Scientific Newsletter

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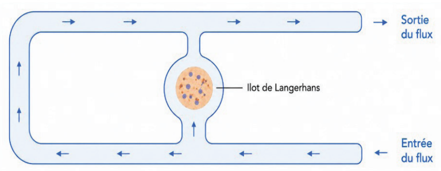
Type 1 diabetes: performing functional tests using an automated lab-on-chip

Flora Clément
[Biosciences and bioengineering for health Laboratory]

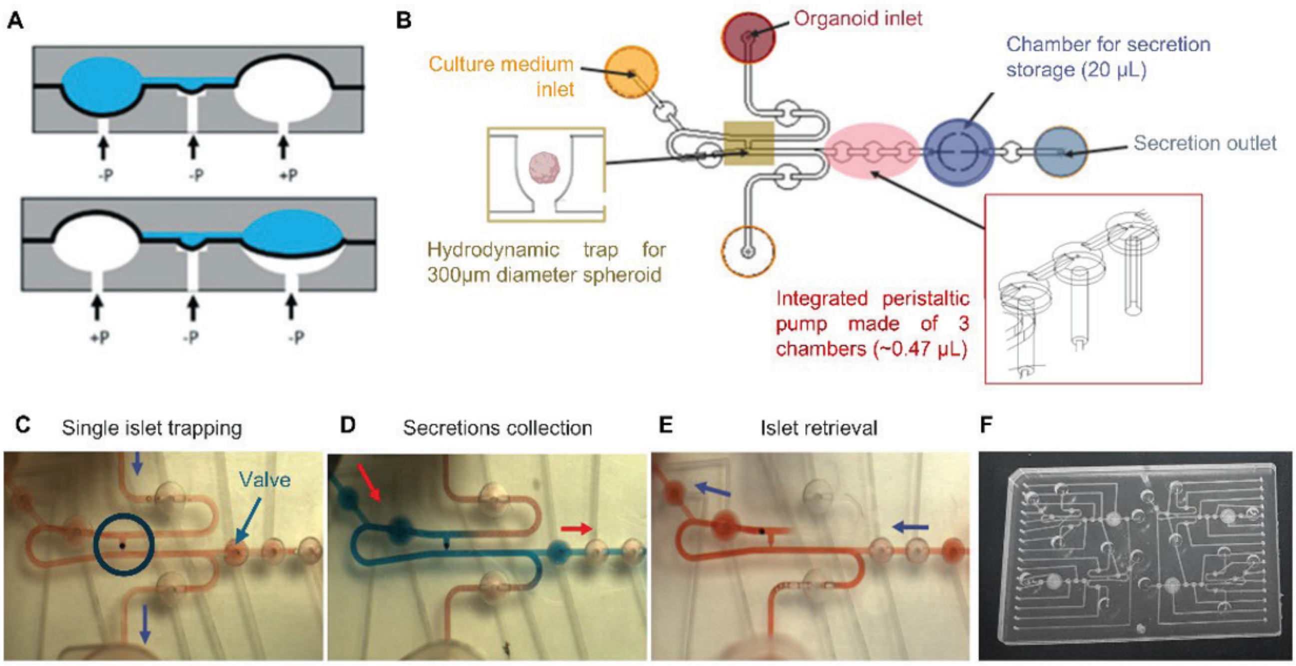


As part of the **FOCUS OSP program***, researchers from CEA-Leti/DTIS/SEMIV and CEA-Irig/BGE have developed and validated an automated platform with an integrated micropump that enables precise measurement of insulin secretion from a single pancreatic islet. This breakthrough paves the way for precision and personalized diabetes medicine, and aligns with the CEA's strategic focus on "Medicine of the Future".

Diabetes affected 589 million people worldwide in 2024. To better understand this disease and test new treatments, researchers are studying the **islets of Langerhans*,** which are responsible for insulin secretion and are dysfunctional in **type 1 diabetes***. Conventional approaches often group together many islets to measure insulin concentration, but this masks their individual differences. Furthermore, current systems rely on external and manually operated devices (such as syringe pumps or fluidic pumping systems), resulting in complex and less user-friendly workflows. This study presents an integrated and automated solution that enables the parallel analysis of multiple individual islets.

In collaboration with CEA-Irig/BGE/Biomics, researchers at CEA-Leti/DTIS/Semiv have developed an innovative microfluidic chip with an integrated micro-pump that circulates fluids, eliminating the need for bulky external pumps and ensuring ultra-sensitive measurement of secreted insulin. Thanks to precise flow control, the islets are individually captured in hydrodynamic traps. Through a collaboration, researchers from CEA-Irig/BGE/Biomics have performed functional testing in cell biology by using two biological models to measure the individual response of the islets: **spheroids*** (from cell lines) and **human islets** (from organ donations). Both models demonstrate remarkable viability of 99% and a robust response to glucose.

The originality of this study lies in the complete and automated integration, within a microfluidic chip, of a true lab-on-a-chip platform encompassing the entire experimental workflow, from the capture of a pancreatic islet and its perfusion to the functional assessment of its physiological response through the quantification of secreted insulin. This approach successfully reproduced the functional variability observed among islets from the same donor, demonstrating the platform's ability to preserve and reveal the intrinsic biological heterogeneity of pancreatic tissue. In the future, the integration of real-time sensors within this microfluidic circuit could provide an *ex vivo* functional representation of patient physiology, facilitating the study of interindividual variability and the personalized evaluation of therapeutic responses.



Microfluidic chip. A) Structure of the microfluidic chip: a hyperelastic membrane sandwiched between two cyclo-olefin copolymer layers deforms inward under negative pressure (-P) to allow flow and is pushed against the upper layer under positive pressure (+P) to block flow. B) Schematic of the microfluidic platform comprising a hydrodynamic trapping region designed for 300 µm spheroids, an integrated micropump consisting of three valves (~µL) for medium perfusion and secretion collection, and a downstream storage chamber for collected secretions. Experimental workflow: C) trapping of a single islet (within the hydrodynamic trap outlined in blue); D) actuation of the micropump to collect secretions (~µL.min^{-1}); E) retrieval of the islet by reverse actuation of the micropump. Flow directions are indicated by blue and red arrows. F) Photograph of the microfluidic chip.

***FOCUS OSP program** interdisciplinary program called “Focus Organoids on a Chip” to develop organoids on a chip (OSP) to promote groundbreaking concepts and technologies in the medical field. Co-supervision DRF/DRT (Anselme Perrier/ Fabrice Navarro).

***Islets of Langerhans :** small clusters of cells located in the pancreas. Their role is to produce hormones (such as insulin) to regulate blood sugar levels (glycemia). These islets are implicated in diseases such as diabetes.

***Type I diabetes :** chronic disease in which the autoimmune system alters the cells in the pancreas that produce insulin.

***Spheroïds** : three-dimensional aggregates of cells cultured in vitro, typically formed from cell lines.

Tutelles UMR : UGA, CEA, CNRS et INSERM (UA13)

Fundings : Programmes FOCUS OSP et OOC inflexion du CEA ; LabEX GRAL (ANR-10-LABX-49-01).

Collaborations : AP-HP (Hôpital Saint-Louis), Centre Européen des Études sur le Diabète (CeeD, Strasbourg), ILONOV.

REFERENCE

Hut M, Clément F, Tubbs E, Caullet P, Armanet M, Domet T, Bouzakri K, Bietiger W, Navarro F. P, Fouillet Y et Agache V.
Integrated pneumatic micropump for automated glucose-stimulated insulin secretion in single-islet microfluidic platform
Biofabrication 2026

A new electronic nose with a keen sense of smell

Yanxia Hou Broutin
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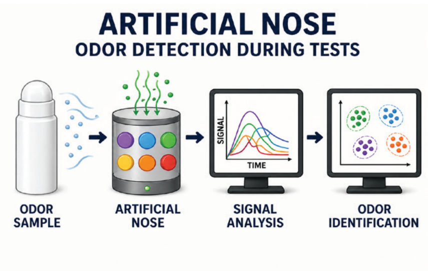
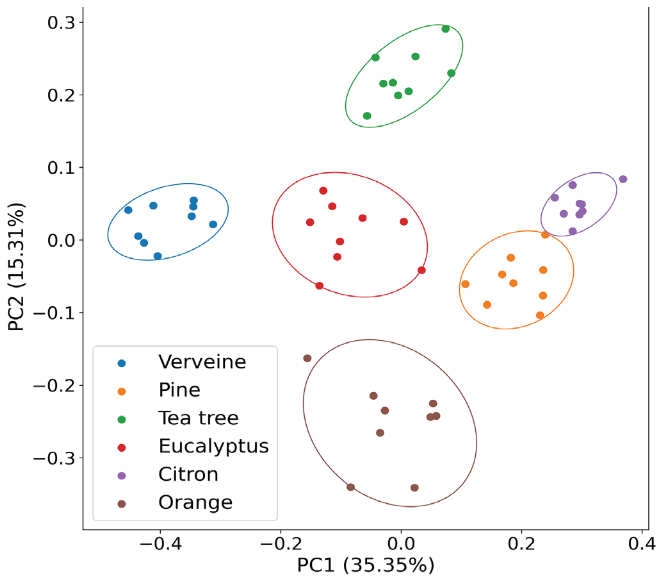


The sense of smell, one of the five human senses, remains the most complex to replicate to date. The detection and measurement of odors are indeed one of the major scientific and technological challenges that have not yet been fully resolved. However, researchers at CEA-Irig/SyMMES have just developed a new biomimetic electronic nose with performance levels unmatched to date, opening up the prospect of a new generation of devices whose performance would come close to that of the human nose.

Thanks to the numerous combinations of its 396 different types of olfactory receptors, most of which exhibit cross-reactivity to odor molecules, the human nose is capable of analyzing over a billion olfactory stimuli. In order to mimic its performance, or even surpass it (with continuous operation or the detection of hazardous gases imperceptible to humans), and to measure these odors or chemical substances present in the air in an objective and reproducible manner, artificial noses are being developed. Among these artificial noses, electronic noses (using sensors based on inorganic or organic materials) represent the least expensive and most stable systems. However, a problem of selectivity, linked to the sensor's weak interactions with odor molecules present in the air, limits their performance.

For the first time, researchers at SyMMES/CREAB came up with the innovative idea of combining, on a single chip, "generalist" peptides with cross-reactivity and "specialist" peptides with specific affinities for targeted odor molecules.

To achieve this, using a model target for proof of concept, in collaboration with the LIPhy laboratory (CNRS/UGA), they carried out a large-scale screening using the "**phage display***" technique, enabling them to identify five highly specific peptides exhibiting optimal sensitivity and selectivity for air pollutants BTEX (Benzene – Toluene – Ethylbenzene – Xylenes).



Principal component analysis* of six essential oils used as complex mixtures, showing how the samples cluster or separate according to their chemical signatures, and thus demonstrating the discrimination performance of the biomimetic electronic nose, which combines cross-reactive 'generalist' peptides with more selective 'specialist' peptides. © CEA

They demonstrated that the electronic noses produced by adding these new "specialized" peptides were able of distinguishing between pure volatile organic compounds from different chemical families, as well as complex mixtures, with great precision and across a range of concentrations, paving the way for the development of a new generation of biomimetic electronic noses with unprecedented performance.

This pioneering biomimetic electronic nose strategy, which combines these two types of peptides within a single device, represents a significant step forward in the development of artificial olfactory systems, paving the way for versatile applications in environmental monitoring, food quality control, and the fields of health and safety

Tutelles UMR : Univ. Grenoble Alpes, CEA, CNRS, Grenoble INP - UGA

Fundings : ANR Siena

Collaborations:
- LIPhy (CNRS/UGA, Grenoble) France

***Phage display:** A technique developed in the 1980s that enables the selection of peptides capable of binding specifically to a given target. This technique allows for the large-scale screening of peptides (a library of 109 bacteriophages displaying different peptides).

***Principal component analysis:** allows samples to be categorized relative to one another according to principal components (PCs). Each point represents a sample, and its position indicates how closely it resembles or differs from the others. The principal components summarize the information contained in many initial variables (responses to different peptides). The first principal component (PC1) combines the variables where the difference between samples is greatest. The second principal component explains the second largest source of variation.

REFERENCE
Vanessa Escobar et al.
A novel biomimetic opto-electronic nose combining cross-reactive peptides with selective phage display peptides for enhanced performance
Biosensors and Bioelectronics
2026

CO_2 conversion: towards more controlled molecular assemblies

Bertrand Reuillard
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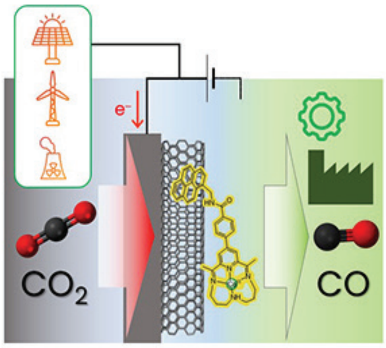
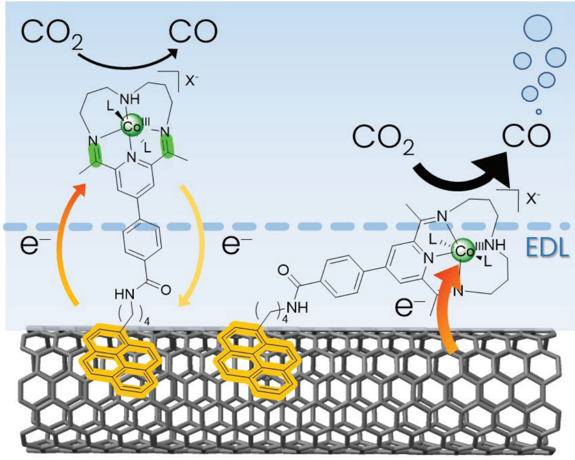


Given the steady rise in energy consumption and its environmental impacts, developing strategies to reduce carbon emissions and utilize CO_2 is a major challenge. In this context, researchers at CEA-Irig/LCBM, as part of a consortium based in Grenoble, have developed and c haracterized molecularly functionalized cathodes that efficiently convert CO_2 into useful products with potential industrial applications.

The conversion of CO_2 into useful compounds *via* **electrocatalytic conversion*** is one of the strategies being considered to limit CO_2 emissions and develop a circular carbon economy. For this purpose, modified electrodes based on molecular catalysts are excellent candidates because they allow for control not only of the catalyst's structure but also of its surface environment, thereby enabling the development of selective and efficient cathodes. These electrodes are indeed capable of producing carbon monoxide (CO, an essential **synthon*** in the chemical industry for **Fischer-Tropsch*** or **hydroformylation*** processes) very efficiently thanks to the integration of cobalt macrocycles* onto carbon surfaces.

In previous work, the modification of the CoN_4H catalyst (a cobalt-based tetraazamacrocyclic complex) with a **pyrene anchoring group*** enabled researchers at CEA-Irig/LCBM to develop an active and selective molecular cathode for CO production in an aqueous medium. In this new study, the researchers leveraged the non-covalent nature of the interaction between the catalyst and the surface to control and decreased the surface concentration of catalytic sites in order to measure their intrinsic activity. Under these conditions, catalytic rates on the order of 5 s^{-1} were observed, and post operando measurements allowed for the characterization of ligand degradation processes responsible for the electrode's loss of efficiency over time.

The authors were thus able to postulate the existence of at least two populations of catalytic sites at the electrode: a first population whose redox response can be observed and whose degradation over time can be measured; and a second population, whose redox responses remain "silent" while catalytic activity continues to be measurable, at very low surface concentrations. The hypothesis that site orientations vary depending on surface concentration could explain these differences in electrochemical responses and have implications for the modulation of site activity as well as for the degradation processes of these sites.



Schematic representation of the surface of the carbon nanotube-based electrode modified with the cobalt macrocycle.
Two populations are proposed: one solvated, the other "conjugated" with the surface and believed to be the most active species in the conversion of CO_2 to CO. © CEA

This work has made it possible to characterize the intrinsic activity of catalytic sites grafted onto the surface, while improving our understanding of the deactivation mechanisms of the electrode during operation. In particular, this study highlights the importance of detailed characterization of molecular assemblies at the surface in order to better understand the mechanisms at play.

The ability to control the orientation of active sites and their surface environment opens up new avenues for research, particularly to modulate the selectivity and stability of electrode sites, with the aim of integrating these cathodes into functional electrolysers designed for CO_2 utilization

Tutelles UMR
CEA - Univ. Grenoble Alpes – CNRS

Fundings
ANR (Labex ARCANE, CBH-EUR-GS, ANR-17-EURE-0003, ANR-21-CE50-0004 and ANR-22-PESP-0010: Project "POWERCO2" within the PEPR project SPLEEN). We acknowledge the European Synchrotron Radiation Facility (ESRF) for provision of synchrotron radiation facilities under proposal number CH-6609

***electrocatalytic conversion:** chemical process driven by an electric current in the presence of a reaction accelerator (catalyst) that transforms a compound into other molecules.

***synthon:** molecular entity used in the synthesis of a molecule to introduce a specific structural motif.

***Fischer-Tropsch processes**: catalytic process that produces hydrocarbons from synthesis gas (CO and H_2).

***hydroformylation:** synthetic route enabling the synthesis of aldehydes.

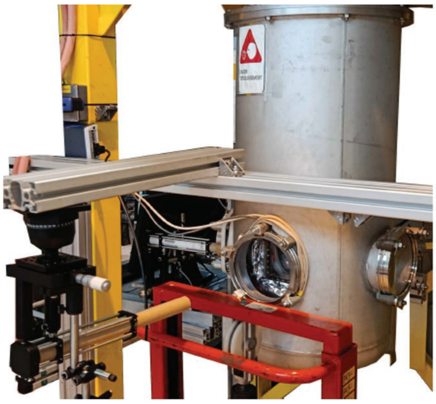
***macrocycle:** organic molecule possessing a large cyclic structure.

***pyrene anchoring group:** allows a catalyst to be attached to a carbon-containing surface without chemically modifying that surface, while ensuring good stability and conductivity thanks to pyrene, an aromatic molecule that forms non-covalent pi-pi interactions with the surface of pi-conjugated materials

REFERENCE
Hake M. et al.
Investigating the Intrinsic Activity, Nature, and Deactivation Pathway of a Carbon-Nanotube-Confined Molecular Co Catalyst for CO_2 Reduction.
J. Am. Chem. Soc. 2026

New instrument to investigate turbulent transport — up to the superfluid regime

Bernard Rousset
Low Temperature Systems Department

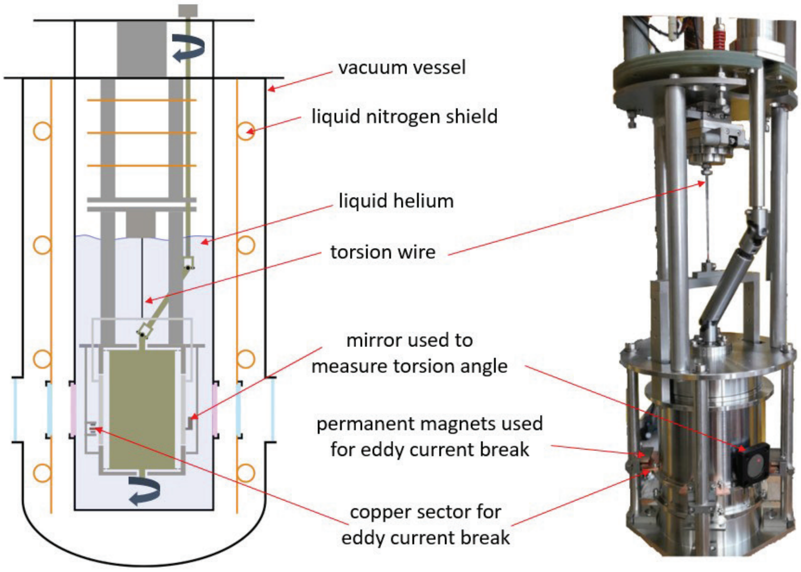


As part of the **CEA PTC-ID program***, the LRTH team at CEA-Irig/DSBT has developed a **Taylor–Couette*** facility dedicated to the study of turbulent fluid transport over a wide range of Reynolds numbers*. The setup relies on an original **torque measurement*** technique, in which the outer cylinder is suspended as a torsion pendulum. This approach enables precise measurements, even under cryogenic conditions. The instrument can also operate with gases and liquid helium, allowing direct comparisons between classical and **quantum turbulence***.

Understanding turbulent transport remains a major challenge in fluid physics, particularly for high Reynolds number's flows where multi-scale interactions become dominant. In this context, Taylor–Couette flow — between two coaxial cylinders in relative rotation — provides a good model system for investigating such phenomena. Indeed, it allows precise control of boundary conditions (i.e., what is imposed on the fluid at the walls, such as the rotation rates of the cylinders) and offers direct access to turbulent transport through torque measurements.

Conventional measurement techniques often rely on sensors mounted on rotating parts, which are difficult to implement in constrained environments, especially at low temperatures. However, the study of liquid helium, and in particular its **superfluid*** phase, opens new perspectives for exploring forms of turbulence involving quantum mechanisms. This requires experimental devices capable of operating under extreme conditions while maintaining high measurement accuracy.

We have therefore developed an experimental setup in which only the inner cylinder rotates, while the outer cylinder is suspended from a torsion wire and directly acts as a torque sensor. The angular deflection of this cylinder, measured optically, allows the torque exerted by the fluid to be determined without the need for rotating instrumentation. An **eddy-current*** damping system ensures rapid stabilization, enabling steady-state measurements..



Taylor-Couette.setup © CEA.

The apparatus is designed to operate both with gases and with liquid helium over a wide temperature range. This flexibility makes it possible to cover more than five decades in Reynolds number and to explore both classical and superfluid regimes. Initial measurements show excellent agreement with known scaling laws in classical turbulence, while also providing access to conditions where quantum effects may play a significant role in transport. Direct access to the torque enables a global measurement of angular momentum transport, which is particularly relevant for comparing these different physical regimes

This new device therefore constitutes a versatile and pioneering experimental tool for the study of Taylor–Couette flow, using either classical or quantum fluids. Torque measurements provide a global diagnostic of turbulent transport, paving the way for a better understanding of the differences and similarities between classical and quantum turbulence

Tutelles UMR (E 9004)

- Univ. Grenoble Alpes
- CEA

Collaborations

- CEA-IRAMIS/SPEC
- CEA-IRESNE/STMA

Fundings

- Programme Transversal de Compétences « Instrumentation et Détection

***PTC-ID program:** Programme Transversal de Compétences « Instrumentation et Détection ».

***Taylor-Couette flow:** Flow of a fluid confined between two concentric cylinders, with at least one of which is rotating.

***Reynolds number:** A parameter used to characterize the flow regime, defined as the ratio between inertial (motion-related) forces and viscous (friction-related) forces in the fluid.

***Torque measurements :** In Taylor–Couette flow, the fluid transmits tangential stress from the rotating cylinder to the stationary one, generating a resisting torque.

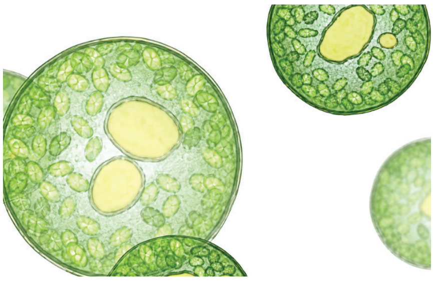
***Quantum fluid/superfluid:** A fluid whose behavior is governed by quantum effects, notably exhibiting zero viscosity under certain conditions.

***Eddy currents:** Electric currents induced in a conductor moving through a magnetic field, producing a force opposing the motion; used here to damp oscillations (a principle also used in heavy-vehicle braking systems).

REFERENCE
DIRIBARNE P, CHARTIER J, DUPLAT J. & ROUSSET B.
CHIMERA: A wide Reynolds number range Taylor-Couette facility.
Review of Scientific Instrument
2026

iMgadit23 : a new tool for modelling lipid metabolism

Juliette Jouhet
Cell & Plant Physiology Laboratory



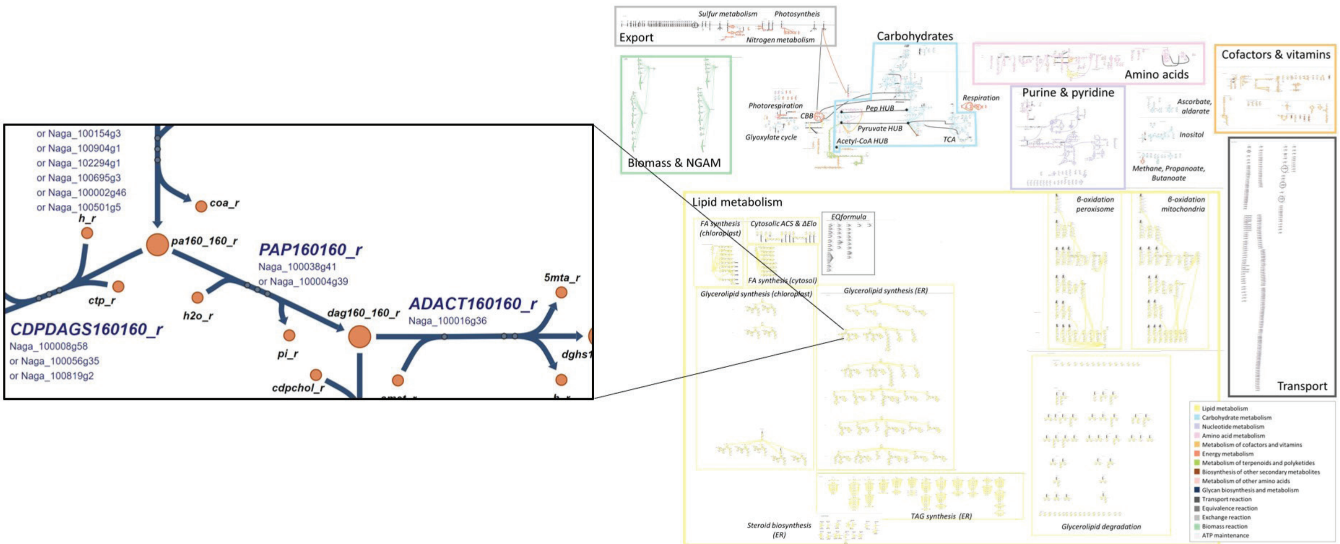
In collaboration with their partners, researchers at CEA-Irig/LPCV have developed a new tool, “**iMgadit23**” which, with a few adjustments, could eventually enable the complete modelling of **lipid metabolism*** in other evolutionarily closely related organisms.

Microalgae are photosynthetic single-cell microorganisms capable of storing energy in the form of lipids in very large quantities. Operating this lipid production is of growing interest for numerous biotechnological applications, such as the production of biofuels. In this study, the researchers of LPCV used the oil-producing microalga Microchloropsis gaditana as a model organism due to its ability to produce high levels of **biomass*** and lipids, and its tolerance to a wide range of culture conditions (pH, temperature, salinity).

In addition to having a complex metabolism, due to the unique nature of its evolutionary history, Microchloropsis gaditana produces and accumulates lipids when the environment is deficient in nitrogen, thereby stopping its biomass production. To optimise and improve the yield of this microalga, an *in silico* approach has been developed: iMgadit23, a **genome-wide metabolic model (GEM)*** for *Microchloropsis gaditana*.

In addition to **predicting metabolic flows***, which are based on system constraints, GEMs enable the prediction of the influence of genetic and environmental factors on **cellular phenotypes***.

iMgadit23 is a new metabolic model of Microchloropsis gaditana with a complete and validated lipid metabolism. The metabolic pathways have all been exhaustively annotated and can be visualised using a *2D ESCHER map*



Escher diagram -Visualisation of the metabolic model of Microchloropsis gaditana. © CEA

Following validation of the model—based on intrinsic quality characteristics such as reaction balance, annotations, etc., as well as experimental data—this model has enabled the simulation of the strain's behaviour in different environments and genetic conditions, and has helped elucidate the metabolic phenotype of a mutant strain exhibiting a highly interesting lipid profile (an eightfold increase in lipid content compared to the wild-type strain).

The development of this new genome-wide metabolic model, iMgadit23, makes possible, for the first time, to fully model the lipid metabolism of Microchloropsis gaditana, thereby enabling the cost-effective elucidation of the metabolic phenotype of candidate mutant strains with a lipid profile that yields higher productivity than the wild-type strain..

As the lipid metabolism has been fully characterised, the strategy used to construct this model is intended to be applicable and transferable to any other living organism.

Tutelles UMR
CEA – CNRS - INRAE – Univ. Grenoble Alpes

Collaborations
- TotalEnergies (France)
- SilicoLife Lda (Portugal)

Fundings
- Cifre PhD (TotalEnergies & CEA)
- GRAL (ANR)

***Lipid metabolism:**
Set of chemical reactions involved in the production, conversion and storage of lipids within an organism.

***Biomass:** Organic matter produced, comprising all the organic molecules (lipids, proteins, carbohydrates) that make up living matter.

***Genome-wide metabolic model (GEM)**: Metabolic network bringing together all known metabolic information about a biological system: metabolites, reactions, genes, enzymes and the associated 'gene-protein-reaction' rules.

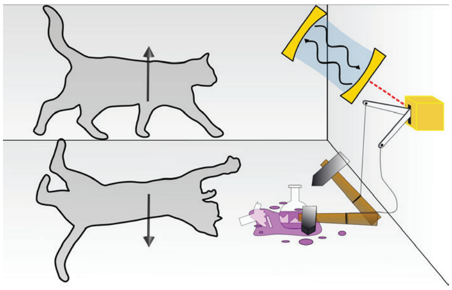
***Metabolic flows**: Rate at which products are synthesised.

***Cellular phenotype:** Set of observable characteristics of a cell resulting from the expression of its genes and the influence of its environment.

REFERENCE
Clemence Dupont-Thibert et al.
A new genome-scale metabolic model of oleaginous microalgae with refined lipid metabolism clarifies Microchloropsis gaditana mutant phenotypes
Bioresource Technology 2026

Why can't cats be dead and alive at the same time?

Simon Zihlmann et Léo Noirot
Quantum Photonics, Electronics and Engineering laboratory



A consortium of scientists, including researchers from CEA-Irig/Pheliqs, has unveiled a new type of **flopping mode qubit*** resulting from a **hole*** spin in a silicon nanowire coupled to microwave photons. While the coupling of the hole spin to the electromagnetic environment is highly desirable for efficient quantum operations, it imposes at the same time limits on the coherence of the spin. Careful mitigation and control of this environment by the researchers lead to a high-performance qubit.

The famous thought-experiment of Schrödinger, where he imagined a cat to be dead and alive at the same time, represents the paradoxical behavior of quantum systems. While microscopic objects can be in a superposition of states, what we call quantum coherence, macroscopic objects cannot. The frontier between these two worlds is given by the interaction of the object with its noisy environment.

A main challenge in quantum physics hence lies in achieving coherent control of a quantum system through cleverly engineering coupling schemes without degrading its coherence properties. Such quantum systems, also called qubits, find increasing interest for quantum computing and quantum simulation.

A promising candidate for these applications is spins trapped in **quantum dots*.** However, as spin-spin interactions are short-range, the construction of large quantum processors with spin qubits is limited and hence a long-range interaction is sought for. By using a system that amplifies electromagnetic microwaves (a superconducting resonator), the coupling of spin qubits to microwave photons will allow such long-range spin-spin interaction in the future. To achieve this, the delocalization of a spin in a double quantum dot ('flopping mode' (FM) qubits), which confers a sizeable electric dipole to the spin, is essential in order to realize strong spin-photon coupling. However, current implementations of this system have so far shown reduced performances.

This study presents a novel hole-based flopping mode (FM) spin qubit in a silicon nanowire coupled to a niobium nitride microwave resonator. Two unprecedented discoveries for this system have been made. First, the achievement of high quantum performances, and second, the identification of its main limiting factor - noise in the electromagnetic environment.

This promising finding calls for a mitigation of this well understood noise source, regularly tackled by improving the electromagnetic environment.

With the limit on quantum properties identified, spin-photon coupling can be implemented without tradeoff. This places the hole spin flopping-mode qubit as a promising tool to leverage light-matter interaction, such as entangling distant spins, or fast spin state measurement.

Tutelles UMR
CEA – UGA – Grenoble INP-UGA

Fundings

- European Union's Horizon 2020 research and innovation program
- National Strategy France 2030, spin–photon PEPR chair
- Spanish Ministry of Science, innovation and Universities.

Collaborations

- Université Grenoble Alpes (UGA)
- CEA-IRIG/MEM/L_Sim
- Instituto de Ciencia de Materiales de Madrid, Consejo Superior de Investigaciones Cientificas, Madrid, Spain.
- Université Grenoble Alpes (UGA)
- CEA-Leti
- Minatec Campus, Grenoble

***flopping mode" spin qubit:** a delocalized spin qubit between two quantum dots with a large electric dipole.

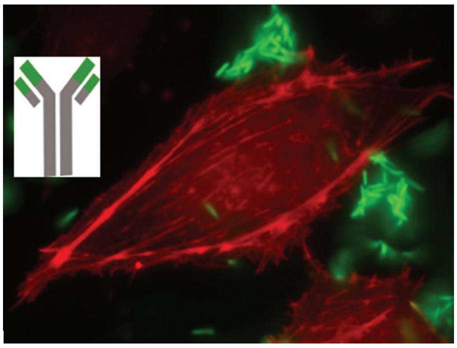
***hole:** absence of an electron in a semiconductor.

***quantum dots:** artificial atoms where single electrons or holes are trapped.

REFERENCE
Noirot L, Yu X. C, Abadillo-Uriel J. C, Dumur E, Niebojewski H, Bertrand B, Maurand R and Zihlmann S.
Coherence of a hole spin flopping-mode qubit in a circuit quantum electrodynamics environment
Nature Physics 2026

Human monoclonal antibodies to combat bacterial resistance to antibiotics

Pascal Poignard et Ina Attree
Institute of Structural Biology



A consortium of researchers from CEA-Irig/IBS identified two human monoclonal antibodies (mAbs) from patients at the Grenoble University Hospital (CHU) suffering from cystic fibrosis and chronically infected with *Pseudomonas aeruginosa* (*P. aeruginosa*) a bacterium responsible for hospital-acquired infections. These two antibodies block the injection of **toxins*** into host cells and significantly reduce the virulence of *P. aeruginosa*.

Superbugs are antibiotic-resistant microorganisms responsible for approximately 700,000 deaths per year, a number that could potentially reach 10 million per year by 2050. P. aeruginosa, a major pathogen in hospital-acquired infections, is often multidrug-resistant, and is particularly dangerous for patients on mechanical ventilation. It also frequently causes persistent lung infections in patients with cystic fibrosis.

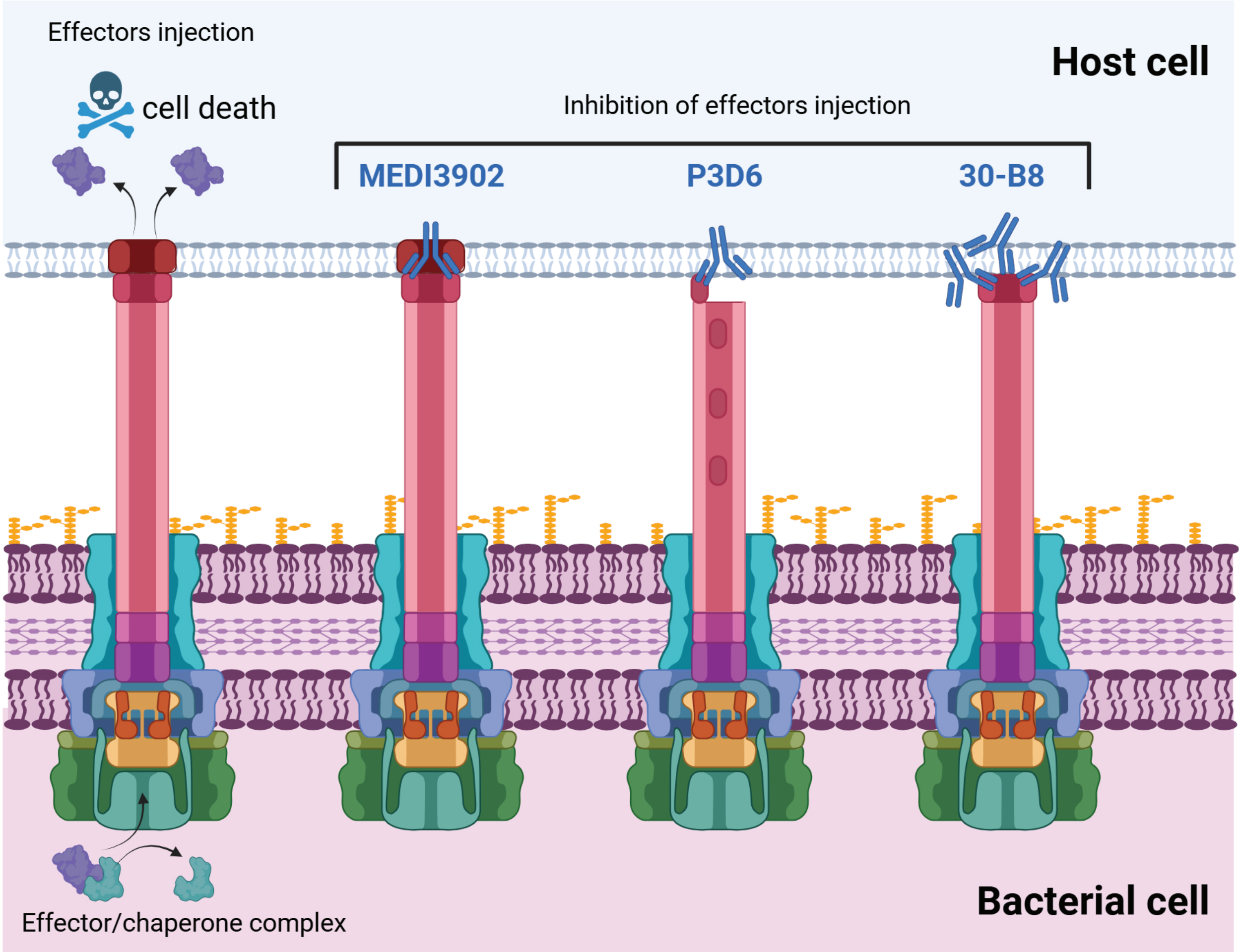
Due to its key role in pathogenesis, the **Type 3 Secretion System* (T3SS)*** *a virulence factor of P. aeruginosa, represents a major therapeutic target. Inhibition of this factor has been shown to reduce the virulence of P. aeruginosa in in vitro and in vivo models.*

The goal of the project was to isolate human monoclonal antibodies (mAbs) capable of reducing the pathogenicity of P. aeruginosa by targeting the T3SS. To achieve this, the researchers screened **specific B cells*** *from patients with cystic fibrosis, and successfully isolated mAbs that target T3SS proteins from P. aeruginosa. They identified two antibodies that bind the PcrV protein located at the tip of the* **injectisome*** *and block toxin injection by the T3SS, thereby reducing the virulence of P. aeruginosa.*

By combining approaches from cellular microbiology, genetics, immunology, and structural biology, the consortium also demonstrated that various anti-PcrV antibodies that inhibit T3SS activity—identified in this study as well as in previous work—act through distinct mechanisms, depending on the **epitope*** they recognize.

This research led to the identification of human mAbs capable of blocking T3SS activity, as well as to the characterization of distinct modes of action for different T3SS-inhibiting antibodies. Comparative analysis of these mechanisms contributes to a better understanding of the differences in efficacy observed among antibodies depending on the recognized epitopes, highlighting that certain mechanisms of action are more effective than others and thereby helping identify which epitopes should be prioritized for the isolation of new effective anti-T3SS mAbs.

Furthermore, these results provide important insights for the structural design of potential anti-Pseudomonas vaccines based on the PcrV protein. Taken together, this work opens new avenues for the development of effective alternative therapies in the context of increasingly widespread antibiotic resistance



Following the oligomerization of PcrV into a pentamer at the tip of the injectisome, a pore forms in the host cell membrane, allowing toxins to be injected and ultimately leading to cell death. A single molecule of mAb MEDI3902 binds to the PcrV pentamer and, although it does not effectively block pore formation, strongly inhibits toxin injection. In contrast, mAb P3D6 can bind only to PcrV monomers, and its mechanism of action appears to involve the inhibition of PcrV pentamer assembly. Finally, up to five mAbs 30-B8 molecules can bind simultaneously to the assembled PcrV pentamer, thereby very effectively blocking both pore formation and toxin injection. This latter mechanism of action appears to be the most effective. © CEA

Tutelles UMR
Univ. Grenoble Alpes – CEA – CNRS

Collaborations
CHU Grenoble

Fundingss
ANR, Région Rhône-Aloes.

***Toxins:** substances of bacterial origin that promote infection by directly damaging the host's cells and tissues.

***Type 3 Secretion System:** a nanomachine that injects toxins into host cells using a molecular syringe, called an injectisome*, or T3SS needle.

***B cells:** immune system cells that produce antibodies.

***Epitope:** site on a protein where an antibody binds.

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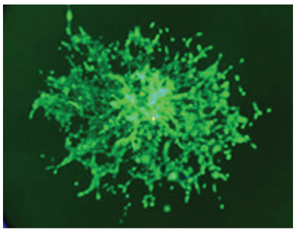
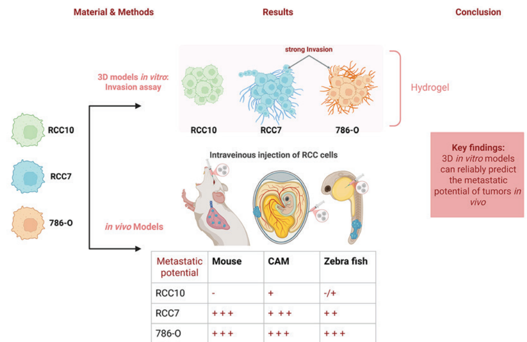
Neutralizing human monoclonal antibodies that target the PcrV component of the type III secretion system of Pseudomonas aeruginosa act through distinct mechanism.
Elife 2026

Advancing neonatal outcomes: a strategic initiative in prematurity care

Odile Filhol - Cochet
Biology and Biotechnology for Health Laboratory



Researchers at CEA-Irig/Biosanté have developed 3D models of renal cell carcinoma that accurately replicate the tumor's aggressiveness. These models are promising predictive tools for assessing metastatic progression and response to treatment.



Les modèles 3D de carcinome rénal sont corrélés au potentiel métastatique observé *in vivo*, permettant une prédiction fonctionnelle de l'agressivité tumorale. © CEA

Renal cell carcinoma* (RCC) is characterized by significant tumor heterogeneity, both at the molecular and functional levels. This diversity complicates the prediction of **tumors' metastatic potential*** and limits the effectiveness of personalized therapeutic strategies. In this context, it becomes essential to develop experimental models capable of accurately reproducing both the intrinsic properties of tumor cells and their interaction with the microenvironment.

In this study, the researchers decided to combine several complementary experimental systems—2D/3D in vitro models and in vivo models—to characterize the invasive behavior of three renal cell carcinoma cell lines: RCC10, RCC7, and 786-O.

The originality of this approach lies in:

- the use of advanced 3D *in vitro* models (**spheroids***),
- *in vivo* cross-validation across multiple models (zebrafish, **chorioallantoic membrane***, mice),
- the ability to validate the results using patient-derived tumors (**tumoroids***).

Researchers have shown that 3D models (spheroids and tumoroids) correlate with differences in aggressiveness observed in vivo and are therefore promising predictive tools for metastatic progression and treatment response.

Thanks to this approach and this breakthrough, which enables the functional prediction of tumor aggressiveness, these tumoroids will be able to be used to assess treatment response and pave the way for precision and personalized medicine.

***renal carcinoma:** a primary malignant kidney tumor.

***tumor metastatic potential**: the spread of a tumor from its site of origin to another part of the body.

***spheroid:** a three-dimensional aggregate of cells cultured in vitro, typically formed from a cell line.

***tumoroid:** a 3D model derived directly from a tumor (biopsy or surgical specimen), which more accurately reproduces the tumor's architecture and heterogeneity.

Tutelles UMR: CEA, Inserm, UGA

Collaborations: Tumor Biomechanics Lab INSERM Strasbourg ; Université de Strasbourg, Fédération de Médecine Translationnelle de Strasbourg, Équipe Labellisée Ligue Contre le Cancer Strasbourg; CHU Grenoble.

Fundings: INSERM, CEA, Ligue contre le cancer, UGA, CHUGA et le Groupement des entreprises françaises dans la lutte contre le cancer, LabEX GRAL, ANR, PUI Grenoble

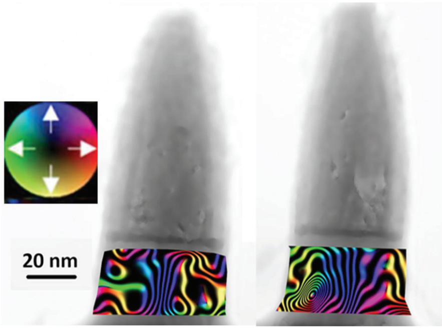
***chorioallantoic membrane:** a highly vascularized extraembryonic structure from chickens that serves as an alternative to mouse models, allowing for direct visualization of tumor development.

REFERENCE

Cesana, B, Nemoz-Billet L, Azemard V, Pillet C, Guyon L, Bigot E. Chaumontel N, Descotes J-L, Osmani N, Goetz J-G. Cochet C, Filhol O.
Using 3D invasion properties of RCC Cell Lines in vitro to predict their metastatic potential in vivo
Cell Death Discovery 2026

New low-noise magnetic nanosensor sensitive to out-of-plane field

Bernard Diény
Spintronics and Technology of Components laboratory



Magnetic field sensors are widely used for **contactless current measurement*** and **position encoding*** in particular in the automotive and robotics industries. Researchers at CEA-Irig/SPINTEC/DEVICES have developed a new type of vortex sensor sensitive to out-of-plane fields, especially promising for contactless current sensing and 3D magnetic-field sensing.

Current technologies of magnetic sensors often face a difficult trade-off between sensitivity, linearity, and magnetic noise. Because of their linear response and weak temperature dependence, **vortex sensors*** represent a good compromise and are widely used as position encoders in robotics or automotive industry.

Conventional vortex sensors are sensitive to magnetic fields applied in the sensor plane (see the image above).

In this configuration, the vortex core shifts transversally to the field direction, yielding a net in-plane magnetic polarization along the field direction. These sensors integrate such a vortex layer with an in-plane magnetized reference layer in a magnetic tunnel junction. These sensors are robust and weakly dependent on the operating temperature. However, they exhibit significant noise due to trapping and untrapping of their very small vortex core (core diameter~5nm) on local defects as the core moves radially under magnetic field.

In the present study, we developed another type of vortex sensor sensitive to out-of-plane field (see **Figure**).
Unlike their in-plane-sensitive counterparts, the aspect ratio of their vortex magnetic layer (thickness/diameter) is here much closer to 1: thickness~60nm, diameter~100nm compared to thickness~50nm, diameter~1mm for vortex sensors sensitive to in-plane field. Consequently, the balance between exchange energy and demagnetizing energy governing the vortex configuration is drastically modified.

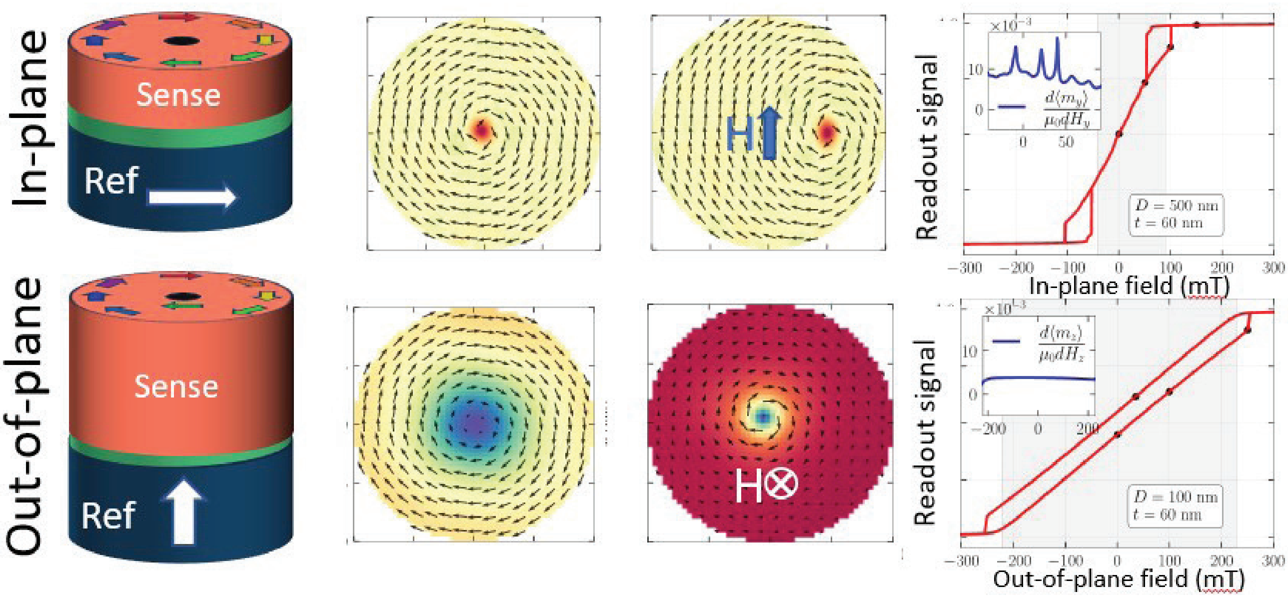


Figure: Comparison of vortex sensors sensitive to in-plane field (top line) and out-of-plane field (bottom line). Sensor configuration, evolution of vortex configuration under field and readout signal (derivative in inset). © CEA

As a result, the vortex core is larger and its diameter varies significantly under out-of-plane applied field. Since the vortex core expansion/contraction and out-of-plane polarization of the magnetization are much more reversible processes than lateral motion of the vortex core in in-plane vortex sensors, these devices exhibit lower noise and improved signal-to-noise ratio..

Thanks to their high linearity, low temperature dependence, and low noise, these sensors are particularly promising for current sensing, especially in battery management applications such as electric vehicles. In combination with sensors sensitive to in-plane magnetic fields, they can also enable **vector measurements of the magnetic field***.

Tutelles UMR: Univ. Grenoble Alpes (UGA), CEA, CNRS, Grenoble-INP UGA

Fundings : ERC PoC projet Nanosense

Collaboration : PTA, sensors team

***contactless current measurement:** When current flows through a wire, a magnetic field is generated around the conductor. A magnetic sensor placed nearby detects this magnetic field and uses it to determine the current.

***position encoding:** determining the position or displacement of an object comprising a magnetic element by measuring changes in the magnetic field.

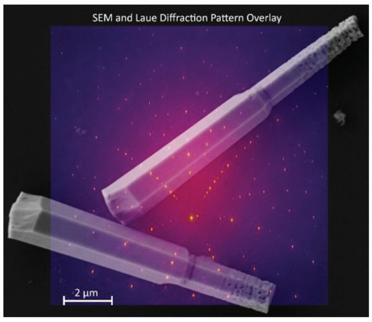
***vortex sensors:** magnetic sensors based on a specific configuration of magnetization within a ferromagnetic cylinder, where the local magnetic moments naturally align themselves by rotating around the center, much like a vortex. This creates a micromagnetic configuration with an in-plane magnetization curling around the cylinder center and a small vortex core at the center, where the magnetization points upward or downward (out of the plane).

***vector measurements of the magnetic field:** measurement of the intensity and spatial direction of the magnetic field.

REFERENCE
Jha A, Palomino A, Auffret S, Béa H, Sousa R, Buda-Prejbeanu L, Fruchart O et Dieny B.
Low-Noise Nanoscale Vortex Sensor for Out-of-Plane Magnetic Field Detection
ACS Nano 2026

Exploring light and strains at the heart of micro-wires

Joël Eymery et Béatrice De Goes Foschiani
Modeling and Exploration of Materials laboratory



Nitride heterostructures* offer advanced electronic and optical properties that have become essential in modern technologies (LEDs, UV lasers, high-power transistors, etc.). In this study, researchers at CEA-Irig/MEM combined X-ray diffraction and X-ray-induced **luminescence*** using a novel experimental setup to map, at the sub-nanometer scale, the deformation and light emission of **InGaN/GaN core-shell microwires*** intended for optoelectronics.

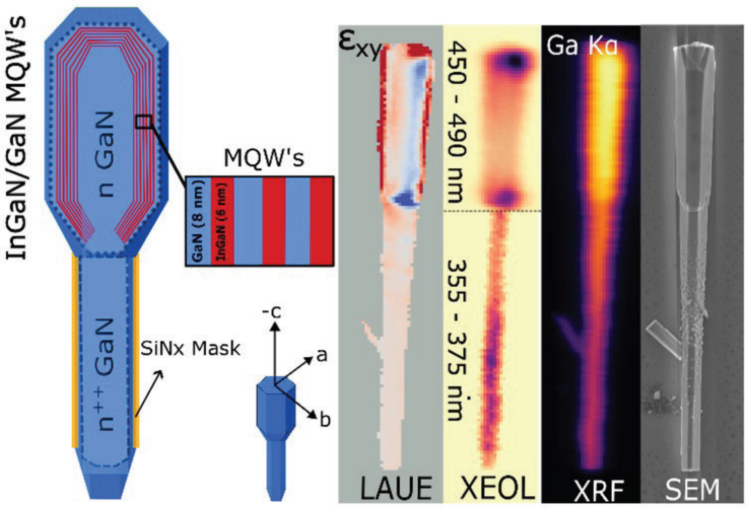
The development of innovative optoelectronic devices (LEDs, detectors) relies on the knowledge of complex nanostructures. Understanding the coupling between internal mechanical strains and light-emitting properties is a major challenge for optimizing their performance. Conventional methods, such as electron microscopy, often have limitations, particularly due to the need to thin the sample, projection effects, and a restricted field of view. This study proposes a non-destructive multimodal approach using synchrotron X-rays to probe these properties at the very heart of the material.

Researchers at CEA-Irig/MEM/NRX used a sub-micrometer X-ray probe (300×300 nm²) at the French BM32 beamline at the ESRF to simultaneously analyze the structure and the light emitted by InGaN/GaN core-shell micro-wires.

Using **Laue micro-diffraction*** and X-ray-induced luminescence (XEOL), they independently measured the internal strains in the core and shell with excellent precision by performing a complete mapping of the **deviatoric tensor***.

An automated analysis, capable of processing tens of thousands of X-ray diffraction images and luminescence spectra, revealed an indium composition gradient in the **quantum wells*** (from 10% at the top to 8% at the bottom), which shifts the emitted color from blue towards the UV.

These measurements, confirmed by numerical simulations, allow for a direct link between the wire's morphology and its luminescent performance.



Schematic of GaN microwires with multiple $In_xGa_{1-x}N$/GaN core-shell quantum wells located at the top of the structure. Maps obtained by micro-Laue diffraction (strain component εxy), XEOL—windows 450–490 nm and 355–375 nm—X-ray fluorescence (Ga Kα) and SEM © CEA

This internationally unique experimental development, conducted on the French BM32 beamline at the ESRF (Grenoble) using the new LaueMax instrument, enables non-destructive structural and optical characterization of nanostructures compatible with high-throughput analysis. This innovative approach paves the way for the optimized design of future ultra-efficient optoelectronic devices.

Tutelles UMR : Univ. Grenoble Alpes, CEA, CNRS

Fundings : Agence Nationale de la Recherche (Projet MAGNIFIX), France 2030 (PEPR-DIADEM-ESRF), PTC CEA Lumix.

Collaborations : CNRS (Institut Néel), European Synchrotron Radiation Facility (ESRF, Grenoble). Ligne française F-CRG IF BM32 (CEA, CNRS).

***nitride heterostructures:** a stack of several semiconductor materials based on gallium nitride (GaN), aluminum nitride (AlN), and indium nitride (InN). The design of the interfaces enables new properties such as the confinement of electrons in one dimension (formation of quantum wells), the creation of two-dimensional electron gases, or even better control of current and light.

***luminescence:** the emission of light following non-thermal excitation. In XEOL, excitation occurs via X-rays; in cathodoluminescence, via electrons; and in photoluminescence, via photons.

***InGaN/GaN microwires:** micrometer-scale wire-shaped structures consisting of stacked layers of indium gallium nitride and gallium nitride, which emit, detect, or modulate light. They can have core-shell or longitudinal geometries.

***Laue micro-diffraction:** X-ray diffraction technique using a focused polychromatic beam to locally analyze the orientation and deformations of a crystal at the micrometer scale.

***deviatoric tensor:** used to describe the shear strains in a material's atomic lattice.

***quantum wells:** layer of semiconductor material (e.g., InGaN) sandwiched between two layers of "barrier" semiconductor material (e.g., GaN), confining electrons in one dimension and causing their energy levels to become quantized. One of the main consequences is a change in optical properties (LED efficiency, color of the emitted light, *etc.*).

REFERENCE
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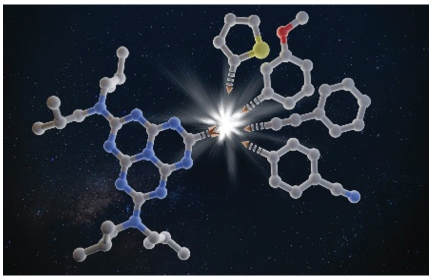
Multimodal Imaging of Strain and Light Emission of Core–Shell InGaN/GaN Wires under a Sub-Micrometer Polychromatic X-Ray Probe
Advanced Materials Interfaces
2026

Other scientific results



Mastering C-C bond formation : Towards tailor-made heptazines for energy and optoelectronics

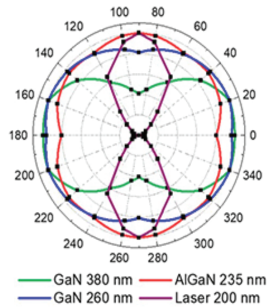
Researchers from the CEA-IRIG/SyMMES laboratory successfully functionalized heptazines, promising molecules for energy and electronics, using carbon–carbon coupling reactions previously inaccessible for these derivatives.

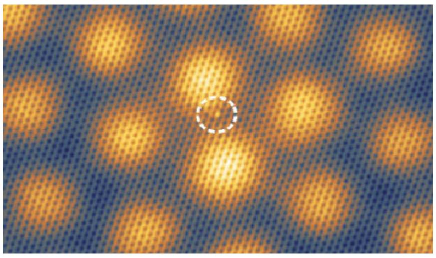
Read more

One-Atomic-Layer Quantum Wells Unlock Efficient Deep-UV Emission

Researchers from CEA-IRIG/PHELIQS, in collaboration with CEA-LETI and Institut Néel-CNRS, have demonstrated that one-atomic-layer-thick AlGaN/AlN multiple quantum wells can provide a highly efficient active medium for deep-UV emission. These nanostructures were grown by molecular beam epitaxy and investigated as active layers for electron-beam-pumped UV emitters.

Read more





An impurity can unveil the topology of graphene bilayers

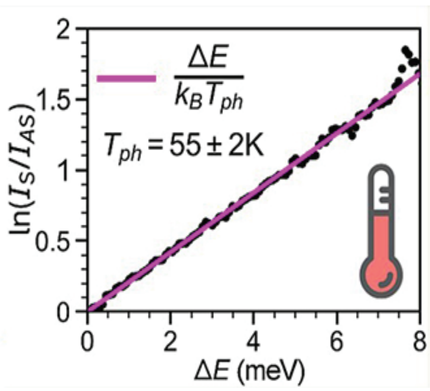
Using scanning tunneling microscopy (STM) to measure an atomic-size defect at the surface of twisted bilayers of graphene, researchers from PHELIQS have confirmed the unusual topology of its electronic bands. This topology has important consequences on the physics of this system.

Read more

Calibration-Free Measurement of the Phonon Temperature around a Single Emitter

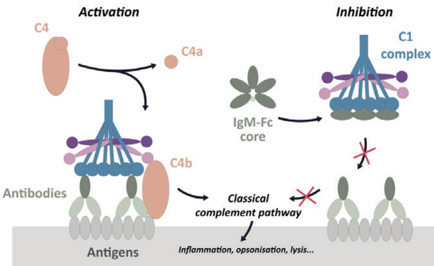
Semiconductor quantum dots are essential components in emerging quantum technologies, including quantum computing, communication, and sensing. However, their properties are highly sensitive to their local environment, particularly the temperature of the surrounding crystal lattice. Traditional temperature measurements provide only bulk or macroscopic readings, failing to capture the local temperature at the nanoscale—where the quantum emitter resides.

Read more



Activation and modulation of complement by the Fc core of IgM

IBS researchers evaluated the ability of the IgM Fc core to interact with C1q and to modulate its activity. Recombinant oligomeric constructs mimicking the native organization were produced, and their biophysical characterization (ISBG platforms) enabled the isolation of homogeneous pentameric and hexameric assemblies.



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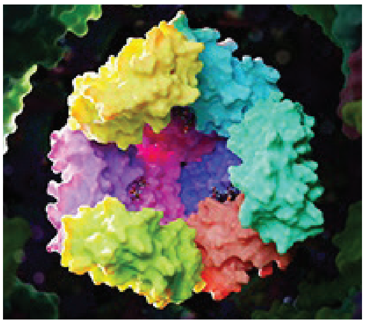

Mining a methane-degrading bioreactor for protein rubies

Anaerobic methanotrophs are microbes that consume methane in oxygen-free environments by preventing the release of this potent greenhouse gas into the atmosphere. Two teams from CEA-Irig/IBS with scientists from the Netherlands and Germany, have now unexpectedly discovered and characterized a new type of protein that encapsulates iron from these microbial consortia.

Read more

Launch of a new European project SPIN-CHIP coordinated by Thales and in which CEA-Irig/SPINTEC plays a key role, was officially launched in Palaiseau on June 2 and 3, 2026. Funded under the Chips Joint Undertaking for a duration of 42 months, this project aims to demonstrate the potential of spintronics, and in particular magnetic tunnel junctions, for the next generation of "Made in Europe" microchips

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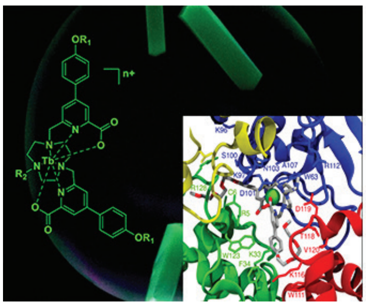


A new tool revolutionising protein imaging

A consortium of European scientists, including researchers from CEA-Irig/IBS, has developed a new molecular tool capable of both promoting the formation of protein crystals and making them immediately visible via fluorescence. This approach could simplify and speed up access to their three-dimensional structures, which are essential for understanding living organisms and developing new therapies.

Read more

Prizes- Media

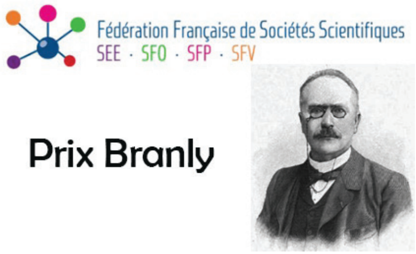
Bernard Dieny winner of the iSIM 2026 Award of Excellence

At the International Symposium on Integrated Magnetism (iSIM, Manchester, 12–13 April 2026), Bernard DIENY, a physicist at CEA-Irig, was awarded the iSIM Award of Excellence in recognition of his lifetime's work on nanomagnetism and spintronics – from fundamental aspects to applications.

[*Read more*]

Philippe TALATCHIAN won he Edouard Branly Prize awarded to a researcher for outstanding research in the field of physical sciences, particularly in the areas of waves, optics or electronics, with the potential for societal application.

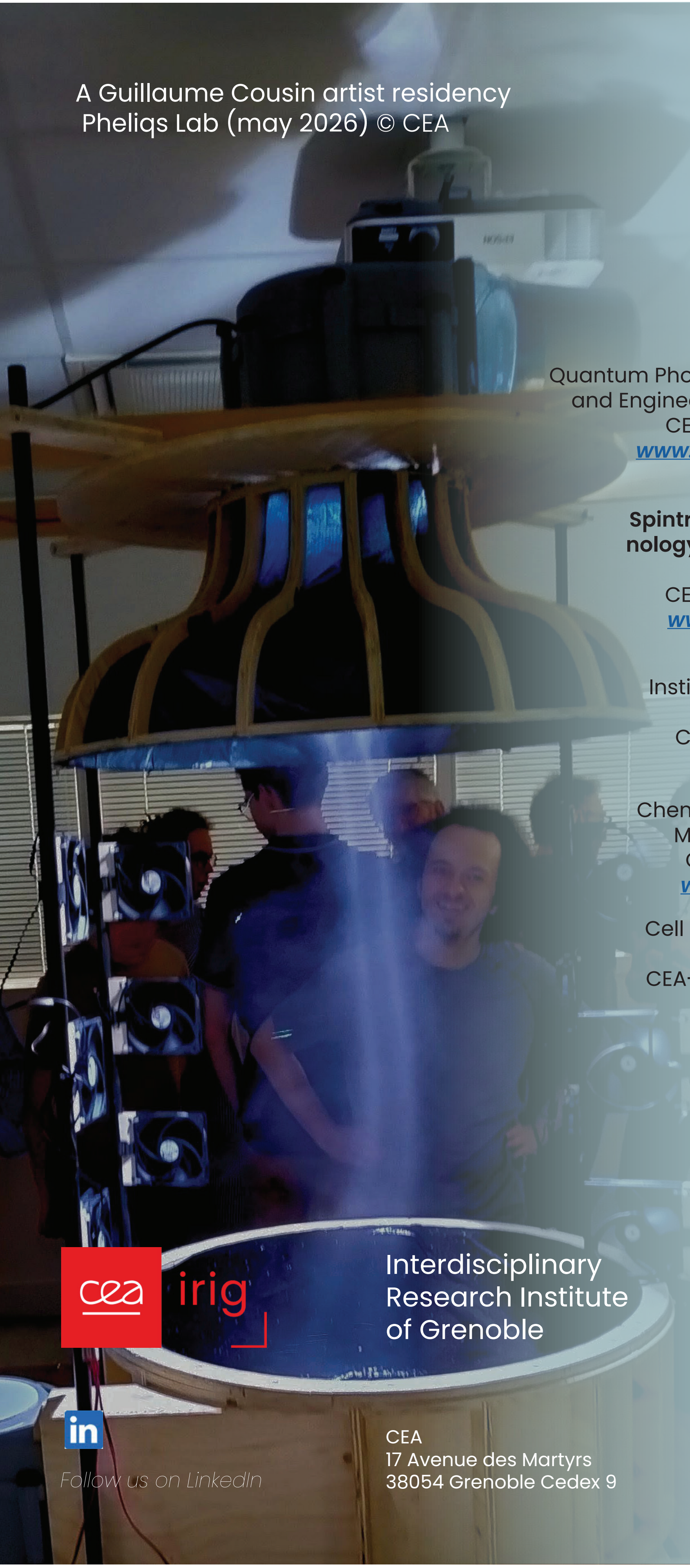
[*Read more*]



Hantavirus : chercheurs en première ligne

Après l'apparition de cas mortels de personnes ayant été infectées par un hantavirus, Hélène Malet (CEA-Irig/IBS) a été sollicitée pour son expertise par le quotidien « *Le Monde* ». Ses travaux, qui utilisent les microscopes électroniques de pointe présents à l'IBS et l'ESRF Grenoble, contribuent entre autres à dresser le « portrait-robot » de protéines virales, afin de mieux comprendre leurs fonctionnements, ce qui pourrait permettre à terme de trouver un traitement.

[*En savoir +*]



A Guillaume Cousin artist residency
Pheliqs Lab (may 2026) © CEA

Quantum Photonics, Electronics and Engineering laboratory
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www.Pheliqs.fr

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CEA-Inserm-UGA
www.Biosante-lab.fr

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www.Spintec.fr

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www.Symmes.fr

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www.MEM-lab.fr

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