative of the SFO's PEPITES program (Preservation of Intangible Technological and Scientific Heritage).

▶ It is available on our YouTube channel.

C2N, A KEY PLAYER IN THE RENATECH AND RENATECH+ 2025 EVENTS

The 2025 Renatech+ Lithography and Etching Days were held at C2N from June 17 to 19, bringing together over 60 participants from 21 technology centers and 8 industrial sponsors (DMO, ElectronMec, NanoSystemSolutions, Hummink QuantumDesign, Sentech, DKSH, and Scia).

Topics covered during the event ranged from HSQ HR to bio-based resins, including etching of glass, diamond, and parylene membranes. A poster session allowed PhD students and postdoctoral researchers to present complete and complex fabrication processes as well as micro-transfer printing techniques.

Industrial partners showcased their latest developments in laser lithography, IBE, ALE, and inkjet microstructuring during a special session dedicated to company presentations.

The Renatech Deposition Days 2025, organized at the Institut des Nanotechnologies de Lyon (INL), notably by members of C2N, brought together 51 participants and offered a rich program combining oral presentations, industrial exchanges, and platform visits. Participants attended technical and scientific presentations from industry representatives (to be confirmed), covering the following topics :

- Constraints in thin films
- Adhesion and cohesion of deposited thin layers
- New materials and new techniques
- Characterization of deposits
- Any deposition-related topic participants wished to discuss

A poster session allowed participants to present their central facilities or platforms. The event also included visits to a platform at INL and the Laboratoire des Matériaux Avancés (LMA), providing an immersion into cutting-edge infrastructures and equipment.

Finally, a roundtable at the end of the meeting fostered discussions and exchanges on the challenges and innovations related to thin-film deposition.

SECOND EDITION OF OUR INTERNAL EVENT, LES RENCONTRES DU C2N

The second edition of the laboratory's internal event, C2N Meetings, brought together all staff for a day dedicated to storytelling and highlighting the laboratory's scientific and technological achievements.

Hosted by science journalist Mathieu Rouault, the event offered an opportunity to reflect on the year's key highlights, showcase the teams' expertise, and emphasize the collective energy that drives C2N.

Roundtables, cross-disciplinary exchanges, and the presentation of the video project Itinérances – Season 2 created an environment that encouraged interactions among all our teams. The event helped break down silos across roles and disciplines, fostering dialogue between research, technology, and support functions.

C2N Meetings contribute to building the laboratory's collective memory.

▶ Recap video of the event

SEASON 2 OF ITINÉRANCES : HIGHLIGHTING THE PATHS OF C2N PHD STUDENTS

Itinérances is a video series dedicated to C2N PhD students, highlighting their journeys, research, and personalities. Each 2-minute episode tells a personal story in the world of nanoscience, reflecting the diversity of paths, which is a true strength of C2N.

This year, Anna Tarasova, Mohamed Mamlouk, Lara Couronné, and Oleh Ivashtenko — PhD students respectively from the MicroSystems and NanoBiofluidics department, the Nanoelectronics department, a CIFRe thesis between C2N and the company Quandela, and the Photonics department — shared their journeys. These videos are one of the highlights of the C2N meetings.

▶ Discover these videos on our YouTube channel

AWARDS AND DISTINCTIONS

DELPHINE MARRIS-MORINI ELECTED OPTICA FELLOW

This prestigious title recognizes major contributions in the fields of optics and photonics, whether in research, engineering, education, or industry. Delphine Marris-Morini is honored for her significant contributions to silicon photonics, from the near-infrared to the mid-infrared range.
Delphine Marris-Morini is a Professor at Paris Saclay University since 2015. Her research interests at the Center for Nanosciences and Nanotechnologies covered first high speed and efficient silicon photonics devices for telecom applications. Since 2009 she developed a new route towards efficient on-chip optical links based on Ge/SiGe quantum wells structures.

She then shifted her research activity towards mid-IR range based on SiGe photonics circuits that she developed during an ERC starting grant (2015-2020). Recently she obtained an ERC advanced grant (2023-2028) on electro-optic frequency comb generation in the mid-IR wavelength range. She received the bronze medal from CNRS in 2013 and the Fabry De Gramont prize in 2017.

PAULA NUÑO RUANO, LAUREATE OF THE "TOUTES DISCIPLINES" SCIENCE PRIZE AWARDED BY THE THE CHANCELLERIE DES UNIVERSITÉS DE PARIS

The Chancellerie des Universités de Paris has revealed the laureats of the 2025 solemn thesis prizes. The C2N warmly congratulates Paula Nuño Ruano, laureate of the "Toutes disciplines" Science Prize for her thesis entitled "Optomechanical Metamaterials on Silicon for Brillouin-Based Devices", carried out at C2N under the supervision of Carlos Alonso-Ramos, CNRS researcher.

Discover her portrait produced as part of our Itinérances video series, which highlights the trajectories of our PhD candidates.

SECOND QUANTUM REVOLUTION : INAUGURAL LECTURE BY PASCALE SENELLART AT THE COLLÈGE DE FRANCE

Pascale Senellart, Research Director at CNRS at C2N, is the guest of the Liliane Bettencourt Chair of Technological Innovation at the Collège de France for the 2025–2026 academic year. Her inaugural lecture took place on December 11, 2025.
Established in 2006, the annual Liliane Bettencourt Chair of Technological Innovation reflects the joint commitment of the Collège de France and the Bettencourt Schueller Foundation to highlight the importance of research dedicated to technological innovation.

Discover her profile in CNRS Le Journal.

SCIENCE OUTREACH : A YEAR OF COMMITMENT AND SHARING

In 2025, C2N further strengthened its commitment to science outreach. The initiatives carried out reached a broad audience, from high school students to PhD candidates, while also engaging the general public. These actions reflect our determination to help shape the future of science. Our mission is essential: making science accessible, sharing knowledge, and inspiring future generations.

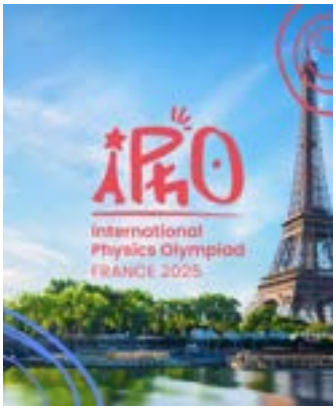
Events in which C2N took part in 2025
Paris Saclay Summit
La Recherche en basket
Déclic collège
Festival Pint of Science
Olympiades Internationales de la Physique
Fête de la Science

Key figures – 2025
Total number of people reached : 1,567
Researchers and staff involved in 2025 projects : 213

Distribution of activities
Off-site activities : 46%
On-site activities : 54%

Audiences reached
Young, underserved and international audiences : 1,443 people (approximately 92% of the total audience)

Breakdown by audience type
National high school students : 38.39%
Middle school students : 21.69%
Adults : 20.10%
University students : 11.92%
Primary school students : 5.13%
International high school students : 2.77%



ART AND SCIENCE : INFINITE ZOOM INTO THE INFINITELY SMALL

This digital artwork, created by Australian artist Luke Conroy and supported by C2N, offers a visual experience based on an infinite zoom, a gradual journey into the infinitely small. Designed from photographs submitted by C2N staff, it embodies a process of collaborative creation.

The work takes the form of a collective visual memory, composed of fragments of everyday life in the laboratory. It reflects the research conducted at C2N, where each individual contribution forms part of a larger whole. The material shared by the laboratory staff gives rise to a vision of C2N shaped by aesthetics, collaboration, and the human dimension of research.
This installation mirrors C2N's principles : sustainable and responsible research, diversity of nationalities, backgrounds, and research areas, scientific ethics, impact on living beings, contribution to the common good, as well as creativity and innovation.

Carrying identity and history, this artwork highlights the human richness of C2N and serves as a reminder that research is oriented toward knowledge in the service of society and the common good.

▶ available on our Youtube channel

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