



leti
cea tech



LETI INNOVATION STORIES

Leti technology in your products

LETI INNOVATION STORIES

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LETI INNOVATION STORIES

LETI TECHNOLOGY IN YOUR PRODUCTS

Leti is a technology research institute at CEA Tech and a recognized pioneer in creating high-performance, secure and energy-efficient miniaturization technologies for a large range of applications and markets. Committed to innovation, its teams create differentiating solutions for Leti's partners—global industrial companies, SMEs and startups.

Inside this document, you will find a selection of successful commercial products our partners have developed leveraging Leti's groundbreaking technologies.

To learn more about how you can innovate with Leti's experts and technologies, please contact: leti.contact@cea.fr

**With Leti inside your products,
anything is possible!**

MULTIGAS ANALYSIS SYSTEM

TAKING GAS ANALYSIS OUT OF THE LAB AND ON THE ROAD

Gas analysis just got a lot less complicated. Apix Analytics' multigas analysis system can determine the composition of a gas sample at the sample collection point and without the need for cumbersome lab equipment. The analysis is just as accurate as traditional lab testing, but at a dramatically lower cost.

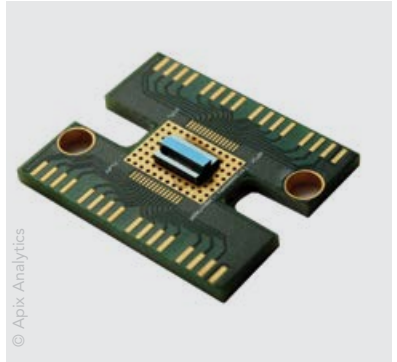


THE TECHNOLOGY

Apix Analytics' silicon-based labs-on-chip are much more compact than traditional lab testing equipment. The technology was invented by Leti and Caltech and is undergoing further development work at a joint Leti-Apix Analytics lab.

The labs feature a miniature chromatography column machined on silicon to separate the gases in the sample. The gases are then detected by nanoresonators that vibrate at a given frequency. The surface of each nanoresonator is covered with a chemical layer that promotes the adsorption of molecules. When the gas molecules are deposited onto the surface, the resonator's mass increases, and its vibration frequency changes. This information is used to determine the concentration of each component in a gas sample.

Apix Analytics is the first manufacturer to offer nanoresonator-based gas detection capabilities—crucial to ensuring sensitivity (down to parts per million or billion) and competitive cost.



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NEW



NANOFORME

KEEP YOUR DATA SAFE FOREVER

Archiving is a key process in any successful organization for administrative, legal or historical requirements, and until recently, organizations depended on material and technology that could not outlast the passage of time. What has changed is that Arnano and Leti developed an analog-based solution, replicating at a microscopic scale thousands of digital documents converted into images on a time-proof disk!



THE TECHNOLOGY

Digital archiving being unsustainable in the long run, Leti developed an analog-based solution able to withstand the test of time. This breakthrough technology has since been transferred to Arnano, a start-up launched by Leti.

Researchers identified synthetic sapphire as a basic storage medium, the second-hardest in the world after diamond. Named "Fahrenheit 2451" because of its ability to resist fire, this Nanoform project of embedded sapphire substrates resulted in the production of new discs (5, 10 or 20 cm) that can store up to 10,000 pages (A4) or photos beyond the millennium. The non-encoded data is written with microscopic images within a thin film of titanium nitride on the first substrate. A second sapphire substrate protects the information. To assemble these layers, Leti researchers have developed a molecular adhesion bonding technique that rebuilds atomic bonds.

Nanoform withstands multiple attacks, including scratches, floods and fires and is unaffected by the introduction of new technologies. A 20-cm disc can store up to 10,000 pages (A4) or photos beyond the millennium. In another application of the technology, Arnano offers stunning sapphire medallions and components for elegant watches.



CONTACTS

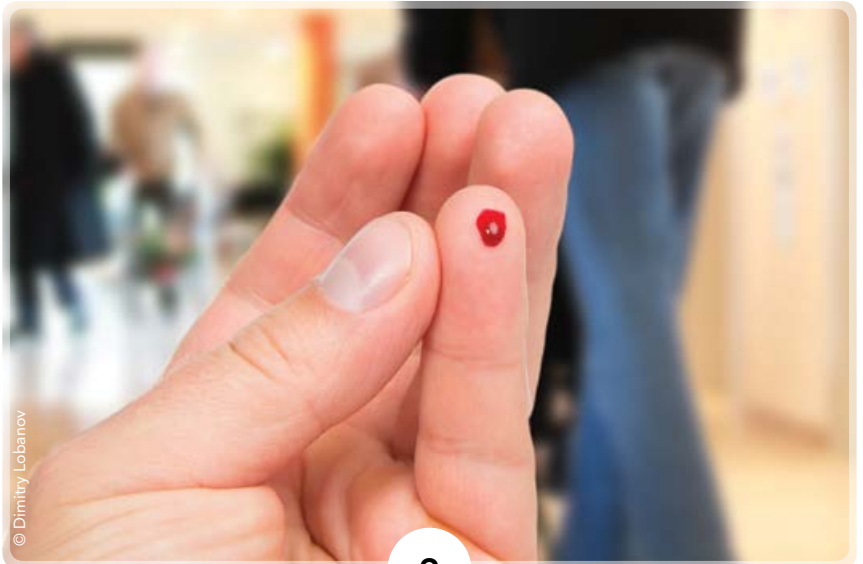
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LABPAD®

MY HANDY LAB

Performing routine blood tests right from the comfort of your own home could soon be a reality, thanks to Avalun's LabPad® mobile point-of-care device. All it takes is a drop of blood to get results like blood coagulation speed, blood sugar, or cholesterol in just minutes. The different types of tests can all be performed on the same reader; users just need to insert the appropriate disposable cartridge for the type of test prescribed by their healthcare provider.





THE TECHNOLOGY

The device is based on an advanced microscopy technology that leverages a CMOS sensor to pick up light diffraction patterns. Leti helped develop algorithms to reconstitute an "image" from the patterns. The image is then used to perform measurements like cell dynamics, colorimetry, and microscopy, all on the same reader.

The disposable cartridges (micro-cuvettes containing custom-developed reagents) round out this innovative system. Leti also helped develop the microfluidics technology used to carry the very tiny volumes of blood required for each test (less than 5 microliters) to the microscope's sensor.



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NEW

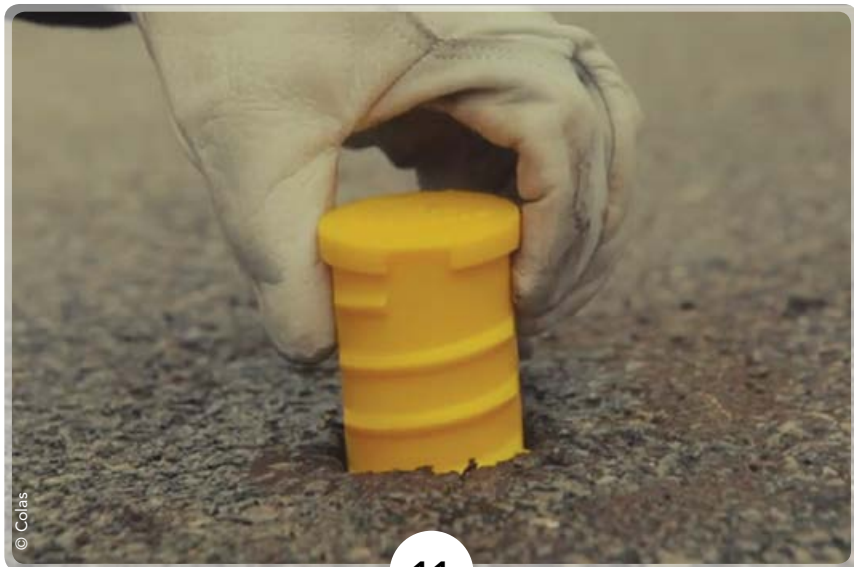
AXIMUM

VEHICLE DETECTION SENSOR

INTELLIGENT PARKING

PATENTS
3
PATENTS

Fed up of driving round in circles? The computerized management system developed by AXIMUM optimizes car park usage and access controls by controlling a set of sensors buried in the road. A totem centralizes information transmitted by these sensors and informs drivers of free or occupied parking spaces in real time. Installation and ease of maintenance are very attractive features: 8 minutes to embed a sensor in the road pavement.



© Colas

NEW



THE TECHNOLOGY

In partnership with COLAS/AXIMUM and MIND, CEA-Leti has developed a computerized management solution that is high-performance, easy to install and cheap to maintain, based on its know-how in digital communication and low consumption electronic architecture. In response to these barely compatible criteria, the researchers have focused specifically on selecting components (cheap and standard), while optimizing sensor size and upgrading its performance characteristics.

The team has developed an onboard vehicle detection algorithm for the sensor. The AXIMUM platform installed in the roadside totems/cabinets communicate with the sensors and collect presence-related data. The researchers have contributed particularly to developing and specifying a radio protocol and to designing a special antenna.

Global maintenance is facilitated by 10-year autonomy, while the innovative design ensures easy installation and replacement. For its part, partner AXIMUM has developed the system's innovative, ultra-robust, watertight packaging.



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TRACKING CHIPS

NEVER LOSE YOUR KEYS AGAIN

Are you tired of losing your keys, phone charger, or wallet? BeSpoon tracking chips can tell you where these and other everyday items are located, both indoors and out, to within several centimeters of accuracy and over distances of hundreds of meters. Simply equip frequently-misplaced objects with a tiny BeSpoon chip and install the app on your smartphone.





THE TECHNOLOGY

The chip on the object communicates with the user's smartphone via IR-UWB (impulse radio ultra wide band) communication. In other words, the chip uses extremely short radio signals to send information about the object's location.

The smartphone app uses the time between impulses to calculate how far away the object is—much like counting the seconds between lighting and thunder to determine how far away a storm is. And, because radio signals travel at the speed of light, the system (developed by researchers at Leti) is ultrasophisticated, with timing capabilities down to a few tenths of a billionth of a second.

The technology offers precision and reliability that far exceed what Wi-Fi can do over comparable distances, opening the door to new solutions to today's challenges.

CONTACTS

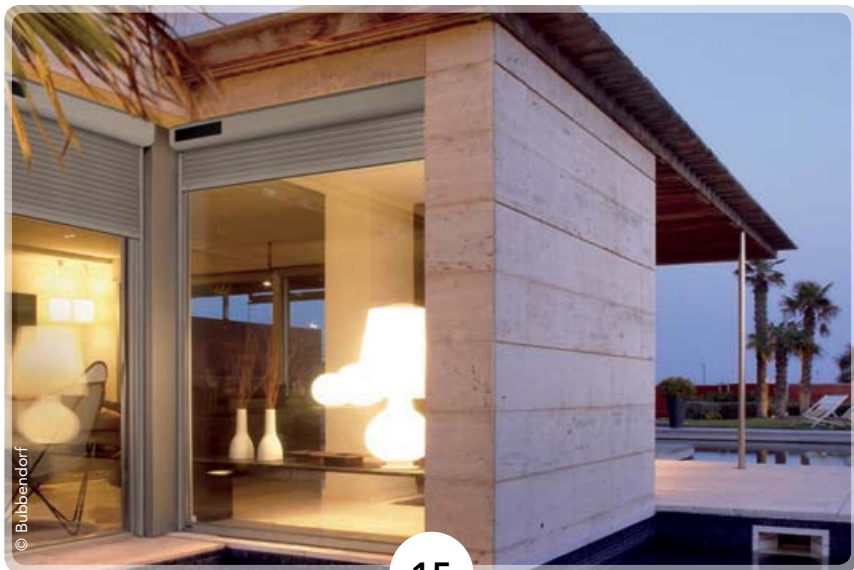
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ID3 ROLLER SHUTTERS

ROLLER SHUTTERS GO OFF THE GRID THANKS TO SOLAR ENERGY

ID3, the new autonomous motorized roller blind launched in 2017 by Alsace-based manufacturer –Bubendorff, is revolutionary in two ways: it is 100% powered by solar energy and it has no back-up power supply. A few decimeter-sided photovoltaic panel is enough to fulfill its power requirement.



THE TECHNOLOGY

ID3 is the 2nd generation of Bubendorff solar-powered blinds. The 1st generation launched in 2012, which had already been designed in partnership with CEA, enjoyed a resounding commercial success. Bubendorff once again called upon CEA to design a new battery pack architecture, qualify components, develop new optimum energy management algorithms accompanied by dedicated electronics and test full system performance and reliability to confirm its position as the only player to offer its customer a 7-year full warranty. CEA Tech institute Leti worked with Liten, a CEA Tech institute specialized in renewable energies, specifically on high-performance battery selection, battery charging/discharging control, blind movement energy efficiency, power consumption reduction on standby and energy efficiency of the radio communication system (controlling the blind).

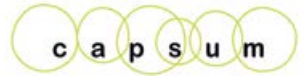
Blinds in the ID3 range are therefore autonomous up to 30 days without sun; the unit's solar collector and battery have been designed to guarantee operation across a -15 to +60°C temperature range at low light and for different sizes of blind.

Bubendorff has established a 12,000 m² site at the heart of Europe for production of this new generation of blinds.

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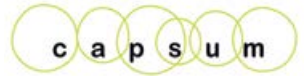
MODERNIST SERUM NO. 4

GENTLE AND BIOEFFECTIVE

For a cosmetic to be effective, its active ingredient must be sufficiently well-protected to penetrate the skin and interact with cells.

Modernist Serum no. 4 is setting a new standard with nanovector encapsulation to protect active ingredients and deliver them to specific cells.





THE TECHNOLOGY

The active ingredient is encapsulated in NeoGouttes Target™, a biodegradable lipid-based nanovector with a hydrophilic membrane that can target specific cells. The product can encapsulate up to 70% of its weight in active ingredients. And, with a diameter of around 100 nm, NeoGouttes Target™ penetrates the skin easily to reach the desired cells.

Leti transferred its nanovector technology to cosmetics science company Capsum in 2010. Capsum encapsulates active ingredients for its customers and manufactures its own line of products. The same nanovector technology is also used to carry drugs to specific organs.

Leti's nanovectors do more than just protect active ingredients. They can be used to target delivery to specific cells by grafting a biomolecule onto their surface.



CONTACTS

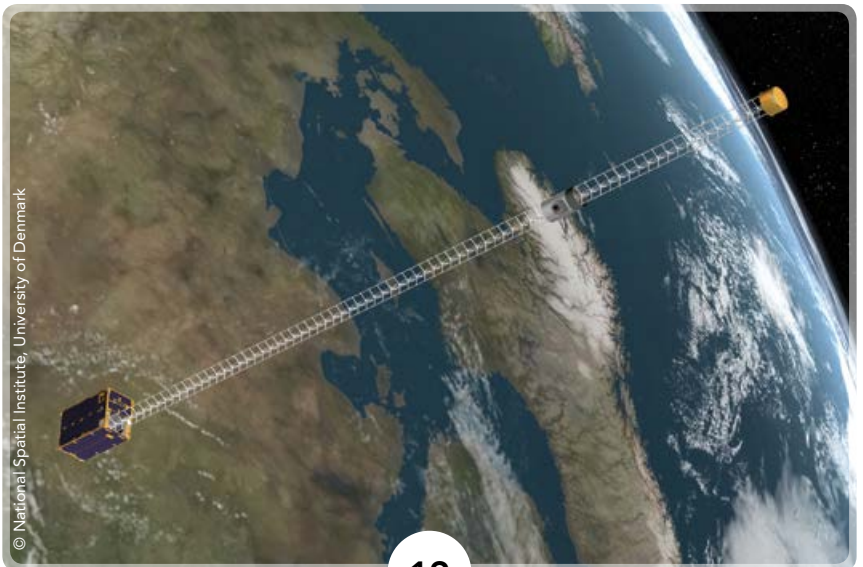
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OERSTED'S NMR MAGNETOMETER

FROM THE TITANIC TO SPACE FLIGHT

A nuclear magnetic resonance (NMR) magnetometer was used in 1987 to search the North Atlantic for the sunken Titanic. Twelve years later, the same high-precision device was launched into space on board the Danish Space Institute's Oersted satellite, where it is being used to measure the intensity of Earth's magnetic field and track any fluctuations. The purpose of the mission is to map the magnetic field for use in scientific and industrial research.



THE TECHNOLOGY

Oersted's NMR magnetometer was developed in conjunction with CNES, the French National Space Agency. Based on a terrestrial version of the device, the "space" version is smaller and lighter in weight: new materials were used to bring it from 2 kg to 800 g.

A full two years of research and development went into issues like vibration—and shock-resistance—radiation hardening, operation at temperatures ranging from -20°C to 50°C , and metrological testing. The scalar magnetometer was combined with fluxgate sensors to determine the direction of the magnetic field.

Oersted was launched in 1999 for a fourteen-month mission, and has been providing data to scientists worldwide since 2006. Today it continues to send data occasionally, depending on its electricity reserves. The NMR magnetometer is the only instrument on board that is still functioning.



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THE SWARM ABSOLUTE MAGNETOMETER

EXAMINING EARTH'S MAGNETIC FIELD FROM ALL ANGLES

Earth's magnetic field—an invisible shield that deflects ozone-damaging solar wind, protecting our planet from radiation—is now under the watchful eyes of optically pumped helium magnetometers launched on board the three Swarm mission satellites. The magnetometers' extreme precision will help create a new model of Earth's magnetic field that will be of great use to both scientific and industrial researchers.

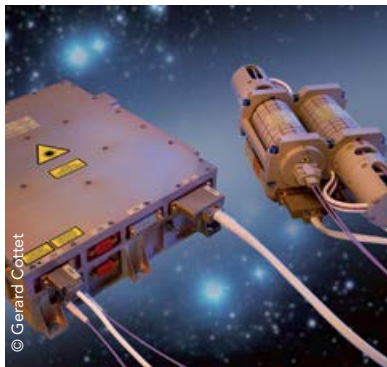


THE TECHNOLOGY

The ESA's Swarm mission positions Europe at the leading edge of global research on Earth's magnetic field. CNES, the French National Space Agency, supported the mission by providing absolute magnetometers developed by Leti. The devices offer never-before-seen precision of 65 picoteslas, making it possible to take scalar measurements—to assess the magnetic field's intensity—as well as experimental vector measurements to determine the field's direction. This is the first time ever that two such measurements have been combined in the same instrument.

Designed by Leti with technical support and financial backing from CNES and the participation of scientists from IPGP (the Paris Institute of Earth Physics), the magnetometers leverage technologies—like a fiber laser with no thermal control system—never before used for space applications. All of the device's materials and subassemblies are, of course, nonmagnetic.

Swarm was launched in November 2013; the magnetometers were delivered in flight in early 2014 and will continue to orbit at between 510 km and 300 km above Earth's surface for at least four years.



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DEBIOJECT MICRO-NEEDLE

DON'T LIKE SHOTS? FEAR NO MORE!

With the Debioject micro-needle by Debiotech, injections are no longer something to fear. Measuring less than a millimeter, the needle penetrates the top layers of the epidermis where it does not significantly affect nerve endings. This makes administering vaccines and other drugs pain-free, more effective, and—because the new injection system reduces the amount of drug required by a factor of ten—more economical.

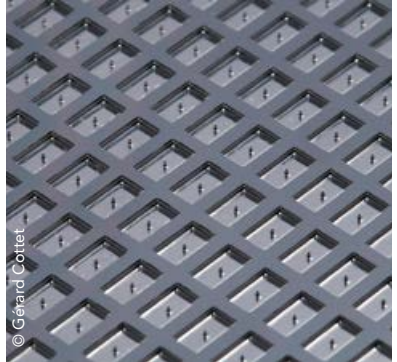


THE TECHNOLOGY

The 700-micron-long micro-needle is made from silicon, chosen for its mechanical properties. The needle was invented and co-patented by KTH (Royal Institute of Technology, Sweden), and later prototyped at the Swiss Federal Institute of Technology in Lausanne. Leti launched larger-scale production of the needle for the first clinical trials, improving production yields by using more stable processes on 200 mm wafers.

The needle is formed by a series of deep engravings on the silicon. The injection canal is engraved on the back side, and then the body of the needle is formed on the front side. The two axes are offset slightly to create a hole located on the side of the needle, through which the drug is ultimately injected.

Each wafer yields around 1,400 needles; the needles are then cut out and mounted on a plastic injector by a plastics subcontractor.



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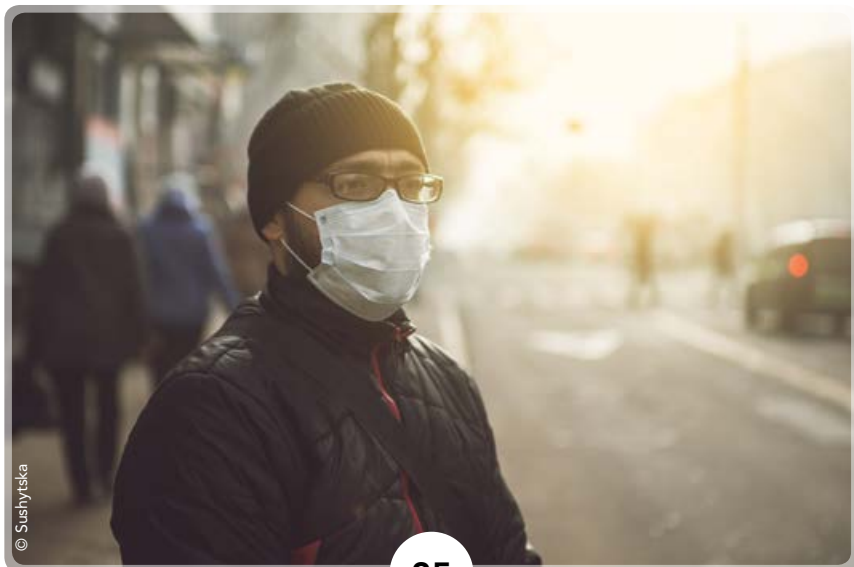
NEW

MINIATURIZED GAS SENSOR

10
PATENTS

HYPERLOCAL CONTINUOUS MEASUREMENT OF AIR QUALITY

Can air quality in an urban neighborhood be monitored hyperlocally and continuously (e.g. at all bus shelters)? Well, it's possible using eLichens miniaturized gas sensors! Detecting within the infrared, they are four times smaller and consume twenty times less than competing sensors, allowing a far more of them to be used for monitoring a site. They are also ideal for the housing and automobile markets.

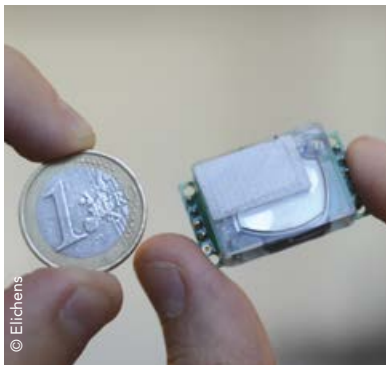


NEW

THE TECHNOLOGY

The innovation doesn't reside in the non-dispersive infrared measuring technique, but in eLichens' and Leti's capacity to miniaturize and reduce sensor power consumption. These goals have been widely achieved. The most recent prototype is hardly bigger than 1 cm³ (1.5 x 1.5 x 0.5 cm) and consumes only 2 mW, so a tiny battery is enough to power it. Measurement sensitivity is less than 10 ppm, matching that of competing sensors and allowing detection of CO₂, CH₄, CO and alkanes.

The key to this performance is an infrared emitter based entirely on MEMS technology and whose architecture has been optimized by multiphysical modeling. The optical cell geometry has also been specifically designed to optimize source/detector coupling. The infrared source and detector are batch-processed (microelectronic technologies), ensuring the sensor's strongly competitive production cost.



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PACS CAMERA

OBSERVING STARS AND GALAXIES FROM SPACE

Among the three state-of-the-art instruments on board the ESA's 2009 Herschel satellite mission was an extraordinarily precise infrared camera which, if used on Earth, would be capable of picking up a 100-watt light bulb 300,000 kilometers away. In space, the camera is being used to observe the early stages in the formation of stars and galaxies to deepen our understanding of the origin of the universe. In the four years since it was launched, Herschel has provided 25,000 hours of data to some 600 observation programs.



THE TECHNOLOGY

Leti developed a new kind of bolometer for the Pacs camera (one of the three instruments on board Herschel) that offers a much greater number of pixels than existing cameras: 2,048 for the blue array (made up of eight perfectly-joined matrices), and 512 for the red array (with two matrices).

The matrices operate at wavelengths of between 55 and 210 microns and offer record-breaking sensitivity of 10^{-16} W/ $\sqrt{\text{Hz}}$. A cooling system keeps them at 0.3 Kelvin.

Leti worked with IRFU, the Institute for Research on the Fundamental Laws of the Universe, to develop a new silicon technology to meet the unique specifications of infrared/submillimeter astronomy. The most critical points in the development work included the pixels' vibration-resistance, the connection to the thermal sensor, and calibration of this new type of instrument.

CONTACTS

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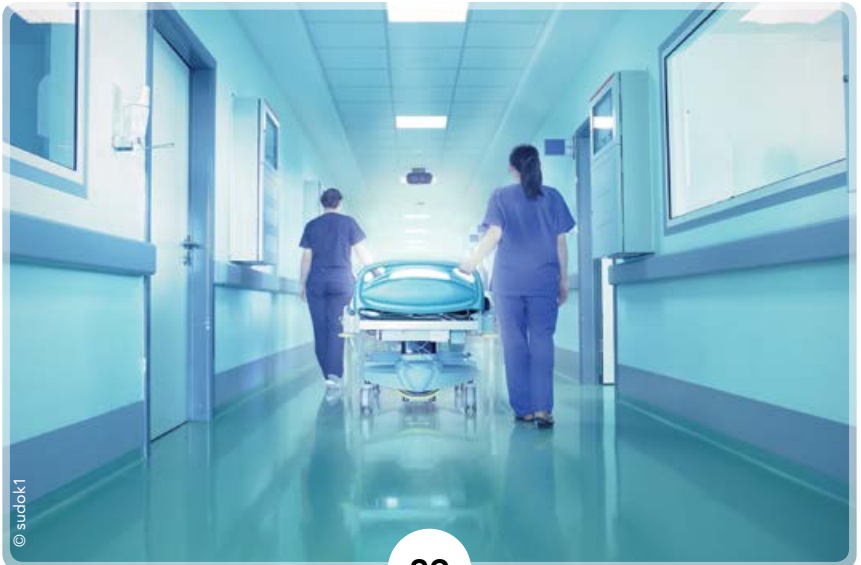
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FLUOBEAM[®]

SHEDS LIGHT ON TUMORS

Fluoptics, a Leti start-up, has developed a fluorescence imaging probe that lets surgeons see the edges of a tumor in real time to within a half-a-millimeter accuracy. The probe helps surgeons make sure they remove all tumor cells and avoid damaging healthy tissue. They can also see tissue vascularization and vein obstructions—useful during stenosis or bypass surgery, for instance.



THE TECHNOLOGY

To develop the technology, Leti had to overcome a significant hurdle: the light signal emitted by the fluorescent tracer injected into the patient is around a million times weaker than the light used to activate it.

The solution took the form of a light filtering system designed and built by Leti. The filter is integrated into the overall acquisition system (made up of a CCD camera and a laser with the right wavelength for viewing the fluorophores).

Early models of the system required darkness for image acquisition. Leti improved the filtering system and adjusted the lighting configuration to allow surgeons to get a sharp view of tissue and the circulatory system in normal operating-room conditions.



CONTACTS

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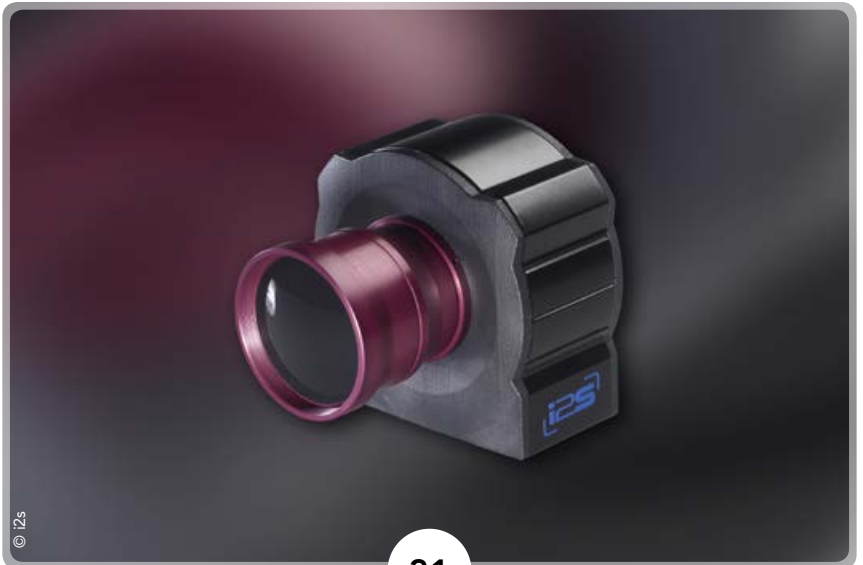
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NEW

TZCAM THz CAMERA

WELCOME TO THE WORLD OF TERAHERTZ VISION

The TZCam camera detects terahertz (0.3-4 THz) frequencies in the far infrared. It sees through paper, cardboard, wood, plastic or fabrics. It detects minuscule objects at high resolution and a sensitivity that's unique worldwide. It also identifies the spectral signature of many compounds such as drugs or explosives. It's marketed by French company I2S.



NEW



THE TECHNOLOGY

The TZCam camera is built around a terahertz imager developed at CEA-Leti based on patented infrared bolometer architecture. Optical acquisition is ensured by crosswise antennas coupled with a 1/4-wave dielectric cavity.

The imager offers exceptional resolution of 320 x 240 pixels in 50 μm steps. Its sensitivity is worldwide state of the art: 30 pW minimum detectable power. It's manufactured at Leti based on 200 nm CMOS technology: production rate is high, cost price is low.

The camera operates at ambient temperature since its bolometers were originally designed for the uncooled infrared. It's therefore more compact (12.5 cm x 11.5 cm x 6.5 cm), cheaper and more reliable in the long term.

Terahertz imagery has never been as high-performance or as accessible. It opens the door to multiple applications: non-destructive testing (NDT), moisture content measurement, security (metals reflect terahertz waves) and fundamental research.

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DIGITAL MICROFLUIDICS

A 100-CM², 50-GRAM FULLY INTEGRATED LAB

Illumina's table-top lab on chip may be small, but it packs in an impressive range of functions. The lab does all the things a "real" lab can do, from dispensing, mixing, and rinsing substances to adding reagents. Testing samples requires only tiny 300-nanoliter droplets of various reagents. That's barely a hundredth of a drop of liquid. The lab is currently used to prepare samples for DNA Next Generation Sequencing on Illumina's platforms.



THE TECHNOLOGY

The lab-on-chip technology developed by Leti and Illumina, which acquired Leti R&D partner Advanced Liquid Logic, is based on an innovative sampling method that differentiates it from other LOCs. By using electrowetting on dielectric to move and mix liquids and reagents, it eliminates the need for pumps and valves.

An electric field-applied by activating an electrode under the droplet-moves the liquid to the desired location at the desired speed. This opens the door to automation, while taking system miniaturization to new dimensions.

Illumina and Leti have each filed many patents for electrowetting technologies. So, it was only natural for them to continue collaborating to improve lab-on-chip performance, reliability and cost.



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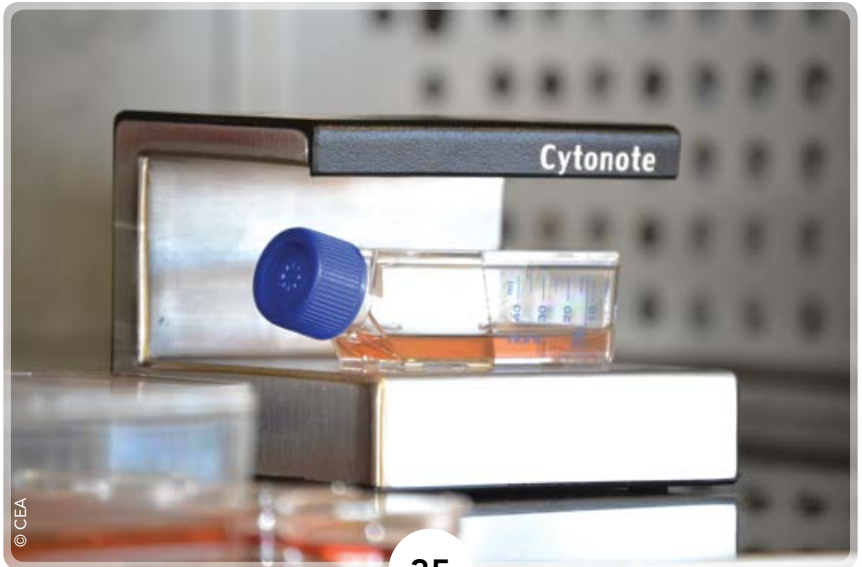
NEW

CYTONOTE

MORE THAN 20,000 CELLS AT A TIME



Flexible, small and powerful, this mini microscope works with standard lab dishes and performs directly in an incubator to record cell-culture images and changes over long periods. In the process, it characterizes cultures in real time, including rate of cell division, cell viability values, migration and total count. Lab techs can track up to 20,000 cells at a time with Cytonote's 29.4 mm² sensor. Highly compact and robust, this low-cost device allows considerable space savings.





THE TECHNOLOGY

Developed in partnership with Iprasense, Cytonote offers an ultra-wide field-of-view with 20,000 cells at a time, per image. Each mini-reader is equipped with LEDs and CMOS sensors that provide timelapse images of cell-culture activity and changes without imprint. No particular settings, such as focus or brightness, are required because several algorithms developed by Leti researchers take care of everything.

Leti wanted to design a lensless imaging technology to increase the field-of-view by 10 compared to standard microscope offerings. Images available on screen are released thanks to holographic reconstruction. Diffracted by cells, light from the LED draws a hologram pattern that is recorded by CMOS sensors. Leti researchers developed several holographic algorithms to rebuild the captured images.

Economic and ergonomic, its 132 cm² foot print fits in any work place. Cytonote is packed with handy features, works with any media culture and offers crisp, high-contrast images.

CONTACTS

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SLATE

DIGITIZE YOUR ARTWORK AND NOTES

Put away your pens and pads? No way! It wouldn't feel natural! Still, digital media does tempt you with all those applications.

Then, this Slate is made for you. Tactile and digital, it lets you work on real paper, in your favorite notebook. You simply slip a magnetic ring on your drawing tool and Slate digitizes all your sketching in real-time. Then simply send your artwork to your computer, and improve it with those great digital editing tools!



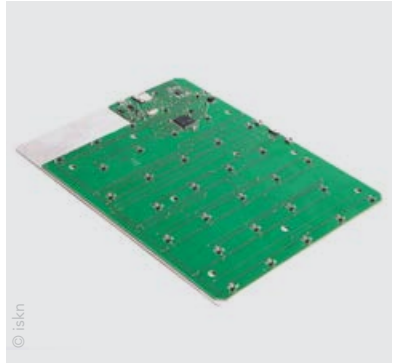


THE TECHNOLOGY

To convert handwritten marks into I's & O's, ISKN—a successful French start-up—adapted Leti's 70 years of expertise in magnetism for pen and paper. The concept is simplicity itself—a magnetic ring added on any pen generates a magnetic field that tracks the pen's movement over a matrix of 32 magnetometers.

To make this breakthrough technology marketable, ISKN and Leti modeled the magnetic ring and set up the signal processing through several algorithms that track the ring's 3D position and orientation with excellent accuracy in real time. This high level of accuracy was made possible thanks to a powerful calibration technique of these magnetometers.

Slate works autonomously, whether online or offline. It provides a long battery life (up to 10 hours) and lots of storage space (400,000 pages). A USB or wireless (BLE) connection transfers scanned artwork or notes to a computer or tablet. ISKN's Imagink software includes a wide range of editing tools—colors, pencil leads, cropping, among many others. So far, ISKN and Leti have filed 20 patents together for this technology.



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MICHELIN TRUCK TIRES

NOW EQUIPPED WITH MEMORY

Tires may seem simple enough, but they pack in some pretty advanced technology. Truck tires in particular must be able to withstand moving several tons over hundreds of thousands of kilometers. Tire maker Michelin hopes to make its truck tires even better by embedding memory right into the rubber. The memory would store the tire's entire history, from manufacturing date and plant through to maintenance and retreading.



© thomaslerchphoto



THE TECHNOLOGY

The memory is an RFID tag much like those used on parcels stored in a warehouse or on certain products found on supermarket shelves. The challenge is to make sure the tags work once embedded inside the tire's structure, where they must overcome hurdles like the tire's metal plies, which interfere with radio transmission; the distortion that occurs with each rotation of the wheel; and harsh road conditions like temperature variations and impacts.

It took Leti and Michelin six years to get the RFID tags to perform up to their standards. To do so, they tested a total of 50,000 tires over 6 billion kilometers. Michelin is the world's first tire manufacturer to introduce tires with built-in memory.



CONTACTS

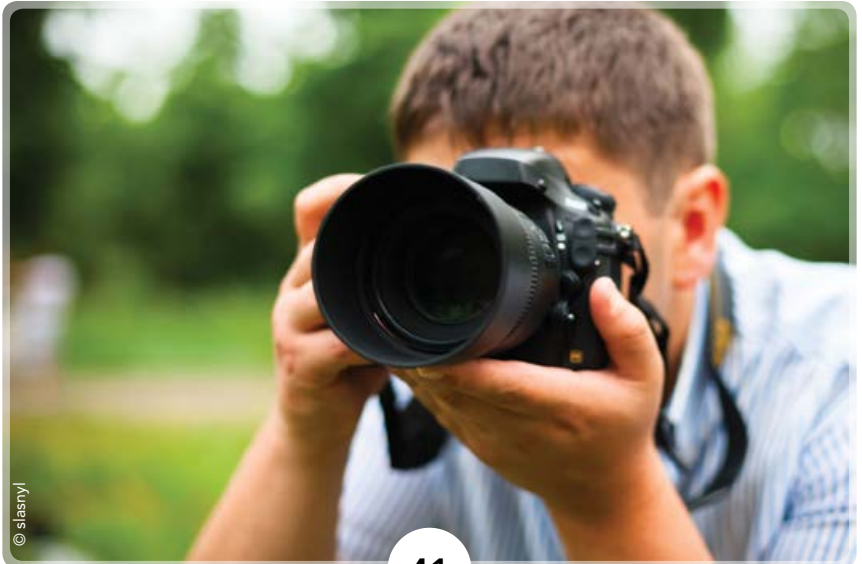
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MARYLAND

HD MICRO OLED DISPLAYS

The Panasonic Lumix GH3's electronic viewfinder packs in a technological advance that doubles resolution while consuming half the energy of other viewfinders—a micro OLED (organic light-emitting diode) display of less than a half-inch on the diagonal. The innovation should eventually find its way into all digital SLR cameras, where it will gradually replace today's optical viewfinders. The micro displays are also used in video glasses and in healthcare and security applications.



THE TECHNOLOGY

MicroOLED is working with Leti on the micro displays. Fabrication is a particularly tricky step, and must be completed in a clean room using microelectronics equipment. And the clean room is where the company's Maryland micro OLED display was hatched.

The display features an active layer made from organic semiconductor material. Less than 100 nm thick, the layer is protected by another layer that is hermetically sealed and transparent. Colored and pixelated filters transform the light emitted, which is white, to create HD color images. The entire system is protected mechanically by a permanent glass cover.

The fabrication process was fine-tuned to obtain around 100 screens per 200 mm silicon wafer. Reliability was also improved, and the process is now robust and cost-effective enough for consumer applications.



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NEW



MULTI GAS PHOTOACOUSTIC DETECTOR

HIGH-ACCURACY MULTI GAS ANALYSIS IN 100 cm³

Methane, NO₂, NH₃, NO, N₂O, gaseous drug and explosive emissions... The multiSense analyzer can detect a wide range of gases in real time with excellent selectivity and state-of-the-art accuracy. Yet, its volume is no greater than that of a packet of tissues! Portable and competitive, it is tailored to industrial applications: process control, quality assurance, environmental monitoring, etc.



NEW



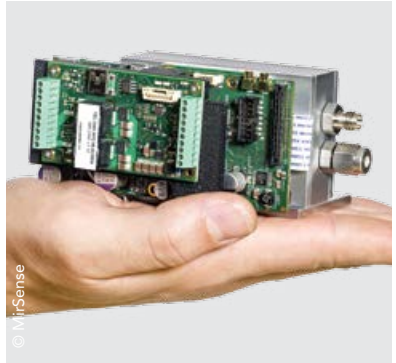
THE TECHNOLOGY

MultiSense exposes gases through laser technology that is photo-acoustic: a combination whose cost and size usually require a laboratory capabilities.

The detector operates in the infrared (3 - 12 μm) range. It combines a multi-wavelength quantum cascade laser in patented III-V semiconductor materials, a microphone and a silicon technology photonic wave combiner based on an innovative Leti optical platform achieving record-breaking performance.

mirSense and Leti have also replaced the conventional large microphone with a 10 mm³ MEMS microphone, prompting a spectacular reduction in the size of all detector components. Most of these are made of semiconductor material, ensuring the highly competitive final cost of the device and a unique capacity for increasing volume. The analyzer thereby ensures an extremely low detection limit of the order of a few ppb with the high-accuracy versions.

All multiSense analyzers can simultaneously detect a range of different species in real time. Total detector power consumption ranges from a few W to a few tens of W.



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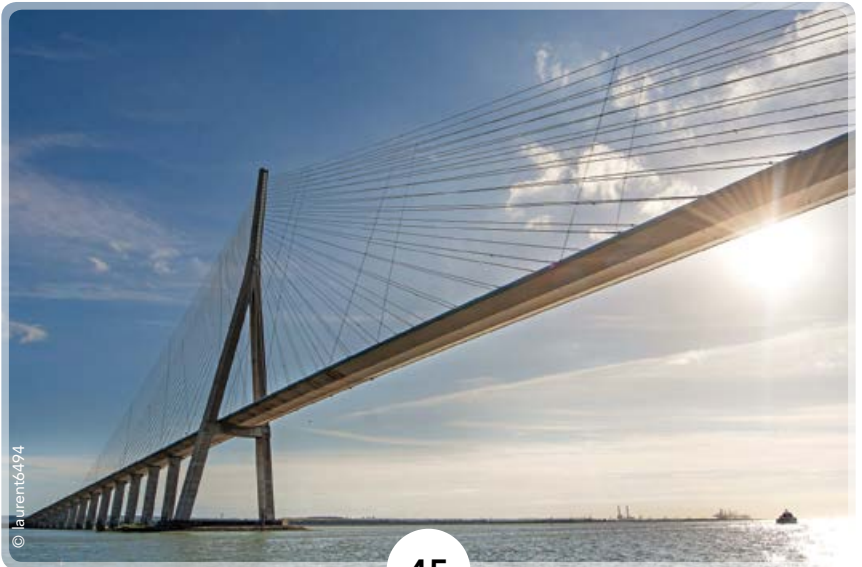
NEW

MORPHOSENSE



STRUCTURAL MONITORING

A structure's deformations and vibrations can now be monitored with an accuracy of 0.1 mm/m thanks to Morphosense's MEMS accelerometers and their processing algorithms. On the Eiffel Tower, just two weeks was long enough to explain a sporadic structural phenomenon. A bridge, a dam or a tunnel can be instrumented "for life" to increase the efficiency and reduce the cost of its maintenance.



NEW



THE TECHNOLOGY

The Morphosense solution is partly based on a decade of Leti R&D in capturing movement. It implements patented mathematical methods for reconstituting structural shape based on tangential data provided by a network of distributed MEMS sensors.

Hundreds of sensors can be deployed to instrument structures of all shapes and up to several hundred meters long. The sensor network is controlled by a master node that centralizes and synchronizes the data before transferring them to a computer server integrating patented algorithms. A customized interface provides the operator with the data he requires: convergence, deflection, torsion, curvature, vibrations, impacts, modal and spectral analysis, etc.

The MEMS accelerometers are mounted on the surface of the structure to be monitored. They can therefore be deployed well after construction for and occasional intervention or long-term monitoring. Advantages for the operator include better risk management due to accurate analysis of structural behavior and maintenance costs that can be curtailed by a factor of 4 to 10, if correctly anticipated.

CONTACTS

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ME100 SPECTROMETRIC DETECTOR

FASTER, MORE RELIABLE BAGGAGE SCREENING

Over the next few years, waiting times at the airport security check could get much shorter. MultiX has developed a detection system capable of identifying suspicious materials and objects with a high degree of reliability. Airport security staff will no longer need to open as many bags as a precautionary measure, because MultiX's system sees inside as if the bags were already open!



THE TECHNOLOGY

Today's baggage screening systems use X-rays and two detectors that "read" the X-rays; one for high-energy photons and the other for low-energy photons.

The new screening system uses a spectrometric detector that counts all of the photons and measures their energy. The information is more complete, the analysis more thorough, and the capacity to differentiate different types of objects and materials more accurate.

Leti leveraged its medical radiography know-how (which includes spectrometric X- and gamma-ray measurement and the associated data processing) to improve the baggage screening system's performance.

MultiX's system uses a detector and data-processing method developed specifically for baggage screening.



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MINIATURE CONDENSER

KEEPING A CLOSE EYE ON CARDIAC FUNCTION

Measuring just a few square millimeters, IPDiA's latest condensers are setting new records for miniaturization—not to mention stability and reliability—for a particularly demanding application, cardiac pacemakers. For a pacemaker to effectively regulate a patient's heartbeat, the heart must receive an electrical signal at perfectly regular intervals. The condensers could also be used in the deep brain stimulation (DBS) therapy used to treat Parkinson's.



THE TECHNOLOGY

Leti helped IPDiA's engineers miniaturize the condenser by replacing the dielectric materials originally used with a new material offering a constant k three times higher. However, because the new material could not withstand temperatures higher than 400°C (vs. 800°C for the original material), several steps in the process had to be overhauled.

The project milestones included ALD and engraving of the dielectric material and improvements to the barrier layers. The new material had to be deposited on 3D structures with a truly atypical form factor—a problem that Germany's Fraunhofer Institute, a Leti partner, helped resolve. The resulting condenser obtained a record-breaking capacity of 500 nF/mm^2 .



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NEW



ACCELEROMETERS FOR CAR SAFETY

MAKING CARS REALLY SAFER

Why does an airbag trigger in the event of a collision and not when one is driving on a stony track or when one slams a car door? The answer to this interesting question is that the airbag is fitted with an accelerometer, which emits an appropriate warning signal and ignores vibrations induced by harmless event... NXP's HARMEMS accelerometer is a reference on this market. More than 350 million HARMEMS accelerometers have been produced so far!



© Dmitry Vereshchagin

NEW

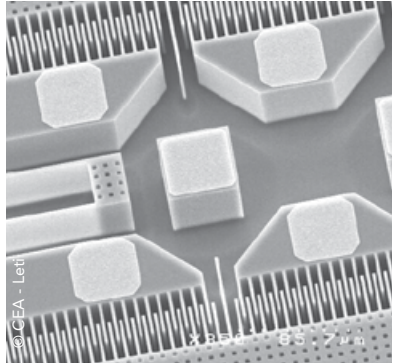


THE TECHNOLOGY

NXP and Leti have been collaborating since 2001 and several generations of HARMEMS accelerometers have succeeded each other over the years. Their basic features haven't changed: an excellent signal-to-noise ratio and an overdamped mechanical response guarantee their immunity to vibrations inherent to car passenger compartments, while they perform with exceptional reliability at competitive cost.

Although most MEMS are composed of thin layers and don't exceed $3\ \mu\text{m}$ in thickness, HARMEMS is fabricated using a different process that allows thicknesses higher than ten of microns. By etching deeply the silicon, a significantly large moving mass can be released to ensure more sensitive detection of accelerations. Furthermore, HARMEMS is made of monocrystalline silicon and this 99.99% pure material ensures perfectly reproducible mechanical properties. This is the key to sensor reliability.

HARMEMS was designed from the start for large volume production. Leti has worked hand-in-hand with NXP on each new generation of technology.



CONTACTS

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NEW



V-BAND BACKHAUL/ FRONTHAUL

5G HIGH-SPEED POINT-TO-POINT COMMUNICATION

Want to help world meet the need for speed? Tailored for fifth-generation (5G) wireless communication networks, these low-cost and adaptable antennas easily integrate into backhaul systems. Unobtrusive, they can be deployed in a wide range of infrastructure—buildings, street lights etc.—to implement point-to-point communication at data-transfer rates of up to 20 Gb/s! Enough to satisfy an ever-increasing craving for speed.



© Thissatan

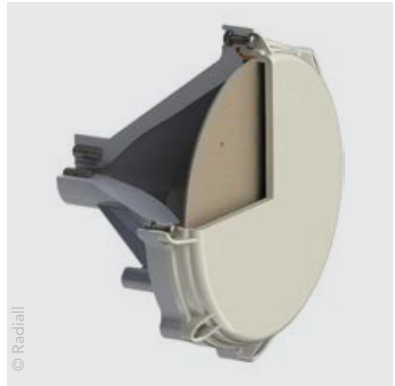
NEW



THE TECHNOLOGY

Leveraging its expertise in radio-frequency technology and antenna design, Leti has partnered with Radiall on technology development for Wireless Backhaul and Fronthaul systems since 2014. These networks require the implementation of high-speed point-to-point communication—or backhaul systems (1-20 Gb/s)—at millimeter wave frequency bands. High-gain antennas are great tools to offset propagation losses. Made on printed circuit boards, these array antennas offer a low cost, efficient, robust and reliable solution to the rapid growth of mobile data traffic and future IoT needs.

A metallized plastic focal source lights up a steel dielectric planar circular-shape array (100 mm diameter) comprised of 1,264 unit cells, just like a lens, focusing the light, which in turn falls within a given solid angle. The antenna's fixed-and-narrow beam transmits information from one point to another with a gain greater than 31 dBi within the 57-66 GHz band. With its low depth format (85 mm) and adaptable focal system, this V-band antenna can be easily integrated into any backhaul system. Today, Leti's team of researchers continues their work to improve efficiency, reduce thickness and build a controlled-radiation-pattern antenna.



CONTACTS

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ELIOT

THE SMART PIPE THAT COMMUNICATES ITS LOCATION

Every year in France thousands of underground assets—like water and gas lines—are damaged during digging work, simply because their exact location cannot be determined accurately. Today there is a solution. Ryb has developed Eliot, a smart piping system equipped with RFID chips capable of sending accurate location information down to the centimeter at depths of up to 1.5 meters. The chips also store information like the type of piping (water or gas), manufacturing date, serial number, and diameter.





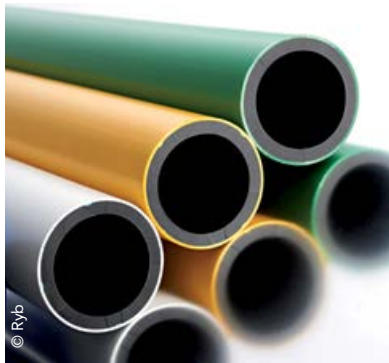
THE TECHNOLOGY

Eliot, which was developed in conjunction with Leti, features RFID tags embedded in the piping material at regular intervals and a reading and detection device used above ground.

RFID technology was originally developed for traceability applications. The technology had to be modified to detect and locate chips underground in a variety of conditions.

Thanks to a patented antenna design, transmission (at 13.56 MHz) remains robust despite use in a wide range of conditions. The antenna design is patented. The RFID tags are also robust, and can withstand the high temperatures of the extrusion process.

Eliot is the world's first communicating piping system.



CONTACTS

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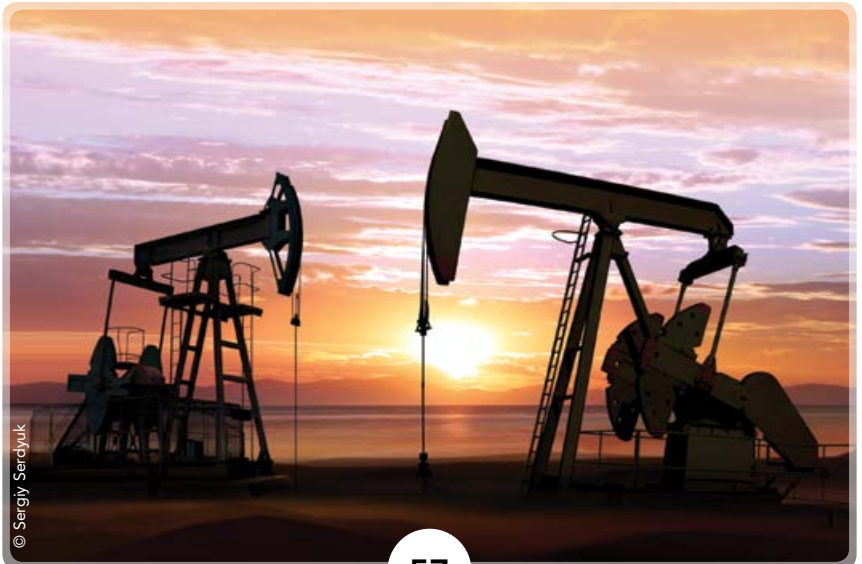


VIBRATION SENSORS

FOR OIL AND GAS EXPLORATION

Sercel's seismic acquisition systems help oil and gas companies pinpoint the best locations for exploratory drilling.

During seismic exploration, thousands of vibration sensors—10,000 times more sensitive than those inside your average smartphone—are positioned across the area being explored. Acoustic waves created by vibrating trucks are then propagated underground, where they are reflected back to the surface from depths of several kilometers and measured at locations up to ten kilometers away. The waves' "travel times" are calculated, providing valuable insights into the geological formations underground.



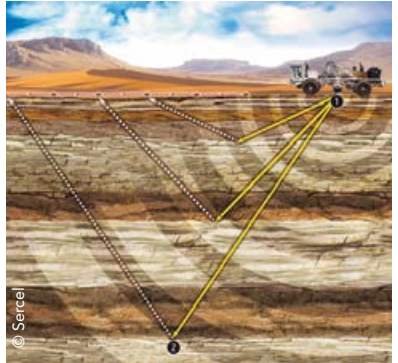
© Sergiy Serdyuk



THE TECHNOLOGY

Seismic acquisition systems generally use analog (a coil and magnet) components. In 1996 Leti and Sercel developed a radically different miniature sensor on silicon. Since then, the system has undergone constant improvements, resulting in performance that remains the best available worldwide.

A suspended mobile structure measuring several square millimeters and integrating a network of intercalated fingers between fixed fingers is subjected to acceleration. The resulting movement—just a few millionths of a millimeter—is measured by capacitive sensing and offset by a feedback mechanism. This structure, so sensitive that the impact of air molecules would be visible, is sealed in a high-vacuum enclosure. The resulting device offers a resolution of 15 nano $g/\sqrt{\text{Hz}}$ and dynamics of 130 dB.



CONTACTS

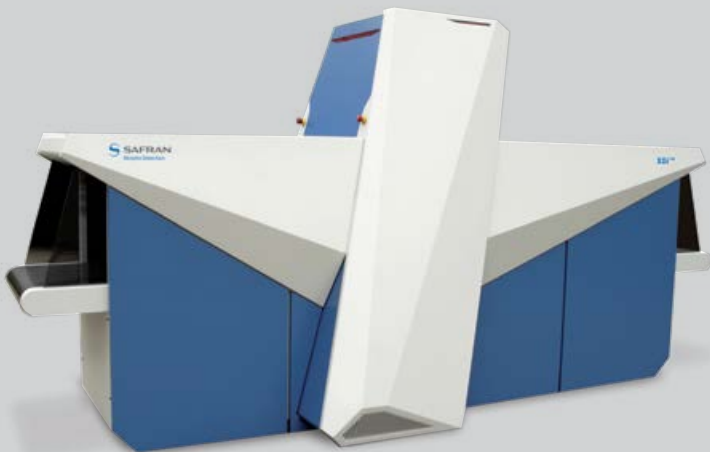
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X-RAY DIFFRACTION SCANNER

MAKING AIRPORT SECURITY CHECKS FASTER AND MORE RELIABLE

Boarding your flight with a bottle of water could once again become a reality. Smiths Detection has developed a new airport baggage scanner that can identify dangerous liquids inside baggage. The new scanner is more accurate than what is currently available on the market, and, with four times fewer false alarms—and the resulting manual searches—it should help get travelers with permissible liquids in their baggage to their gates faster.

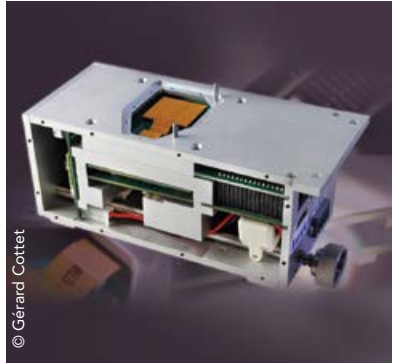


THE TECHNOLOGY

Smiths Detection's checkpoint imaging system, which uses X-ray diffraction, is made up of multiple semiconductor-based detectors developed by Leti. The device, for which Leti holds around ten patents, operates at ambient temperature and combines a Cd(Zn)Te detector and CMOS read circuit providing photon counting and energy measurement capabilities.

Smiths Detection combined Leti's innovation with a multi-energy signal processing method that analyzes the diffracted photons to determine a substance's molecular structure—which is then used to identify the substance.

This unique detection and identification system brings false alarms down drastically, from 20% with current systems to just 5%.



CONTACTS

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MCT DETECTORS

INFRARED VISION: SPACE, DEFENSE, INDUSTRY...

Sofradir's infrared imager matrices are the best when it comes to detecting the infrared radiation emitted by the human body and hot objects. The matrices operate at very low temperatures (-192°C) and only require a few photons to detect the presence of a body or object. They are used in military night-vision systems, on weather satellites and space probes, and in industrial and commercial applications.



THE TECHNOLOGY

Sofradir has been working with Leti on the matrices for 25 years. To develop their innovative semiconductor alloy (mercury cadmium telluride, or MCT), they had to first understand its fundamental properties, perfect fabrication and doping, and improve the material from one generation to the next to make the detectors increasingly powerful.

Today Sofradir is the global market leader for MCT detectors, and the world's second-leading manufacturer of "cooled" infrared detectors.

And additional improvements are under development, including further reducing pixel size without compromising detection capacity, detecting signals from as little as a single photon per pixel, reducing energy consumption to just a few watts to increase battery life, and designing matrices that can operate at higher temperatures.



CONTACTS

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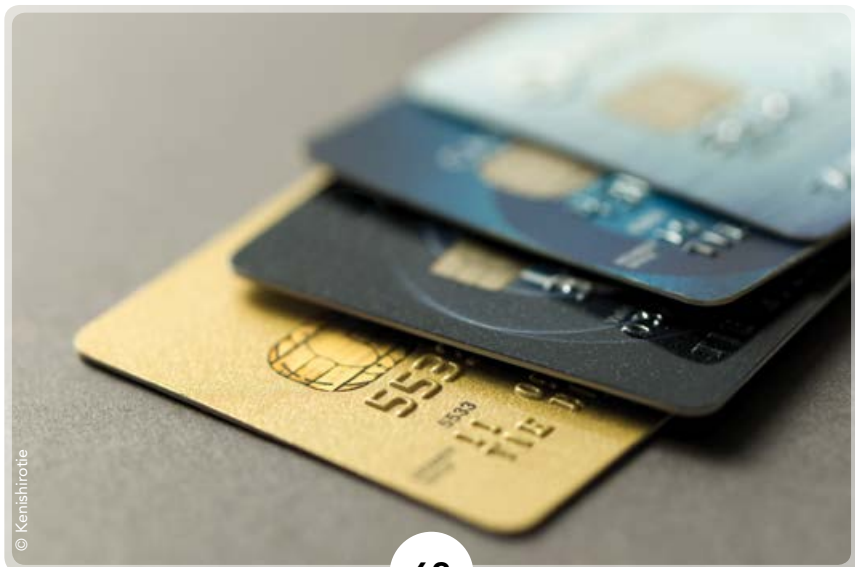
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NEW

CONTACTLESS BUT SECURE

CONTACTLESS MODULE FOR SMART CARDS

As a designer of secure chips for telephony, payment, identification and industry, StarChip specifically offers its clients fast, secure, contactless modules with long lives. Starchip provides solutions that are as high-performance as they are competitive thanks to its original "fabless"-type business model.



NEW



THE TECHNOLOGY

With a view to enriching its smart card offer with contactless technology, StarChip approached Leti to take advantage of the institute's RFID expertise, which spans more than a decade. An ISO-14443 Type A analog interface function was developed by the Leti/Starchip partnership based on the CMOS 110 nm fabrication process. This supports bit rates up to 848 kb/s. Leti transferred this technology and its related skills to StarChip, which is independently integrating it into the secure chips incorporated in its product offer.

In RFID, the signals exchanged are used for both powering the circuit and ensuring 2-way communication of encrypted data between the chip and the reader. Leti's expertise has been essential to producing a robust function compatible with stringent standards, while the circuit operating conditions are extremely variable and irregular.

CONTACTS

www.starchip-ic.com

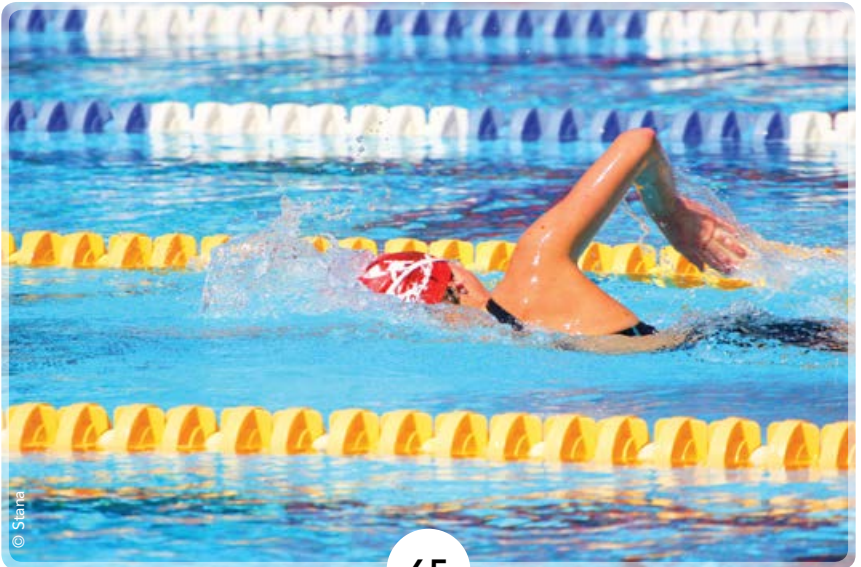
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NABAIJI MP3

SWIMMERS CAN NOW COUNT SONGS, NOT LAPS

Swimming laps just got a little less tedious, thanks to the Nabaiji MP3 player, sold under the Passion Nabaiji brand at Décathlon sporting goods stores (an Oxylyne company). The MP3 player counts the number of turns a swimmer makes to calculate the total distance covered—freeing swimmers from tedious lap counting so they can simply swim and enjoy their favorite music. Another great feature: when time is up or the desired number of lengths has been completed, the music stops, alerting the swimmer.



THE TECHNOLOGY

Leti and List worked with Movea, a start-up specializing in motion-sensing technology, to develop a system to detect a swimmer's turns. Several different sensors—accelerometers, magnetometers, and gyrometers—can be used.

The algorithms developed had to be energy efficient to maximize battery life and powerful enough to interpret the signals from the sensors. The algorithms had to be able to distinguish between turns at the end of the swimming lane and other movements, regardless of factors like the pool's direction with regard to north, the direction in which the sensor is worn on the swimmer's head, the swim stroke used, and the swimmer's ability level.

Movea, Leti, and List worked with Nabaiji product designers to come up with an innovative product that stands out for its reliability. The MP3 player accurately displays the actual distance covered in the pool. The product—currently the only one of its kind on the market—lets swimmers keep an eye on performance even while listening to music.



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NEW

MORPHOPIPE



FLEXIBLE, UNDERWATER PIPE-MONITORING SYSTEM

This technology unlocks the secrets of underwater flexible pipelines! Embedded sensors in the critical first 30 meters continuously monitor any deformations. Cost-effective and safe, this system is designed to improve pipe quality and sustainability, and, at the same time, prevent oil spill emergencies.

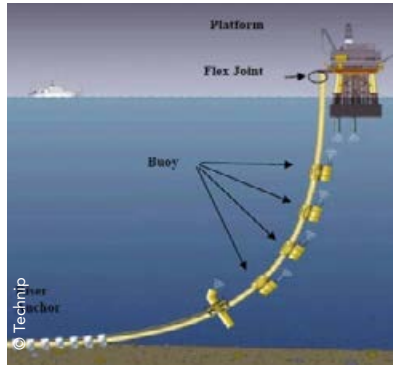


THE TECHNOLOGY

To maximize sustainability, reduce manufacturing costs and tackle a serious environmental problem, Technip tracks conditions of flexible-pipes installed underwater for offshore oil and gas production. As a world leader in engineering and technology for the oil industry, Technip chose Leti for its expertise in mathematical modeling and MEMS technology.

Leti researchers have developed a measuring instrument. Named Morphopipe, it is comprised of MEMS sensors, including accelerometers embedded in the flexible pipe surface. Leti identified and selected several sensors and worked on the implementation of network and system architecture. Additionally, Leti established a specific mathematical algorithm able to determine the pipe's curvature, tracking any deformations caused by sea conditions.

At the same time, a more thorough study was conducted to address integration and sensor-calibration challenges. Reliability, integration and functionality tests were jointly conducted. The Morphopipe project won Technip's Franquelin award for innovation.



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CLIINK®

SMART CONTAINER REWARDS GREEN PRACTICES

Smart, autonomous, incentive-based and cheap... Equipped with the Cliiink® box, this container has it all! Ultra-resistant sensors verify the nature and amount of the waste deposited and, what's more, the Cliiink® app or contactless card rewards users with customized shopping coupons! Ideal for ongoing maintenance, the fill rate is sent every night to optimize collection service. Everyone wins with Cliiink®, even the Earth!



NEW



THE TECHNOLOGY

To reward eco-friendly practices, Leti and Terradona identified and fabricated several low-cost sensors that are strong enough to operate in a harsh and sometimes isolated environment, in both outdoor and buried containers. This unique combination of MEMS sensors identifies glass and other items and calculates both the size and amount of waste deposited, while ensuring minimal energy consumption. Advanced algorithms in each sensor provide high-reliability characterization. To generate appropriate signals, the mechanical part of the system also has been thoroughly studied.

Leti also worked on the communication function, incorporating Bluetooth Low Energy functionality. To implement a fair reward system based on the use of the container, data collected from the sensors is sent to a centralized server that converts this information into gift vouchers with Cliiink's app or a secure web interface.

The container fill level is sent every day to a professional web-based interface via an onboard cellular radio network on Cliiink's card.



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ABSOLUTE PRESSURE SENSORS

ALTITUDE 2,000 FEET, FLIGHT SPEED 207 KPH

Absolute pressure sensors are crucial to measuring a helicopter's altitude and flight speed. And Thales has developed a new sensor that offers revolutionary precision of 0.05% no matter what you throw at it. The sensor's performance even stands up to the vibrations, landing impacts, intense accelerations, and extreme temperature fluctuations (from -40°C to 200°C) found on board your average helicopter.



THE TECHNOLOGY

Leti's all-silicon pressure sensors replaced the bulkier, less-reliable metal-membrane sensors traditionally used. The Leti sensors are made from crystalline silicon, offering excellent mechanical performance and enhanced temperature stability.

The detection principle used was improved to meet the performance and temperature-resistance requirements of the target application. Piezoresistive strain gauges on an insulator were used to measure the deformation of a membrane, one side of which was exposed to a reference pressure level. The gauges are engraved on SOI (silicon-on-insulator). The silicon oxide layer located under the gauges prevents leakage current, which enhances the device's temperature stability.

This absolute pressure sensor was successfully tested for use in aerospace applications. First developed in 1998, the sensor today continues to offer the best performance on the market.



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MEMS RF SWITCHES

MICRO SWITCHES IN SPACE

Switches are important components on board a satellite, performing a range of crucial functions. For example, if there is an incident on a circuit, a switch is used to transfer the load to a working circuit. Thales Alenia Space is planning to integrate a new generation of switches—ten times smaller than those currently in use—into its products. The switches under development were tested on the ground for more than a year. Several test switches were then sent into space in early 2014 to embark upon an impressive fifteen years of reliability testing. The results will determine whether the switches will ultimately make their way into tomorrow's satellites.



THE TECHNOLOGY

The silicon-based MEMS RF switches feature a transmission line whose signal can be interrupted by an electrical contact that moves when subjected to electrostatic voltage. The switches are made using techniques—like photolithography and thin-layer deposition—fully mastered by Leti.

Leti's engineers looked to the electrical contact materials and the charge accumulation mechanisms at work to improve the component's reliability during cycling and confirm its resistance to radiation. Around ten micro switches with varying switching frequencies were sent into space for further testing.

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PRINTED & INTEGRATED ANTENNAS

POWERFUL & COMPACT PAGER

This pager combines more comfort with better efficiency! To make its pager more compact and ergonomic, TPL Systèmes worked on integrating an external antenna in its TETRA terminal... Leti researchers quickly sized up the situation. Today, the challenge has been met with an optimized housing and 2x performance.



THE TECHNOLOGY

TPL Systèmes relied on Leti telecommunications expertise to integrate an external antenna into an existing pager. Size being directly linked to performance, a disruptive technology was required to add superior space savings in this already quite-compact pager.

Leti has developed a novel RF/optical test bench for miniaturized antennas and used its not-so-common anechoic chamber to characterize low-frequency antennas. Researchers conducted a comprehensive study to develop a brand-new miniaturized antenna for the TETRA standard (around 400 MHz) that could be both flexible and reconfigurable at the same time. Through their hard work, Leti researchers were able to double performance, while combining the pager with an active electronic circuit covering all international bands. A compact and low-cost antenna has also been integrated into this optimized receiver for GSM and DCS standards (900/1800 MHz).

Leti researcher Jean-François Pintos received the second-place award in 2014 for FIEEC for overcoming the challenge.



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ALL-SILICON MOTION-SENSING CHIP

MOTION SENSORS MAKE SMARTPHONE GAMING MORE FUN

Have you ever wondered what's behind your smartphone's gaming capabilities? Gaming features like the automatic image rotation you get when you turn your phone in space are made possible by tiny sensors that pick up your movements. Tronics' latest all-silicon motion-sensing chip is a world-first. Although it may be tiny at just 1 mm thick and 4 mm², it packs in an impressive six motion sensors—three accelerometers and three gyrometers.

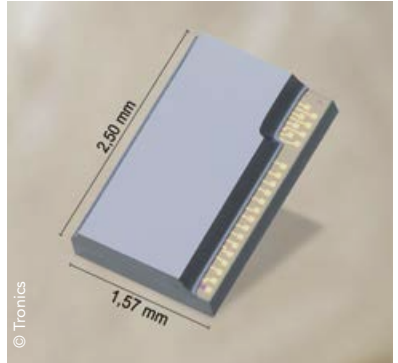


THE TECHNOLOGY

To make the chip, Leti developed a revolutionary MEMS motion sensing concept for which more than fifteen patents have been filed.

The concept is based on a suspended piezoresistive-silicon nanowire measuring several microns in length and 250 nanometers in diameter. This innovative motion sensing method enables substantial signal amplification while keeping electrical consumption very low. It also offers the added benefit of being applicable to all kinds of sensors, from accelerometers and gyrometers, of course, to pressure sensors, magnetometers, and microphones.

Several sensors can be integrated on the same chip via a silicon process routinely used by MEMS manufacturers without the need to include a hybrid assembly step in the process, which is currently the case.



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PICO1024™

INSIDE INFRARED CAMERAS

Infrared cameras—whether they are used to keep an eye on city streets or factories, help drivers see better at night, or check a building’s insulation for heat loss—use bolometric imagers. The imagers feature a temperature-detecting layer that reacts to infrared radiation by heating up and a read circuit that detects the heat and generates video images.

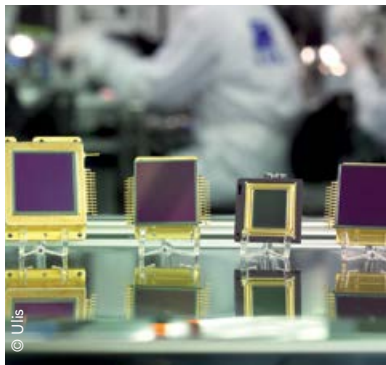


THE TECHNOLOGY

Leti has been developing bolometric imagers since 1992, and transferred the technology to start-up Ulis in 2002. Ulis is today the world's second leading bolometer manufacturer, with a 21% market share.

Unlike competitors' vanadium oxide-based solutions, Ulis' bolometers leverage amorphous silicon for the temperature-detecting layer. The material offers better fabrication uniformity, homogeneous thermal behavior, and higher production yields.

A series of R&D projects have slashed the devices' pixel sizes threefold (from 45 micrometers to 17 micrometers), improved the read circuits, and reduced costs. These advances have improved infrared camera performance and brought prices down, opening the door to new applications.



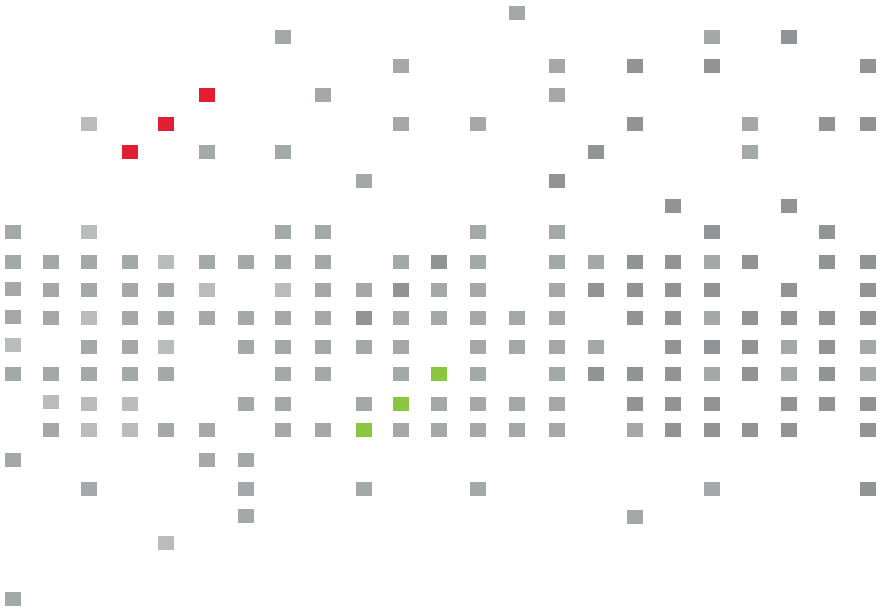
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