Press Release

IMMEDIATE RELEASE

CEA-Leti Validates First Ultra-Fast, Battery-Operated EPR Spectrometer at Chip Scale

ISSCC Paper Presents New 22 nm IC That Delivers Record Scan Speed, Wide Spectral Coverage, and High Sensitivity—Moving Electron Paramagnetic Resonance into Portable Systems

SAN FRANCISCO — Feb. 18, 2026 — Researchers at CEA-Leti and CEA-IRIG-SyMMES* have validated a chip-scale electron paramagnetic resonance (EPR) spectrometer that achieves unprecedented scan speed, spectral span, and sensitivity from a battery-operated integrated circuit. By replacing the bulky electromagnets used in conventional EPR instruments with an ultra-fast frequency-scanned architecture, the system enables high-performance paramagnetic sensing in portable and space-constrained environments where traditional systems cannot operate.

The results were presented today at ISSCC 2026 in the paper **"A 1400 THz/s Ultra-Fast-Scan 14 GHz EPR-on-a-Chip Based on Injection-Locked Phase Detection Featuring 120 µM Concentration Sensitivity."**

Miniaturized EPR spectrometers transform a complex laboratory instrument into a portable, low-power microchip capable of detecting reactive chemical species that influence energy storage, materials reliability, environmental safety, and biomedical processes. By eliminating the bulky electromagnet that traditionally limits EPR instruments to centralized facilities, this technology, sometimes dubbed "EPR-on-a-chip", makes it possible to perform high-precision analysis directly in the field, at industrial sites, or inside research systems where traditional tools don't fit.

Record Performance at Milliwatt Power Levels

The system delivers:

- 1,400 THz/s scan rate
- 100-Gauss equivalent spectral span
- 120 µM concentration sensitivity
- 96 mW power consumption
- 200 ns scan time across the full span

This performance exceeds that of state-of-the-art miniaturized EPR devices, which typically trade sensitivity and spectral range for speed. The combination of ultra-fast scans and wide spectral coverage enables observation of fast-passage effects and transient phenomena in chemical reactions that are difficult or impossible to capture with existing systems.

New Applications Across Healthcare, Materials, and the Environment

By shrinking EPR to chip scale, CEA-Leti and CEA-IRIG open new application paths in healthcare diagnostics, materials characterization, and environmental monitoring. Portable, low-power EPR sensing could support on-site chemical analysis, embedded monitoring in research systems, and distributed sensing networks.

As development advances toward a full prototype, the technology represents a significant step toward making high-precision spectrometry more accessible and deployable beyond the laboratory.

Injection-Locked Phase Detection Enables High Sensitivity

At the core of the system is an original injection-locked phase-detection architecture that encodes the EPR signal as a phase shift rather than an amplitude or frequency change. By exploiting the intrinsically low phase noise of injection-locked oscillators, the design achieves unprecedented sensitivity for a single-sensor, chip-scale EPR system.

“Our goal is to create a compact, portable EPR spectrometer that operates on just a few watts of power, enabling on-site analysis in environments where conventional instruments simply cannot operate,” said Serge Gambarelli, research director at CEA-IRIG and EPR spectroscopy expert.

“By adapting RF and frequency-synthesis architectures originally developed for telecommunications, we were able to integrate a complete EPR system on a single 22 nm chip,” said Alexandre Siligaris, senior research engineer at CEA-Leti.

A Milestone for European Scientific Instrumentation

The circuit is the first scientific instrument fabricated using the advanced 22 nm FDSOI technology. While manufactured by GlobalFoundries, an international fab partner of CEA, the system architecture, circuit design, and measurement approach were fully developed and patented by CEA.

The work marks a major milestone in CEA’s Moonshot µ-RPE program, which aims to develop a compact, deployable EPR spectrometer to support key missions of CEA—and highlights Europe’s leadership in advanced microelectronics for scientific instrumentation.

The Moonshot program also includes R&D on planar magnets, which are key to future spectrometers, because they increase the number and field of applications.

"Typically applied in electric mobility and energy transition sectors, this expertise is now being leveraged to design the magnetic system for the µ-EPR spectrometer, demonstrating a valuable transfer of knowledge into the field of instrumentation,” said Celine Delafosse, laboratory manager at CEA-Liten, which is leading that research area.

About CEA-Leti (France)

CEA-Leti, a technology research institute at CEA, is a global leader in miniaturization technologies enabling smart, energy-efficient and secure solutions for industry. Founded in 1967, CEA-Leti pioneers micro-& nanotechnologies, tailoring differentiating applicative solutions for global companies, SMEs and startups. CEA-Leti tackles critical challenges in healthcare, energy and digital migration. From sensors to data processing and computing solutions, CEA-Leti’s multidisciplinary teams deliver solid expertise, leveraging world-class pre-industrialization facilities. With a staff of more than 2,000 talents, a portfolio of 3,200 patents, 11,000 sq. meters of cleanroom space and a clear IP policy, the institute is based in Grenoble (France) and has offices in San Francisco (United States), Brussels (Belgium), Tokyo (Japan), Seoul (South Korea) and Taipei (Taiwan). CEA-Leti has launched 80 startups and is a member of the Carnot Institutes network. Follow us on www.leti-cea.com and @CEA_Leti.

Technological expertise

CEA has a key role in transferring scientific knowledge and innovation from research to industry. This high-level technological research is carried out in particular in electronic and integrated systems, from microscale to nanoscale. It has a wide range of industrial applications in the fields of transport, health, safety and telecommunications, contributing to the creation of high-quality and competitive products.

For more information: www.cea.fr/english

About CEA-Irig

CEA-Irig, the Interdisciplinary Research Institute of Grenoble (France), is a fundamental research institute at CEA that employs 1,100 people. Based in Grenoble, France, the institute covers a wide range of theoretical and experimental research in the fields of physics, chemistry, biology and instrumentation. The teams associated with other French research institutes are involved in 4 major thematic pillars: Biology-Health, Physics-Digital, Energy-Environment and Cryotechnologies. All of its R&D is supported by the exceptional research platforms with instruments at the cutting edge. Some of these are National Research Infrastructures serving the French and European communities, with the French light and neutron lines at ESRF and ILL (F-CRG: French Collaborative Research Group). The CEA-Irig is a "knowledge factory" and a place of innovation to support societal transitions (digital, health and energy).

***SyMMES**, the Molecular Systems and (Nano)Materials for Energy and Health Laboratory is one of IRIG's joint research units (UMR 5819), bringing together staff from CEA, CNRS, Grenoble-Alpes University, and Grenoble INP-UGA. The laboratory conducts ambitious research rooted in contemporary societal issues, combining the multidisciplinary skills of chemists, physical chemists, physicists, and biologists. The synthesis and advanced analysis of innovative chemical objects is at the heart of SyMMES' activities. Electron Paramagnetic Resonance is one of our areas of expertise for the advanced characterization of paramagnetic systems such as organic radicals, metal complexes, metalloproteins, or defects in solids.For more information: https://irig.cea.fr/drf/irig/english ; https://www.symmes.fr/

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