liten

ANNUAL REPORT 2014

FROM RESEARCH TO INDUSTRY

cea tech

Director's editorial

A JOINT APPROACH WITH INDUSTRY THAT ADDRESSES THE DEMANDS OF THE ENERGY TRANSITION

Renewable energy is more than just a trend. Spurred by the urgent need to develop solutions for the challenges plaguing our economy and society, the energy transition is an undisputed reality. And, like all industrial technologies, new energy systems must prove their performance and cost-competitiveness if they are to carve out a position in the marketplace. At Liten, we help our industrial partners gain competitive advantage in areas crucial to sustainable energy markets, like energy efficiency, energy harvesting, new-material development, and recycling. Furthermore, our 2014 research results prove that our strategy can effectively help companies penetrate and firmly anchor positions in those markets.

In 2014 we continued to make solid progress. Researchers at the INES pre-industrial high-output PV cell line stabilized the line's industrial processes, resulting in the production of a 308 Wp module. Our hydrogen-related and fuel-cell-related R&D made steady progress throughout the year. We achieved notable fuel-cell performance improvements while cutting system costs. We produced a 25-cell stack for high-temperature electrolysis and successfully demonstrated the stack's reversibility in SOFC mode. We also achieved record yields of more than 90% for an HTE system and made progress toward the integration of fuel cells in motor vehicles (up to 300 kW per prototype). Finally, we completed an initial methanation reactor prototype to pave the way for future advances in a new research area at Liten, power-to-gas.

Energy storage remains a major challenge, and over the course of the year we successfully promoted tailor-made electric, thermal, and hydrogen-based solutions for a variety of applications. We now have a tool that allows us to scale energy systems that include renewable energy production and storage for optimal performance.

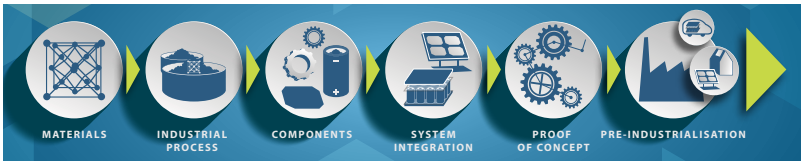
Our relationships with industrial partners remain strong and focused on long-term benefits. The demands of industry and the technological obstacles communicated to us are what spark our researchers' creativity, allowing them to drive innovation even further whilst remaining in step with market needs. In 2014 we were pleased to renew several multi-year partnership agreements with aerospace and defense industry leaders. At the same time, we ramped up support for SMEs through affiliate agreements and the launch of four new CEA Tech regional offices (in Nantes, Bordeaux, Toulouse, and Metz).

Finally, we boosted our international activities in 2014 and appointed an international coordinator to oversee and implement this important part of our strategy. We are currently involved in advanced-stage negotiations with developing countries to build pilot plants similar to the one existing at Liten.

Florence Lambert
Director, Liten

Liten: the driving force behind the sustainable energies of the future

Liten is Europe's largest renewable-energy technology research institute. Based mainly in Grenoble and Chambéry, France, we boast high-quality facilities staffed by world-caliber scientists and engineers prepared to lead the energy transition.



Liten is Europe's only research center to cover the entire renewable-energy value chain.

Liten, the Laboratory for Innovation in New Energy Technologies and Nanomaterials – a branch of France's leading research organization, the CEA – is spearheading the EU's efforts to limit dependency on fossil fuels and reduce greenhouse gas emissions. Unlike any other sustainable energy research institute, our activities cover the entire value chain from the synthesis of materials to the development of complex demonstrators. Our industrial partners benefit from personalized R&D support that speeds the transfer of innovations from lab to market – and boosts their competitive advantage.

400 R&D AGREEMENTS EACH YEAR

We are the partner of choice for manufacturers of all sizes, regardless of where they are on the technology value chain. Our expertise covers all aspects of technology, including materials, processes, components, systems integration, and demonstrators.

Every year we put in place 400 research contracts and carry out R&D on behalf of industrial partners from a wide range of market segments: energy, land transportation, aerospace, construction, civil engineering, environmental, and IT industries, amongst others.

1,100 PATENTS A ROBUST INTELLECTUAL PROPERTY PORTFOLIO

Intellectual property forms a major part of our activities. We have a portfolio of more than 1,100 international patents and are one of the CEA's most active generators of intellectual property, filing 200 patents in 2012, 235 in 2013, and 230 in 2014.

A THREE-PRONGED APPROACH TO STRATEGIC RESEARCH

Our R&D addresses technological and economic challenges in three main areas:

- Renewable energy, especially solar and biomass.
- Energy efficiency and energy storage, including electric vehicle technologies (like batteries and fuel cells), energy-efficient buildings, and power generation systems (from production and storage through to conversion and smart management of thermal energy, electricity, and gas – especially hydrogen).
- Materials for energy, with a particular focus on nanomaterials engineering and new environmental challenges.

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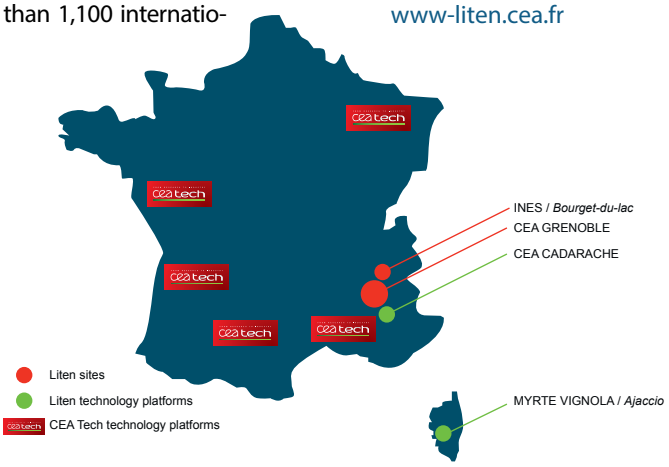


Working with Liten

At Liten, we are poised to meet the needs of businesses of all sizes, from start-ups and SMEs to major multinationals. Our main facilities in Grenoble and Chambéry, France, are supplemented by regional offices in Bordeaux, Metz, Toulouse, Nantes, and Cadarache, and by experimental technology platforms in Cadarache and Corsica. We offer a flexible range of R&D services that can be tailored to our industrial partners' specific innovation strategies. Our turnkey services are designed to boost our partners' competitiveness, with targeted solutions for all stages of technology development, from material characterization and economically-viable components through to complete systems to address the current and future needs of a specific market. Moreover, all our services are provided in an ISO 9001-certified environment with the right systems and resources to ensure confidentiality, cost efficiency, and on-time completion of development projects.

CHOOSE FROM FOUR TYPES OF PARTNERSHIP

- **Industrial research agreement:** Covers a given time period and a clearly-identified R&D topic; can be coupled with a **collaborative R&D project** (like those funded by the French National Research Agency, French Single Interministerial Fund, or EU programs) to secure additional financing and extend a project's reach. Our engineers have proven experience with this type of collaborative project and can provide expert assistance at all stages.
- **Affiliate programs:** Multipartner R&D programs with simplified administrative procedures; especially suited to SMEs with little or no in-house R&D capabilities.
- **Joint R&D lab:** We set up a joint research team with our partner under a reciprocal agreement for a period of up to several years. Shared goals, technology milestones, and joint management mechanisms are outlined in the agreement.
- **Technology transfer:** Partners can license our technology under certain conditions, and benefit from our technical support to transfer mature, patented technology to industry.

A TAILOR-MADE OFFERING

- We tailor the technical resources, number of scientists and engineers, budget, and calendar for each joint development project to meet each partner's unique needs.
- In some cases*, 60% of the R&D costs billed to our partners may be eligible for the French government's Research Tax Credit program.
- Projects can be financed and intellectual property managed in a variety of different ways depending on the technology being developed and its maturity. The CEA has a strong intellectual property policy designed to protect the interests of its partners worldwide.

* Relates to companies paying tax in France.

A NEW SERVICE OFFERING

Liten has drawn upon its in-depth knowledge of many of the components used in energy systems to develop tools and software to effectively scale and manage these systems. Our simulation capabilities cover battery performance; hydrogen production storage, and conversion systems; electrical converters; and renewable energy production sources like PV and wind. We use various control strategies to determine which solutions are the most appropriate and make improvements to the target system to achieve optimal performance and ROI. For certain components, we can also provide a dedicated version of our real-time management software.

Materials

DEVELOPING INNOVATIVE TECHNOLOGICAL SOLUTIONS AND IMPROVING PERFORMANCE

At Liten, we carry out targeted R&D programmes to improve the performance of materials for energy and flexible electronics. For example, if no single material is capable of meeting the requirements of a specific application, our researchers can combine several materials or use nanostructuration to reach the targeted properties. And, for materials including rare earth minerals, indium, gallium, lead, and solvents, we can also develop alternative solutions to mitigate future supply issues such as cost, geopolitical instability, or impending regulatory changes. We are also investigating new processes with the potential to optimize the cost, robustness, weight, and cost-efficiency of materials – factors that impact on virtually all market segments.

MATERIALS PROCESSING

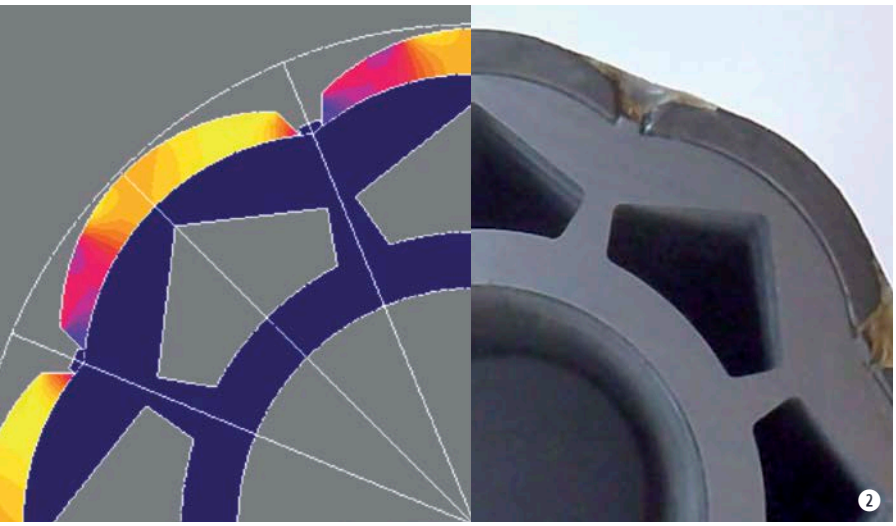
POUDR'INNOV NOW OFFERS 3D PRINTING

Emmanuelle Rouvière
Head of Material Efficiency and Energy Harvesting Research Department, CEA-Liten

Poudr'Innov, our powder metallurgy platform, has recently invested in three new 3D printers that can be used to manufacture prototypes from metal powders and polymer resins, either charged or not. The maximum finished prototype dimensions are 30 cm x 15 cm. The printers offer significant potential for our industrial partners in that they can now assess the mechanical properties or the resolution of complex shapes of injected products without having to fabricate an injection mold, which is difficult to modify at a later stage. Poudr'Innov will also be able to support Liten's partners through an additional post-processing step that is crucial to the development of certain products.
And we plan to modify the machines to allow the manufacture of new products. For instance, we plan to add glove boxes, for the implementation of oxygen-sensitive powders. We would also like to develop new ink and powder formulations that are of interest to aerospace and dental industries.

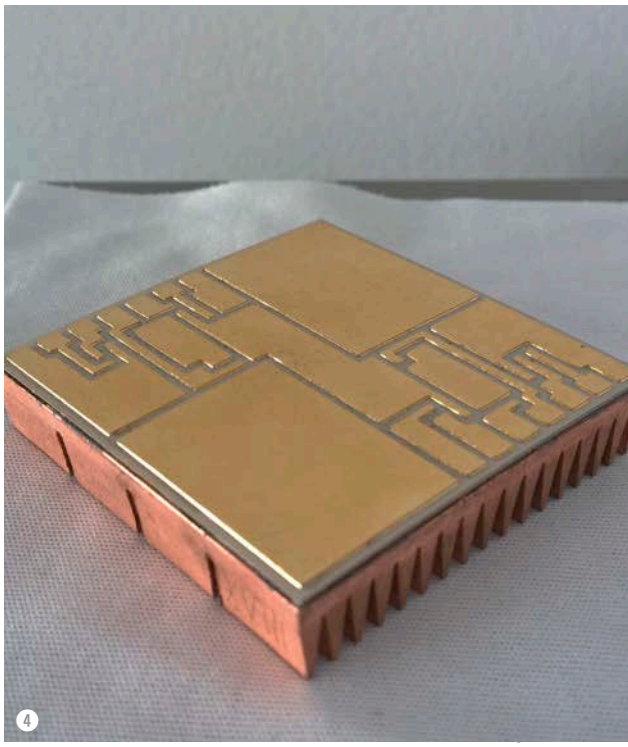
RECOVERING THE SILVER IN RECYCLED PHOTOVOLTAIC PANELS

We are currently developing a breakthrough hydrometallurgical process to recover the silver in crystalline silicon photovoltaic panels. Silver accounts for 90% of the panels' value. The selective dissolution process slashes reagent consumption by 98% as compared to traditional total dissolution methods and removes all of the silver. A patent has been filed and R&D work focusing on further improvements is expected to continue with an industrial partner. 1



MORE EFFICIENT USE OF RARE-EARTH MAGNETS IN ELECTRIC MOTORS

At Liten we are working on ways to improve the performance of a 25 kW compact permanent magnet electric motor. Our experts developed an innovative assembly technology and complex magnet shapes that, together, reduce vibration threefold by 3 and boost torque by 15% (comparison based on the same amount of raw material). They also came up with an injection-sintering process, coupled with numerical simulation, to manufacture the neodymium iron boron magnets. 2 3

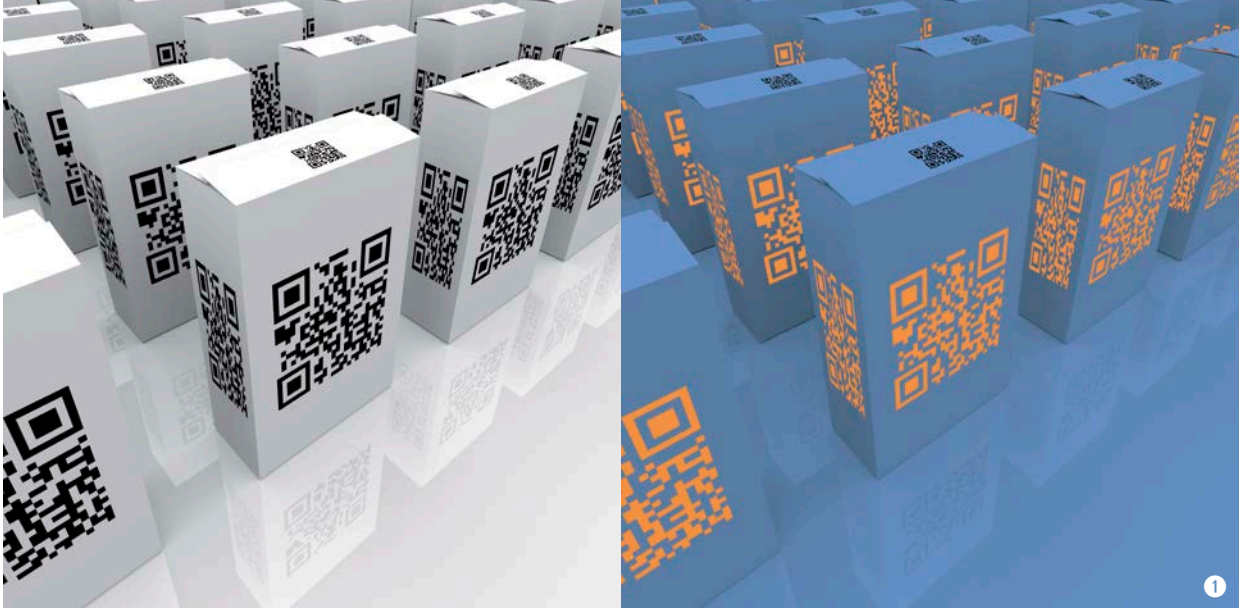


UNUSUAL ASSEMBLY TECHNIQUE HELPS COOL POWER ELECTRONICS

We developed a direct copper-ceramic bonding technique using reactive brazing and tested the technique on prototypes over more than 300 cycles at temperatures varying between – 40°C and 160°C. The technique could be used in cooling systems for power electronics, shaving 90% off of their weight depending on the type and structure of the materials used. The assembly process has been patented, and further enhancements are being perfected under a collaborative R&D project backed by the French Single Interministerial Fund with partners Renault, Valéo, Safran, and Schneider Electric. 4

HOT ISOSTATIC PRESSING READY FOR METHANATION REACTORS

Two 1:10 scale models of the future Sabatier methanation reactors developed at Liten were successfully assembled using hot isostatic pressing. The reactors are made from 316L stainless steel laser engraved or machined front and back. The conventional machining method used offers better precision in terms of dimensions and better plate flatness. The research also validated the hot isostatic pressing temperature/ pressure cycles. The next step will be to make a 1:2 scale model.



SAFER-BY-DESIGN PAINTS AND CLOTHING THAT MITIGATE THE RELEASE OF NANOPARTICLES

We are using advanced characterization techniques and weather-related and mechanical aging tests to study the release of nanoparticles used in industrial paints throughout their lifecycle. The results are being used to develop new formulations that mitigate the release of nanoparticles. Our experts are also looking at how well clothing protects construction workers against nanoparticles found in mortar. So far, three types of clothing materials have been proven effective.

NANOMATERIALS

LUMINESCENT BLACK INK FOR PRODUCT AUTHENTICATION

A partnership with Naomarq (an Alcen company) resulted in the development of a new product authentication technology that entails printing optical codes directly on products with a special luminescent black ink. This simple system is compatible with existing industrial printing techniques like continuous inkjet (CIJ), thermal inkjet (TIJ) and drop on demand (DOD) technologies. In 2014 we developed several innovative applications for the technology: luminescent marking on precious metals and metals used in aerospace applications; authentication of raw materials for elastomers; and authentication of surface treatments for metals used in aerospace applications. A total of four new patents were filed and several manufacturers have begun testing these innovations. 1

SILVER NANOWIRES FOR CAR WINDSHIELDS

We signed an agreement with Protex International subsidiary Protavic for the joint development of silver nanowires for electronics applications. The nanowires, which offer very good conductivity, could also be used in transparent heat-producing films for car windshields and helmet visors. Several patents have been filed for the liquid-phase chemical synthesis technique used to synthetize the wires. A PhD research project in progress is investigating the wires' stability. Since 2010, we have participated in eight French and/or European research projects on silver nanowires.

CARBON NANOTUBES COULD CHALLENGE COPPER IN ELECTRICAL WIRING

Our experts have found a way to spin carpets of vertically aligned carbon-nanotubes into a conductive thread measuring between 7 µm and 15 µm in diameter. The conductors demonstrate excellent electrical resistivity of 1.9 mOhm/cm, regardless of current frequency. They are also very lightweight and flexible enough to be tied into a knot. Conductors of this type could be viable competitors for copper in applications with high-frequency-performance requirements. We are currently working on several enhancements to tube density and doping that could potentially increase the wires' conductivity tenfold.

MICRO ENERGY SOURCES

PROOF-OF-CONCEPT TESTING COMPLETED ON PV THREAD FOR TEXTILES

Our researchers successfully deposited a functional photovoltaic coating leveraging inorganic thin layers on textile thread suitable for both weaving and knitting. The ultimate goal is to integrate this "solar thread" into products like awnings, greenhouses, and backpacks without altering the original products' appearance, features, or performance. The research is carried out under an affiliate program (SOL-TEX, www.sol-tex.com) led by SunPartner Technologies. A patent has been filed for the PV thread.

LARGE-SURFACE LI-ION ELECTRODES MADE BY SCREEN PRINTING

Research carried out at Liten has validated an approach to screen-print Li-ion electrodes repeatedly– a simple and alternative process to coating. Electrode patterning on large surface is thus possible. We used this technique successfully on a 174 mm x 140 mm^2 graphite electrode. Production output is significantly higher with printing than with coating. After enhancement, the electrode is homogeneous enough for industrial requirements in terms of packing density. And further improvements are possible, including achieving the film densities required for high energy applications. 2

2

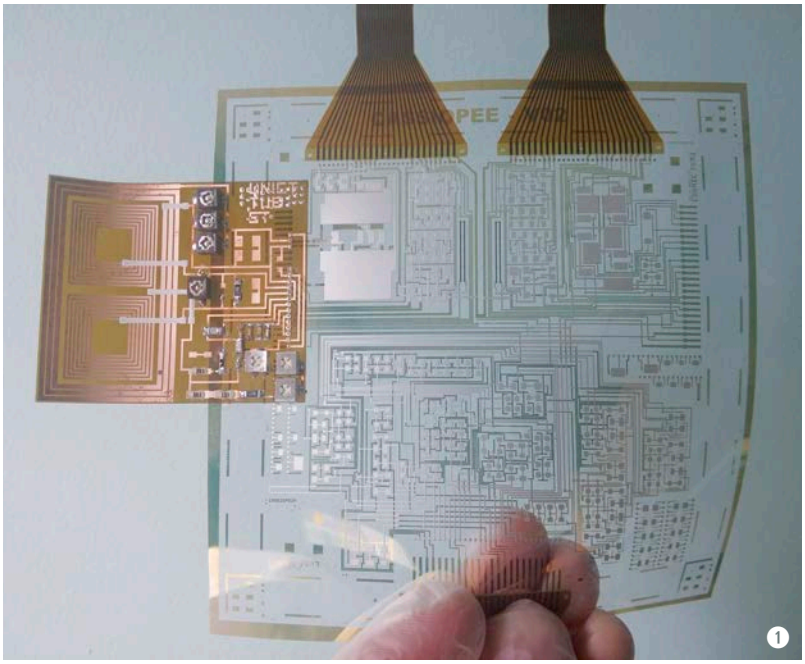
MICRO FUEL-CELL TECHNOLOGY REACHES MATURITY

Philippe Capron
Head of Energy
Microsources Laboratory,
CEA-Liten

We developed a pre-industrial micro fuel-cell with the potential to be transferred to industry in the very short term. This achievement represents ten years of R&D resulting in 50 patents. Liten exploited the PICTIC platform's low-cost printing technologies to make the fuel-cell core, a one-millimeter-thick, seven-centimeter square and combined the fuel-cell concept with a special cartridge that produces hydrogen on demand. The resulting energy source offers power up to 5 W – perfect for charging mobile devices off the grid.
Our planar fuel-cell core and hydrogen cartridge technologies can also be produced in other formats to meet the needs of more demanding applications. For example, we custom-developed a 120 Wh cartridge and 10 W fuel-cell system under research financed by the French Defence Ministry's Armament Division. Additional applications ranging from 10 W to 100 W are currently in development.

UNDERSTANDING ORGANIC PHOTODIODE AGING

We set up a controlled-environment testing unit to investigate organic photodiode aging, selectively exposing the photodiodes to water, oxygen, and an inert gas. Current-voltage measurements were taken in situ with the photodiodes in illuminated conditions. In one study, exposure to water had an impact on the PEDOT:PSS electrode's operating function. Exposure to oxygen doped the active layer, reducing the photogenerated current.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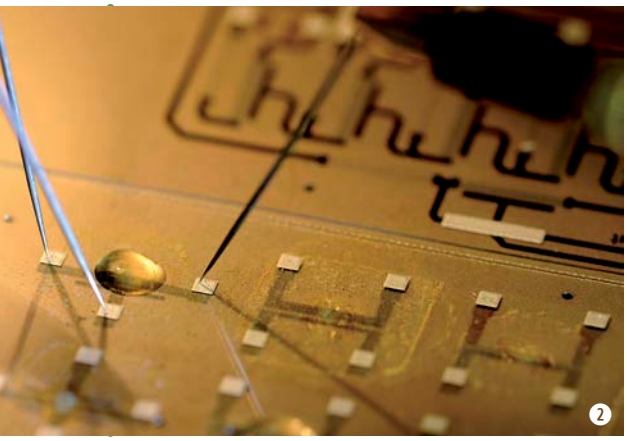
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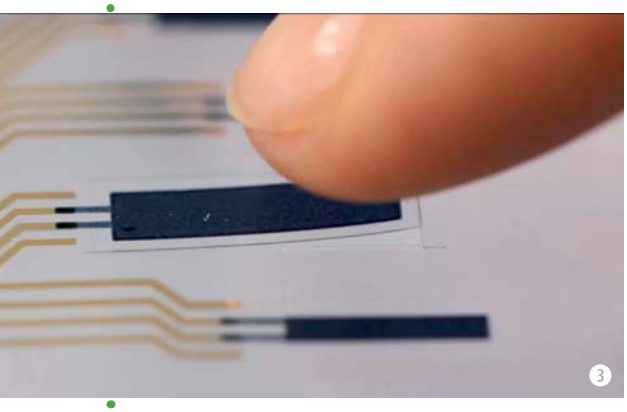
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ORGANIC ELECTRONICS

200-TRANSISTOR PRINTED RFID CIRCUITS NOW POSSIBLE

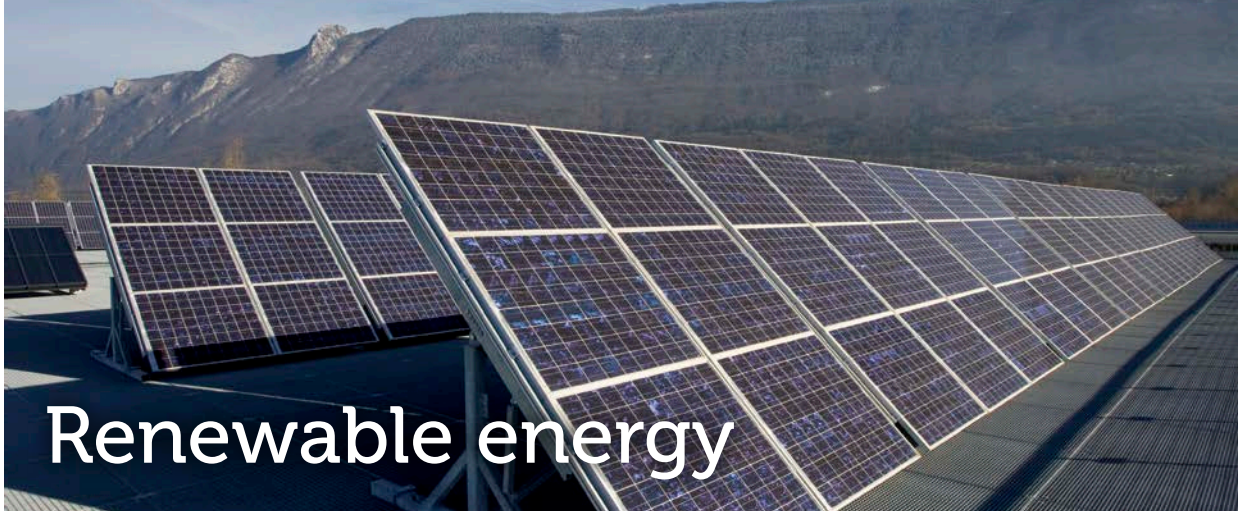
In research conducted under the EU-funded Cosmic project, we used printed organic CMOS technology to produce 200-transistor circuits for 13.56 MHz RFID tags. The information receiver and processor and identity verification are built in to the fully-functional chip. Processes were improved to achieve transistor operating yields in excess of 99%. The work will continue under a new research project, Atlas^2, which will focus on improving yield and preparing the technology for manufacturing. 1

PRINTED ELECTRONICS COULD BRING BENEFITS TO HEALTHCARE

Printed electronic components are affordable, flexible, conformable, and biocompatible – all crucial qualities in fields like biology and healthcare. In 2014 we started several research projects with partners, including CEA Leti, in the field of biosensors. The projects are focusing on a lactic acid sensor to track muscle activity; a CO_2 sensor for sleep apnea monitoring; and a glucose sensor for diabetes. Prototypes have been completed and we have initiated negotiations with manufacturers. 2

ARKEMA'S FLUORINATED TERPOLYMERS ARE ON THE MOVE

Arkema, the world's leading manufacturer of fluorinated polymers, turned to Liten for integration work on the company's terpolymers. Terpolymers present the particularity of undergoing deformation of several percent under an electrical field. Our researchers developed a screen printing process to deposit stacks of thin layers measuring less than 1µm thick on flexible substrates. The stacks were then used to make electromechanical switches that operate at 40 volts. Proof-of-concept testing was completed and a patent is being filed. 3



Renewable energy

FROM SOLAR POWER TO BIOMASS

Our renewable energy R&D portfolio focuses on photovoltaic, solar thermal, hydrogen, and biomass, covering the entire value chain for each type of energy – from advanced materials through to grid-connected systems. And, equipped with prototyping capabilities and pilot manufacturing lines, we are ideally positioned to meet the specific needs of manufacturers, designing powerful systems suited to a broad range of applications – often crossing traditional industrial boundaries. Our cross-disciplinary research approach combines photovoltaics and hydrogen; evaluates mix storage systems (electrochemical, mechanics, thermal etc); and is driving crucial advances in power-to-gas.

SOLAR ENERGY

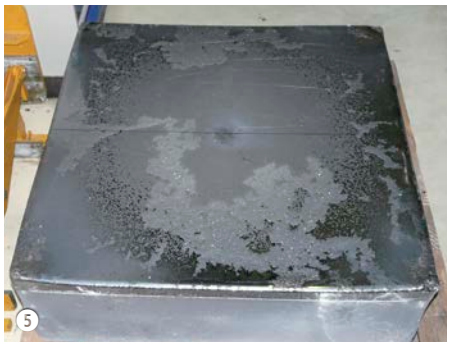
A HIGH-PURITY COATING TO CRYSTALLIZE SILICON

A high-purity crucible coating made from silazane, an inorganic polymer, helped improve the characteristics of G2 (60 kg) silicon ingots. The coating reduced the ingot red zone by 38%. Because the quality of the silicon is better at the ingot core, the cells made from the material deliver higher conversion yields. These improvements more than offset the higher cost of the patented coating. We are pursuing their investigations, with a particular focus on the coating's stability and thickness. 4


4

MONO-LIKE SILICON MAKES A LEAP IN QUALITY

We validated the furnace design and thermal recipe for 60-kg mono-like silicon ingots on 450-kg industrial-grade ingots. Our researchers confirmed that the process is reproducible and that the monocrystalline area consistently covers more than 98% of the usable volume. Plus, the PV yield improved, approaching that of monocrystalline ingots, but at far lower production costs. A PhD candidate is pursuing research on the origin of certain defects in the material. 5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THERMOCOMPACT WIRES UNDERGO TESTING FOR CUTTING SILICON BRICKS

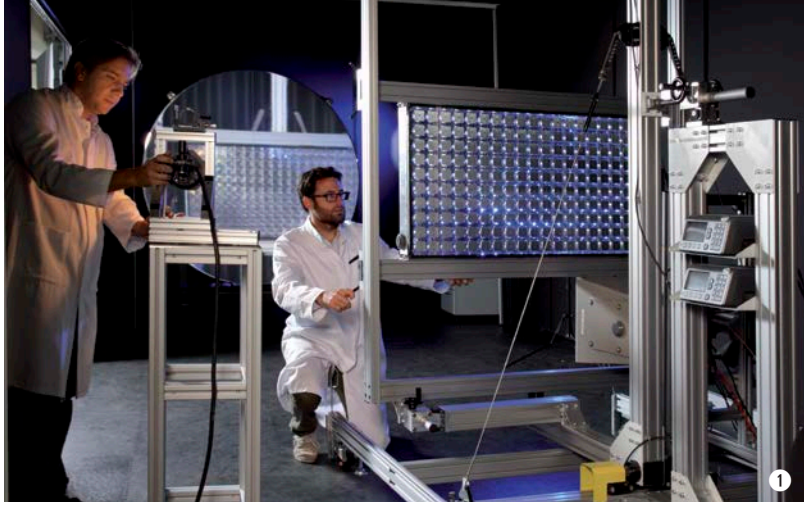
Thermocompact, an SME, now has prototype lines to test its 120 µm diamond wires and diamond wire loops, which were developed for cutting solar-grade silicon bricks and silicon wafers. The company's joint R&D programme with Liten is ongoing, with a current focus on characterizing the manufactured wires and extending their lifespan in the run-up to commercialization planned for end-2015. The wires will position Thermocompact as an alternative to the world's leading supplier. 6


6

CPV CHARACTERIZATION BENCHES

Mathieu Baudrit
Head of the CPV Laboratory, CEA-Liten

There are a number of characterization tools available for traditional photovoltaics. But the testing resources for concentrator photovoltaics (CPV) are relatively scarce. We decided to develop two indoor characterization benches dedicated exclusively to CPV.
They have now been used with success for testing with two of our industrial partners.
The first bench offers spectral response testing capabilities for encapsulated and unencapsulated cells. It assesses the decrease in cell yield under different temperatures and incident light angles representative of real-world conditions. This is due to the variability of the encapsulation materials' optical properties.
The second bench is used to characterize prototype mono-lens CPV modules with variables like the light spectrum, lens and cell temperatures, and the lens-to-cell focal distance.
An automated mode analyzes all of these variables to find the optimal combination. We demonstrated that lengthening the focal distance by 4 mm, for example, results in a yield increase of several points in actual operating conditions. 1



TWO NEW METHODS FOR ANALYZING SILICON QUALITY

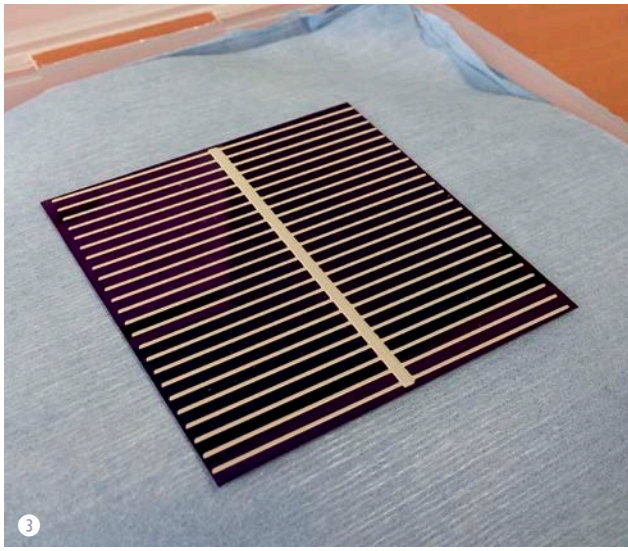
Liten's scientific experts have developed two innovative methods that will enable manufacturers to analyze the quality of solar-grade silicon. The first uses laser-induced breakdown spectroscopy (LIBS) to take on-line quantitative measurements of boron and metal impurities in molten silicon at 1,430°C. A functional prototype based on an NRC Canada patent was built in collaboration with this partner and set up at INES, France's national solar energy research center. The prototype was tested with success on 3-kg batches of molten silicon. A PhD research project focusing on ways to lower the detection thresholds and detect other impurities is in progress. The second method, called Oxymap, measures and maps the interstitial oxygen content in monocrystalline silicon Cz crystals, regardless of thickness or surface state. The model predicts the loss of cell yield due to the formation of oxygen-related defects. AET Technologies, an SME, developed an initial Oxymap testing machine prototype, which is located at Liten. The industrial version of the machine, which has also now been completed, will position the company to penetrate international markets. 2

HETEROJUNCTION CELL GET MORE EFFICIENT AND AFFORDABLE

We have set a new heterojunction-cell-yield record of 22.8%. The result was obtained by replacing screen printing with a copper metallization technique implemented using Leti's microelectronics equipment. The new technique reduced the line width from 90 µm to 40 µm, minimizing shading effects. Line resistivity was slashed fourfold. And it means that copper can be used as a replacement for silver which is 20 to 30 times more expensive and is currently the major contributor to heterojunction cells' high cost.

GALLIUM PHOSPHIDE A POTENTIAL ALTERNATIVE TO HYDROGENATED AMORPHOUS SILICON

Gallium phosphide could one day replace hydrogenated amorphous silicon in heterojunction cells. In experiments with the material, our teams obtained better current and open-circuit voltage. They also completed simulations that demonstrated a conversion yield 2% higher than that of hydrogenated amorphous silicon. Implementing gallium phosphide still poses a number of challenges, such as substrate degradation and surface passivation. Our researchers are looking at several potential technological solutions and workarounds. A PhD research project on the material began in late 2014 and is ongoing. 3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HIGH-VOLTAGE MODULES TO BOOST YIELD

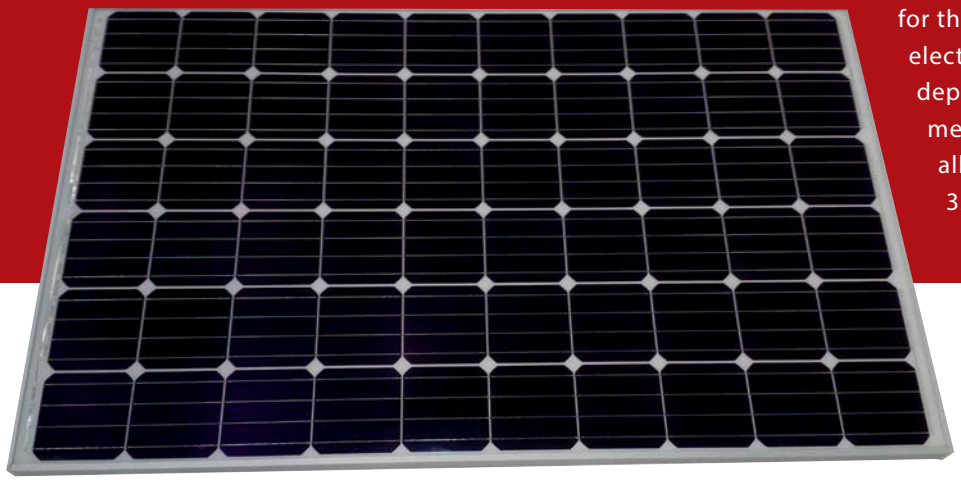
We are currently looking at how a high-voltage PV module could reduce resistive losses generated by the Joule effect. In the module, each cell is further broken down into sub-cells of the same voltage. We built two demonstrator panels of 576 sub-cells (originally 64 cells, each broken down into 9 sub-cells); the 300-volt panels offer yield increases of 3% to 5%. We plan to test two additional panels (18-volt and 110-volt, with cells broken down into 6 sub-cells) outdoors for a year.

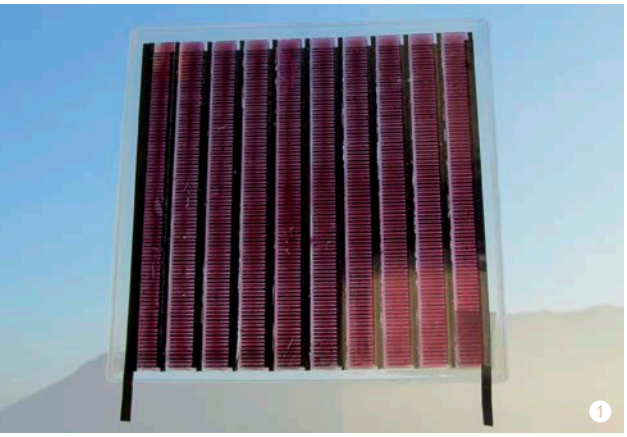
interview

HETEROJUNCTION TECHNOLOGY: FROM CELL TO POWER MODULE

Charles Roux
Operations Manager,
Heterojunction Labfab

We reached a milestone in 2014 when we built 60-cell modules with a record power of 308.2 Wp. We built on two years of heterojunction PV cell R&D to make further enhancements: we reduced leakage current, worked with a partner to develop a stringer to assemble the cells, and used an encapsulation material developed by Arkema. During testing, the average cell yield observed was 21.34%. The module technology is ready for transfer to a manufacturer. We filed 60 patent applications to protect our innovation. Because we used heterojunction technology, the module is cost-competitive and behaves better than competing technologies in terms of temperature. The additional improvements we are currently working on – wired instead of bus connections, new transparent oxides for the conductors, and electrochemical copper deposition for the metallization step – will allow us to go up to 320 W and beyond.





ORGANIC PV YIELDS GET A LIFT FROM INKJET PRINTING

Our experts produced flexible organic photovoltaic modules measuring 5 cm x 5 cm solely with inkjet printing. The modules' impressive 4.5% yield is the best ever reported for inkjet technology, a highly versatile process that is particularly well-suited to custom product manufacturing. The research is ongoing, with a focus on system stability, encapsulation, and scale-up to 15 cm x 15 cm modules. 1

THE HYDROGEN CHAIN LOWERS ENERGY COSTS FOR OFF-GRID SITES

A research project completed in partnership with Areva Energy Storage demonstrated that one way to reduce both capital expenditure and electricity production costs for isolated sites is to add a hydrogen chain to a hybrid PV/lithium battery system. The study, which focused on an isolated site in the Gulf of Guinea, leveraged the simulation capabilities of Liten's Odyssey platform to compare several operational system strategies. The findings showed that integrating a hydrogen chain reduced battery size substantially.

INDUSTRIAL-SCALE MANUFACTURING OF R&D MODULES AT INES

Stéphane Guillerez
Head of the PV Module Department, CEA-Liten

We built a 15-MW-capacity PV module production line with industrial-scale equipment, flexible enough to handle various types of materials, modules, and dimensions. This means we are capable of producing the kinds of volumes our partners need to test module reliability, validate the reproducibility of a process, or measure indicators like defect and reject rates, which have a major impact on costs. The production line has answered a lot of questions, and, as a direct result, we are able to transfer processes to our industrial partners faster. Manufacturers (material, cell, module, or equipment) can also use the line for their product development work – a type of partnership we started offering in 2014. Arkema has already worked with us on encapsulation polymers. End-users can also work with us on pre-industrial production runs of prototype modules for specific applications.

A HEAT PIPE SOLAR COLLECTOR THAT KEEPS ITS COOL

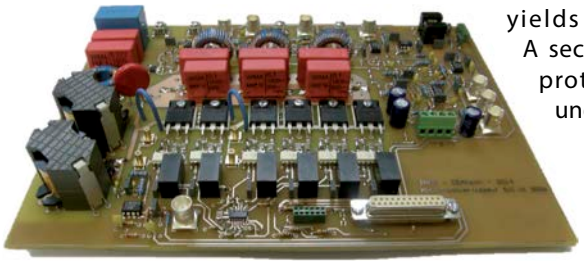
We developed a heat pipe solar collector with a cutoff mechanism to prevent the solar collector heat-transfer fluid from overheating during high-sunlight hours when the storage tanks are already full. The heat pipe contains a fluid that gradually changes from liquid to vapor until no fluid remains limiting the exchange of heat to what is conducted by the wall of the pipe itself. The cutoff effect is complete at 145°C, in line with the specifications for the project. Results of testing on an entire solar collector were good, with minimal yield loss. We are working with manufacturer Viessmann to develop a new residential solar collector and, in a separate project also with Viessmann, to upgrade an existing sensor for use in heat networks which was developed in a previous project and led to 2 patents. 2

THERMOCLINE HEAT STORAGE MODEL VALIDATED

A numerical model for a thermocline-type oil-rock bed heat storage system was developed and validated on data from two prototypes, including one with 30 m^3 of useable volume. Alcen, our industrial partner on this project, now has a reliable method for dimensioning industrial-sized tanks and determining their critical management parameters. Liten will be able to use the model for simulations of potential CSP solar farm sites. 3

A SPECIAL SILICON CARBIDE MICROCONVERTER FOR PV APPLICATIONS

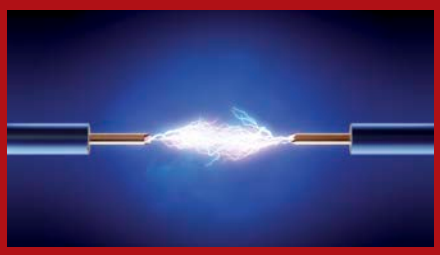
Today's PV micro-inverters are plagued by low yields, are not compact enough, and don't offer sufficiently long lifespans. We designed and built a totally original prototype with SiC components. The structure of this type of three-phase current switch limits the capacitive components required thus reducing the overall component volume. The early results obtained on the 300-watt prototype indicate yields in excess of 95%. A second version of the prototype is currently under development.



DESTINATION THE UNITED STATES FOR ELECTRIC ARC DETECTION TECHNOLOGY

Franck Barruel
Head of the Photovoltaic Systems Laboratory, CEA-Liten

We worked with our partner Socomec to develop a new technology to detect electric arcs in photovoltaic systems. We are setting our sights on the US market, where growth is driven by centralized detection products covering a chain of several modules.
In just three months, we developed a solution that offers two advantages over competing products on the US market. First, our system is more reliable, with more correct detections and fewer false ones. Second, our system detects parallel arcs, which are rarer, but just as dangerous as serial arcs.
We tested the system at four sites in France and Italy, with encouraging results. Socomec has started preparing the technology for industrial-scale manufacturing, and expects to launch its first products – PV arc fault detection and circuit interrupters – on the US market in the second half of 2015. The technology is protected by more than 15 patents and can be used on PV chains with up to 25 modules.



BIOMASS AND SYNGAS


1


2

METHANATION REACTOR SCALE-UP IN PROGRESS

A methanation reactor using CO_2 hydrogenation successfully processed 1 Nm^3/h of gas with a 95% conversion rate that remains very constant even when powering up or down. This flexibility will prove to be important when the reactor is coupled with renewable energy sources. Liten has set up a joint R&D lab with Atmostat to prepare the reactor for manufacturing. And, under an EU-funded research project, a coal-burning power plant in Poland will be equipped with an experimental 25 Nm^3/h reactor in mid-2016. 1


3

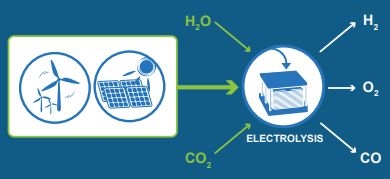
PAPER INDUSTRY SEEKING BETTER WAYS TO RECYCLE BLACK LIQUOR

When it comes to recycling black liquor, a waste product of the paper industry, there is definitely room for improvement. Our researchers worked with Grenoble Institute of Technology's Pagora School of Pulp and Paper Engineering to compare the traditional evaporation-plus-combustion process with hydrothermal liquefaction. Not only did hydrothermal liquefaction deliver higher energy yields, it was also effective at recovering phenols, used in the production of vanillin, and other potentially-useful substances. A PhD candidate is currently furthering this research and a patent has been filed. 2

BIOMASS AND BIOFUELS READY FOR SCALE-UP

The Syndièse biomass-to-biofuel project continued in 2014, with improvements to the grinding parameters, enhancements to the injectors, and powder characterization to measure factors like granulometry, moisture, and density. The target of 50 kg/h of biomass particles injected at 5 m/s was achieved under atmospheric pressure. Based on these results, scale-up to 1 ton per hour under 35 bars of pressure on the demonstrator, slated for completion in 2015, will begin. 3

POWER-TO-GAS WORKING TOWARD A 100 KW-MINIMUM PROTOTYPE

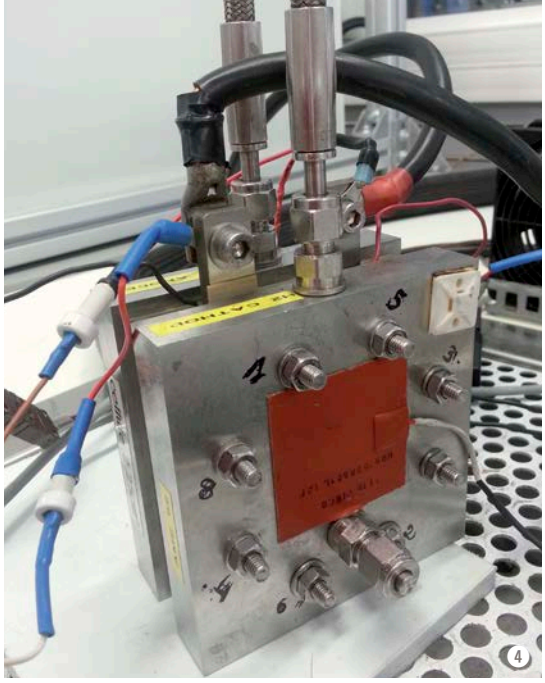


Our power-to-gas research over the past several years has led to breakthrough advances in methanation and advanced electrolysis. In particular, we demonstrated the high-yield and reversibility of our high-temperature electrolyzer in fuel-cell mode.

We now need to investigate the perfect way to combine the two technologies by looking at optimal operating points. We are already doing it at the lab scale, on equipment of just a few kilowatts – still a long way from tomorrow's full-scale plants, which will be in the tens of megawatts.

To reach a scale representative of an actual plant, we will need to build an integrated prototype of at least 100 kW – 1 MW would be ideal – that rolls in both electrolysis and methanation modes. We are working with several industrial partners in France to reach this goal by 2018–2020. In the process, we hope to make a landmark contribution to France's emerging power-to-gas industry.

François Le Naour,
Head of CEA-Liten's Hydrogen and Biofuels Programs



HYDROGEN

REVERSIBILITY OF 25-CELL STACK DEMONSTRATED

A prototype 25-cell high-temperature electrolyzer stack was tested, alternating operation between hydrogen production (SOEC) and fuel-cell (SOFC) modes. In fuel-cell mode, overheating was voluntarily limited to 20°C. A patent is currently being filed for the cooling strategies developed for the hydrogen-powered SOFC. Reversibility opens up promising new possibilities for high-temperature electrolysis, especially as a solution for managing the intermittence of energy from renewable sources.

PEM ELECTROLYZER DEGRADATION MODEL OFFERS NEW INSIGHTS

A multiphysics performance and degradation model of a PEM electrolyzer was developed based on data obtained from experiments on small (25 cm^2) cells. The model confirmed certain hypotheses, provided deeper insights into some mechanisms, and even revealed some new ones – such as the absence of degradation at very low currents. The patented model is already being used to help manage electrolyser parameters (based on aging factors) and for the development of new accelerated aging test protocols. 4

REDUCING THE COST OF SOLID HYDROGEN STORAGE

A PhD research project is looking at whether one way to bring down the cost of solid hydrogen storage could be to reduce the cost of the storage (absorption-desorption) material used. The PhD candidate is developing an intermetallic hydride (titanium-vanadium-iron) that could generate cost savings by starting with less-pure precursors in exchange for a 10% to 20% loss of absorption capacity. The research is focusing on the different impurities and how to neutralize those most detrimental to absorption. 5

HIGH-TEMPERATURE ELECTROLYZER OBTAINS YIELD OF 90%

A major advance toward carbon-free hydrogen production has been achieved. The high-temperature (700°C) electrolyzer developed by the CEA produced hydrogen from water vapor at 150°C and electricity. The heat of the output gases is recovered to preheat the input gases, which explains the 90% yield. The very-compact system can produce from 1 Nm^3/h to 2.5 Nm^3/h of hydrogen depending on the water flow rate and temperature, which can reach up to 800°C. A total of 10 patents were filed in 2014.

Electric and hybrid vehicles

VEHICLES FOR LAND, AIR, AND SEA

We strive to develop innovative electric drivetrains for all types of vehicles. All of the technological advances that come out of our labs meet the highest safety and performance standards – and are designed for the real-world constraints of industrial-scale rollout. Our researchers adopt a holistic approach to the drivetrain, from materials through to the operational demonstrator. They work on lithium-ion batteries and alternative materials (sulphur, sodium-ion, etc), proton exchange membrane fuel cells (PEMFCs), and hybrid solutions combining the two technologies. They also draw on our Nanocharacterization Platform (PFNC) – the only facility of its kind in the world – to observe, understand, and finally optimize materials for maximum performance.

BATTERIES

LFP/G CELLS DELIVER 4% ADDITIONAL CAPACITY AFTER 500 CYCLES

In research conducted with startup Prollion for transportation applications requiring high energy density and lifespans, lithium iron phosphate graphite 50125 cells delivered 4% additional capacity after 500 cycles during testing. The increase in capacity was due to better stability of the passivation film (SEI) on the graphite. Our researchers chose an enhanced type of graphite and adjusted the amount of vinylene carbonate in the electrolyte. 1

LI-ION BATTERY ELECTROLYTE DEGRADATION ANALYSIS IMPROVED

Lise Daniel
Head of the Electrochemical Generator Characterization Laboratory, CEA-Liten

The electrolyte of a Li-ion battery degrades over time, generating gases. Identifying and measuring the gases is one way to understand the degradation mechanisms under operating conditions. This year we worked with the manufacturer of our testing equipment to couple the gaseous-phase chromatography with infrared analysis (GC/IR). These improvements allow us to analyze less samples and individually identify dozens of gases. We can also determine peaks more accurately. It is now possible to correlate modifications to the electrolytes like solvents, salts, or additives to the types of gases generated. These are extremely useful insights in improving electrolyte formulations.
We first used the improved equipment on high-voltage batteries we developed with an industrial partner. We can also use it on other Li-ion systems and fuel cells and to analyze liquids and solids in addition to gases.

TWO FLAGSHIP R&D PROJECTS FOR RENAULT IN LESS THAN A YEAR

Thierry Boudet
Head of the Electronics, Energy, and Power Laboratory, CEA-Liten

We completed two innovation projects for Renault in 2014 – both with very tight deadlines. The first was for a prototype of Renault's Eolab hybrid vehicle, which was showcased at the Paris Auto Show. We designed and manufactured a 90 kg, 6,700 Wh, 99 litre Li-ion battery pack and the electronics for the BMS. The battery pack made a major contribution to the prototype's record-low fuel consumption of just one litre per 100 kilometers. The Eolab can reach speeds of 120 km/h and offers a range of 60 km in all-electric mode.
The second project, which we completed in just eight months, was an isolation fault detector for EV batteries – at around 400 volts. We came up with an economical concept that drastically reduced the amount of cabling while offering measurement accuracy to within 1% at 100 kOhm. We transferred the technology to Renault at the end of 2014 and it is currently being tested and validated.

MOVING TOWARD JELLY BATTERIES

We developed two jellified electrochemical systems – LFP and NMC – for Li-ion and Li-metal batteries. The systems, which were developed in button-cell format, offered performance on par with liquid electrolyte systems. The gels are non-flammable and non-toxic, and potentially easier to implement in flexible batteries or in 3D configurations. A patent is being filed, and the technology, which has garnered interest from several manufacturers, is already being used in two collaborative R&D projects.

2

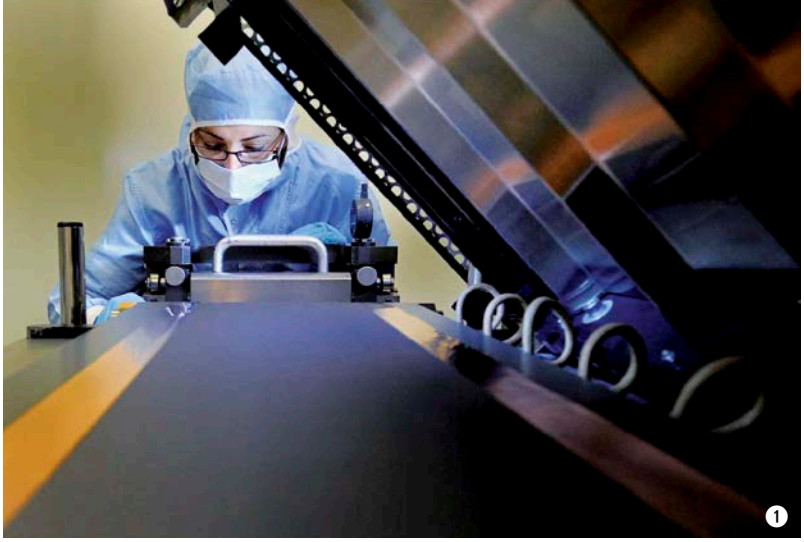
A WORLD-FIRST FOR NA-ION BATTERIES

We developed the world's first sodium-ion batteries in rigid packaging in collaboration with RS2E (storage network for electrochemical energy). The cyclability, specific energy, and charge density measured during electrical testing were promising as compared to Li-ion batteries. And the improvements underway – to the active materials, electrodes, and lighter packaging – are expected to further improve the batteries' performance. Na-ion technology, of interest because it eliminates some of the material availability concerns of Li-ion batteries, is shaping up to be a strong contender. 2

ZERO CO_2 SAILING VESSEL GETS NEW, 100% CEA BATTERY PACK

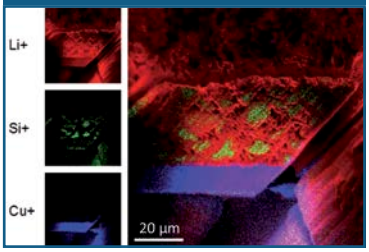
The Zero CO_2 sailing vessel came back to the CEA after logging four years and 3,000 nautical miles on the high seas. The vessel's LFP batteries were replaced with an entirely new battery pack developed by our researchers. The new pack is the same size as the one it replaced, but delivers 19 kWh instead of the old pack's 15 kWh. The battery management system was also hardened and implemented at module level to improve management and safety. The overhauled vessel will be relaunched in the spring of 2015. 3

3



CHARACTERIZATION REVEALS THE SECRETS OF SILICON ANODES

Our researchers combined two spectroscopy techniques – TOF-SIMS and AES – to characterize nanostructured silicon-carbon anodes for Li-ion batteries. They observed the distribution of lithium through the electrode and individually characterized micrometric particles with the goal of gaining a deeper understanding of the stages of the material aging process. Silicon is a contender to replace graphite as an anode material, but presents the disadvantage of expanding to triple its original volume during the lithiation process.



ADVANCES IN THE CYCLABILITY OF SILICON AS AN ANODE MATERIAL

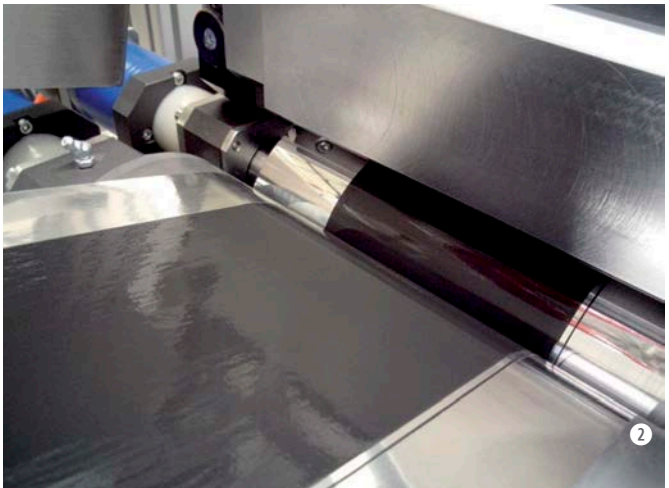
When used in combination with graphene and amorphous carbon, silicon could become a high energy density anode material for Li-ion batteries. But only if the material's expansion during lithiation can be controlled – and progress has been made at both the material (up to 200 cycles) and cell (specific energy of more than 300 Wh/kg) levels. The research is ongoing, with a focus on the materials (patent being filed), formulation, electrolyte, and cell design. 1

SULFUR ELECTRODES READY FOR COATING

Sulfur electrode coating tests were carried out on a semi-industrial test bench using two ink formulations. The process does not present any insurmountable obstacles. The two electrodes completed in testing are 10 meters long, were coated at 7 mg/cm^2, and feature a single-sided part and a double-sided part. They were tested in button-cell batteries. The approach is promising, in that sulphur is cheap, widely available, non-toxic, and has an excellent storage capacity. 2

LI-ION BATTERY RECYCLING: A FOCUS ON CRITICAL METALS

A hydrometallurgical process to selectively extract transition metals (Co, Ni, etc.) from the active electrode materials of Li-ion batteries was developed with SNAM, a company from France's Aveyron region that recycles various types of batteries – from NiCd, alkaline, and saline through to NiMH and Li-ion. The process, which is currently being fine-tuned, should ultimately extract more than 90% of the cobalt and nickel, either together or separately depending on the market prices of the materials. The goal is to get the best possible financial return on the recycling of these metals. 3



FUEL CELLS

FUEL CELL INK PRODUCTION SCALES UP

We produced two 20-litre batches of ink for fuel-cell gas diffusion layers in just a month to fulfil a request from one of our industrial partners. Previously, batch sizes had been under a litre. Our researchers used Li-ion battery ink mixing equipment, making adjustments to two control techniques, one for ink dispersion and the other for rheology. The control techniques are now undergoing reliability testing to ensure that the entire process is reproducible.

NAFION®-BASED MICROPOROUS MEMBRANE BOOSTS YIELD

Our experts formulated a microporous membrane material for PEM fuel cells that uses Nafion® instead of PTFE as a binder. They tested the membrane in 220 cm^2 mono cells. The improvement in performance – around 5% – is very significant. In addition, production yields for several dozen units on a pre-industrial production line were above 90%. Finally, the use of Nafion® eliminates the need for sintering at 350°C. The research is continuing with work to adapt the microporous material for new membranes, this time for automotive PEMFCs. 4

REAL-TIME PEM FUEL-CELL DIAGNOSTIC TOOL VALIDATED

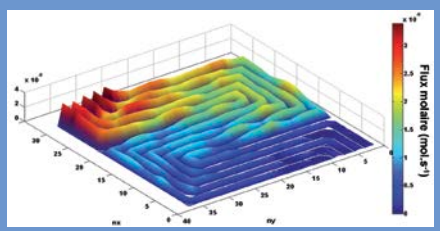
In research conducted in partnership with Leti and List, we used the CEA's Epicea1 system (power: 3 kW) to develop and validate an embedded real-time diagnostic tool for PEM fuel cells. The diagnostic tool uses multiple voltage measurement points to detect, in real time, faults like a loss of pressure or excess moisture in the circuits and fuel-cell temperature anomalies. It will undergo further adaptations and will be reused to design an automated PEM command-control system. 5

PEM FUEL-CELL LIFESPAN: MANUFACTURERS BANK ON MULTISCALE MODELING

Mathias Gerard, Fuel-cell Modeling Expert

Didier Jamet, Head of the Modeling and Monitoring Laboratory, CEA-Liten

We believe that multiscale modeling is the way to better predict PEM fuel-cell lifespans. The approach provides crucial insights into what happens to the catalyst at the particle scale, the electrochemical double layer, the electrode, the cell, and so on, right up to system scale. For a number of years now we have been working on a multiscale modeling method leveraging different models. We are also working with major automotive-industry manufacturers. For example, in 2014 we used results from our multiscale modeling experiments to predict how PEM fuel-cells subjected to different cycles would behave throughout the aging process. We also dimensioned fuel-cell auxiliaries to meet one of our partner's performance requirements. So, it is now clear that multiscale modeling delivers real added value. We are currently engaged in a number of R&D projects – some are EU projects, others are for our industrial partners. One example from 2014 is the PumaMind project, which enabled us to continue to improve upon our model of elementary reactions at the catalyst grain scale.



Energy efficiency

RECOVERING, STORING, AND REDISTRIBUTING ENERGY

Finding solutions for managing the intermittent availability of power generated from renewable sources is critical if they are to be connected to the grid. That's why we are developing systems to store both renewable energies – like PV, wind, and thermal solar – and for use as electricity or heat when it is most needed. These systems can store energy from a few hours up to a few months, depending on the needs of the application. We are also working to make buildings more energy efficient by developing models capable of predicting building energy performance based on building envelope materials used in walls and windows and HVAC systems, for example, and occupant needs and preferences like air quality and temperature. We validate the models we develop at the state-of-the-art INCAS technology platform, a set of life-sized, fully-instrumented low-energy-consumption homes.

BUILDINGS AND HEATING SYSTEMS

1

2

A YEAR-LONG EVALUATION OF INTERSEASONAL HEAT STORAGE

In June 2014 we equipped a 90 m^2 experimental home at the INCAS lab at INES with a 1:1 scale interseasonal heat storage demonstrator. In summer, the six tons of strontium bromide salts in the storage system are left dry; in winter, water vapor is introduced, resulting in an exothermic reaction that produces enough heat for domestic heat and hot water. The demonstrator offers a capacity of 1,590 kWh. The goal is to be able to cover 80% of the energy required for domestic heat and hot water with 18.5 m^2 of standard solar panels. 1

SOLAR COOLING MACHINE GATHERS MOMENTUM

Our researchers successfully cooled a 60 m^2 building at INES for five months by combining the 5 kW version of the Solammor absorption machine with solar collectors. In other solar-cooling news, we are working with Alsolen (an Alcen company) to develop a new machine with 100 kW of cooling power for air-conditioning and refrigeration applications. A patent has been filed for the machine management technology – capable of determining the most efficient operating mode depending on the environmental conditions and adjusting the machines' power within a 30% to 130% range. 2

HYGROTHERMAL PERFORMANCE OF WOOD LINKED TO BUILDING COMFORT

In research conducted under an affiliate program called Hygrobat, we studied the hygrothermal behavior of walls made from wood fiber and solid wood for two years. The walls were set up at INES testing labs. Over short periods of time (72 hours) the distribution of moisture depended mainly on temperature and insulation. Over longer periods (several months), it depended primarily on the humidity of the indoor and outside air. A numerical analysis of these behaviors was completed with the objective of coming up with a more complete description of the phenomena.

COMPUTER MODELS FOR COOLER HOMES IN SUMMER

Our researchers used heat measurements taken in August 2013 and August 2014 to validate individual numerical models for each of the four experimental homes at the INCAS lab for different use scenarios. The models can be used to compare the impact on occupant comfort of different scenarios like open or closed windows or shutters, for example, for different types of building construction materials, insulation, and techniques with more or less inertia, and other variables. The models leverage EnergyPlus software. 3

ADVANCES MADE TOWARD THERMOELECTRIC GENERATOR FOR EXHAUST PIPES

We produced batches of several kilograms of silicide-based thermoelectric materials for a partner developing a thermoelectric generator for vehicle exhaust pipes. The materials were made in the form of functionalized plots and tested under hot gas, where they demonstrated figures of merit well above the state of the art. The silicides developed also have the advantage of being made from cheap, abundant, and non-toxic materials. The technology is currently being transferred to a startup, Hotblock Onboard. 4

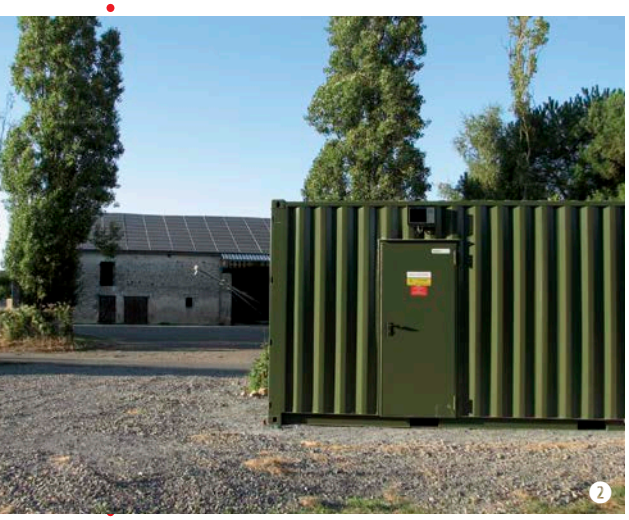
PV-ENABLED WINDOWS THAT LOOK AS GOOD AS THEY WORK

Simon Perraud
R&D Project Manager

We have been working with Crosslux on semi-transparent PV-enabled window glass for commercial buildings since 2012. The PV cells are deposited onto the glass in microstructured thin layers, where they can produce up to 50 W/m^2 of energy. We conducted an analysis of the environment to determine whether the technology is suitable for vertical surfaces in countries with high solar irradiation. And the answer is yes! We also produced 15 cm x 15 cm demonstrators, improved the thin-layer functionalization and encapsulation, and filed new patents, bringing the total to five. The process is versatile enough to create a gradient effect of transparency or a logo on a pane of glass. This will give architects an opportunity to create glass walls that are both useful and attractive. We are now ready to scale the demonstrators up to a square meter and start looking at readying the technology for industrial-scale manufacturing.

POWER GRIDS AND STORAGE

1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STUDYING ELECTRIC VEHICLES' IMPACT ON THE GRID

In research conducted under the GreenLys project, we developed a tool leveraging various models of components to assess the impact of electric vehicle (EV) charging on a grid with and without PV panels. The tool can be used to determine and adjust EV charging management strategies in real time for fleets of up to 100 electric vehicles. For predictive strategies, the tool can handle fleets of up to 1,000 electric vehicles. A demonstrator at the CEA Grenoble campus is monitoring the campus' four EV charging stations, which have a total of 30 charging terminals. The research resulted in two patent applications and six published articles. 1

SMART-GRID TECHNOLOGY: LI-ION STORAGE COULD HELP REGULATE LOCAL GRIDS

Research and development conducted under the IPERD project is looking at how a Li-ion storage system (60 kVA, 150 kWh) could help regulate voltage, promote the use of local PV energy, and reduce loads during peak demand periods. Liten and its project partners (grid operator SRD and Séché-environnement) developed the management software and implemented the Li-ion system on a neighborhood grid (powered by a 120 kWp PV plant and serving 27 delivery points) in the Poitou-Charentes region of France, and validated the solution. 2

SPIDER SOFTWARE HELPS RIGHT-SIZE ENERGY SYSTEMS

Our Spider software, released in 2014, uses physical modeling of system components like renewable and conventional energy sources, storage, and consumption points to right-size all types of energy systems. The software takes into account both technical and financial data. The system architecture and time intervals can be adjusted as needed. The software is of particular interest to energy-technology developers and systems integrators.

HIGH-POWER STATIONARY STORAGE ON THE PRISMES EXPERIMENTAL MICROGRID

Olivier Wiss
Head of the Smartgrid Platform at INES

High-power stationary electrochemical storage units are starting to crop up on island grids where they are used to offset instability due to renewable energy sources like wind and PV. However, we had not been using this type of storage on our Prismes experimental microgrid – used for characterization, modelling, and functional testing – until 2014, when we hooked Prismes up to the Colosse platform. Colosse can contain up to three stationary storage systems with maximum power of 150 kVA. It is connected to the Prismes grid and the equipment on the grid, which includes a mixed electric-solar charging station, instrumented homes, and a rooftop PV power plant. These storage capabilities give us the flexibility to configure the experimental grid into "neighborhoods." They can be connected and disconnected to the main grid and resynchronized as needed. This lets us reproduce a complete mini-power-plant and work on different microgrid strategies, the key to integrating production into the grid.

Startup news

ISORG RAISES €7.9 MILLION

Isorg, which specializes in optical sensors leveraging organic electronics, attracted €7.9 million in fresh capital in late 2014 in its first round of fundraising. Dynalym, a regional investment fund based in France's Limousin region, where the company has elected to build its first plant, joined the existing consortium of Isorg investors: BPIfrance, CEA Investissement, and Sofimac Partners. Construction on the new plant has already begun in Limoges. Slated for delivery in 2016, the new facility will offer 3,000 m^2 of cleanroom and office space; production will start in 2017. Isorg is pursuing its R&D contract for large-surface image sensors on glass and plastic with the CEA for a leading X-ray imaging equipment manufacturer.
In other news, Isorg is also developing a million-pixel plastic image sensor and innovative connected systems for automated inventory management.

STEADYSUN INTRODUCES NOVEL FORECASTING SERVICE

Steadysun, which specializes in solar power forecasting, is the first company on the market to offer a comprehensive forecasting solution integrating hardware plus software. The company's Sky Imager SW02 camera, released in 2014, takes fish-eye images that are then processed to predict fluctuations in PV production over the very short term (several minutes). Weighing in at just 3 kg, the camera is easy to set up and can withstand 200 temperature cycles (–40 °C to 85 °C). Even better, the forecasts generated are impressively accurate. The error rate has been reduced by a factor of three to four for a ten-minute forecast.
Steadysun also raised €500,000 in capital to finance the next stages of its development plans. The company has won new customers in France, Switzerland, Spain, and Germany and has opened a new sales office in Stuttgart.

PROLLION BRINGS HOME A MAJOR WIN

Custom lithium-ion battery system specialist PROLLiON and Liten have signed a major multi-year contract with a leading defence-industry player. This is just the latest in a series of wins for the startup, which reported a record year in 2014 with a 60% growth in revenue, as well as increasing its headcount with ten new members of staff.
The company also completed its development contract with Swiss luxury watch manufacturer Breitling, and subsequently obtained international certification for its EnerSi 250 rechargeable battery, now found in Breitling's Emergency II line of watches featuring emergency distress beacons. Mass-production of the EnerSi 250 is now underway.
Finally, PROLLiON delivered an 18 kWh battery system for construction vehicles as well as a system for undersea applications.

Technology Platforms

NANOCHARACTERIZATION PLATFORM

The nanocharacterization platform (PFNC) studies the morphology and physical and chemical properties of nanomaterials and components—insights crucial to conducting nano-scale* research and development. The platform's advanced nanocharacterization resources are unique in the world, with equipment capable of generating 2D and 3D images of matter at close to the atomic scale. The platform also works with the ESRF and ILL to obtain even higher-resolution images. The platform supports CEA research programs, develops new analysis techniques, and works with around 20 scientific equipment and other manufacturers.

*1 nanometer = 1 billionth of a meter

FUEL CELL PLATFORM

The fuel-cell platform aims to improve fuel-cell performance and lifespan and decrease production costs. The platform's integrated approach covers materials, membrane-electrode assemblies, stacks, and testing in real-world conditions. The platform's resources include test benches and some of the most advanced equipment anywhere. Its R&D work, which targets transportation and stationary applications, is at the international state of the art. The platform has around ten industrial partners, including Symbio FCell.

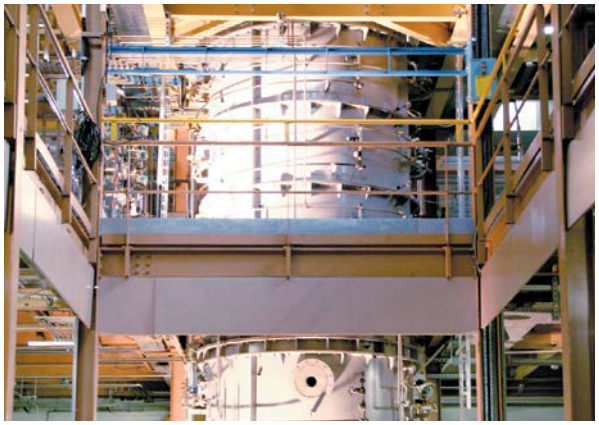
BATTERY PLATFORM

The battery platform's R&D focuses on lithium-ion battery development and small-run production, from materials synthesis through to integration. The goal is to develop end-to-end production systems for applications ranging from hearing aids to electric-powered buses, with the broader objectives of cutting costs, increasing battery life, and improving reliability. Whether it is in terms of size or equipment, the platform, available for use by manufacturers, is unique in Europe.

ELECTRIC MOBILITY PLATFORM

The electric mobility platform integrates battery and fuel-cell prototypes developed by the CEA into land, air, and marine vehicles and vessels, and tests them in real-world conditions. The platform boasts equipment ranging from assembly shops and test benches to charging stations and monitoring and analysis software. Tests, carried out on the open road/water or at closed facilities, provide valuable feedback on cycling, ageing, and other factors while facilitating market penetration for the ten or so participating battery, fuel-cell, and traditional and electric vehicle manufacturers.

BIOMASS PLATFORM



France's only biomass research facility of its kind, the biomass platform focuses on the grinding, torrefaction, and gasification of biomass from wood and farm and forest by-products. Potential energy sources studied at the platform include household waste, paper and pulp by-products, wastewater treatment sludge, and micro-algae. R&D at the platform focuses on the analysis and modeling of physical phenomena; experimentation at the lab and demonstrator scales; process evaluation; and demonstrator development—with the goal of devising economically-viable solutions by 2020. The platform works with around fifteen industrial partners.

PHOTOVOLTAIC SOLAR PLATFORM

The photovoltaic solar platform contributes actively to building France's solar industry. R&D at the platform, conducted in association with a large number of industrial partners, focuses on PV materials, processes, and equipment. The platform's signature asset is its Hetero-junction LabFab, a pre-industrial production line capable of producing PV cells with yields in excess of 20%. The platform also helps France-based solar-energy SMEs grow their export sales and build turnkey PV solar plants.

HYDROGEN PRODUCTION AND STORAGE PLATFORM

The hydrogen production and storage platform develops hydrogen production, conversion, and storage processes for energy applications. It is one of the world's leading high-temperature electrolysis and SOFC patent-filers. The platform tests demonstrators of significant size – such as solid-hydrogen storage tanks with a capacity of 15 kg, the only ones of their kind in the world – with partner McPhy Energy. The platform's research also focuses on applying these hydrogen processes to other gases like carbon dioxide, natural gas, and biogas.

SMART-GRID SYSTEMS PLATFORM

The smart-grid systems platform looks at how to scale, operate, and optimize energy systems connected to intermittent power sources and electricity storage systems at the scale of an individual home, building, or neighborhood. The platform possesses a range of resources – both real and virtual – to test various configurations, manage individual system components, determine operating strategies, and optimize profits. R&D at the platform is carried out with around fifteen industrial partners.

Technology Platforms

THERMAL TECHNOLOGIES PLATFORM

Researchers at the thermal technologies platform work on concentrated solar power (CSP), thermal storage, and thermal systems for industry. The platform helps industrial partners deepen their understanding of thermal technologies, optimize their use, and develop new products. The platform possesses a full range of equipment including test loops, exchangers, solar-power systems, and rock-bed or phase-change-material thermal storage systems, used to build demonstrators and carry out testing.

LARGE-SURFACE PRINTING PLATFORM

The PICTIC large-surface printing platform develops formulations for electronic inks and scales up printing processes for industrial rollout. Its novel printing technologies are used to give large (320 mm x 380 mm), flexible surfaces electronic functions like pressure or temperature sensing, signal conversion, and display capabilities. The platform's advanced printing and characterization equipment and innovative processes make it unique in Europe. It works with several manufacturers worldwide, including France-based Isorg.

POWDER METALLURGY PLATFORM

The powder metallurgy platform develops magnets and other high-added-value metal and ceramic components characterized by their complex shapes, lightweight structures, special physical properties, or multi-material assemblies. The platform is the only R&D center in Europe to possess a complete range of semi-industrial and industrial equipment. It is capable of running an entire production process, from blending powders to manufacturing final components. The platform works with a variety of manufacturing companies. The components developed have applications in the connector, lighting, power electronics, healthcare, fine chemicals, and energy markets.

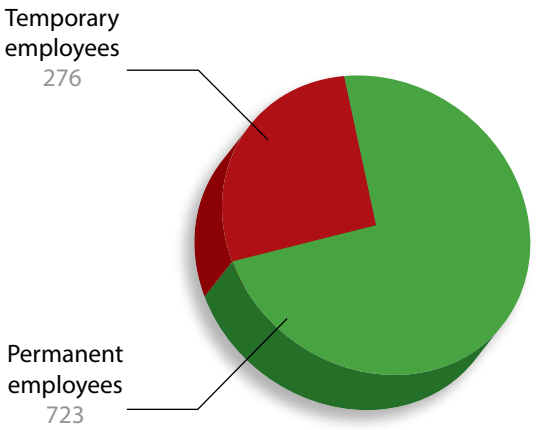
MICRO-ENERGY-SOURCE PLATFORM

The micro-energy-source platform develops micro-fuel-cells and thermoelectric systems to power smart cards, sensors, laptop computers, and other mobile devices. The platform leverages a full range of pre-industrial equipment. Its R&D activities focus on innovative materials using a variety of physical and chemical vapor deposition processes. It works with a slate of industrial partners including Bic** and HotBlock OnBoard, a CEA spin-off.

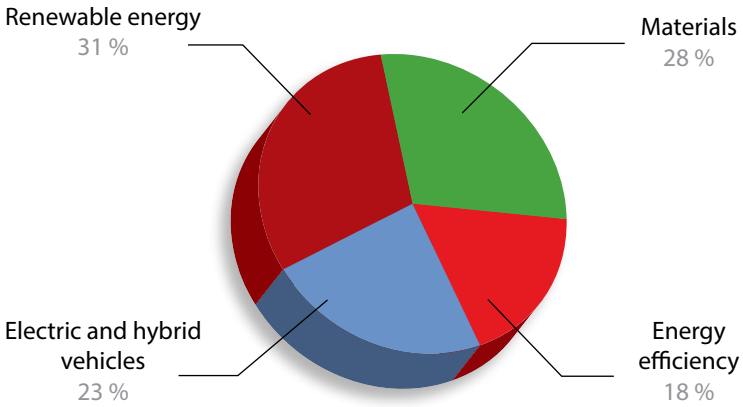
**Bic sold its micro-energy-source business to Intelligent Energy in early 2015

Key figures

Total staff

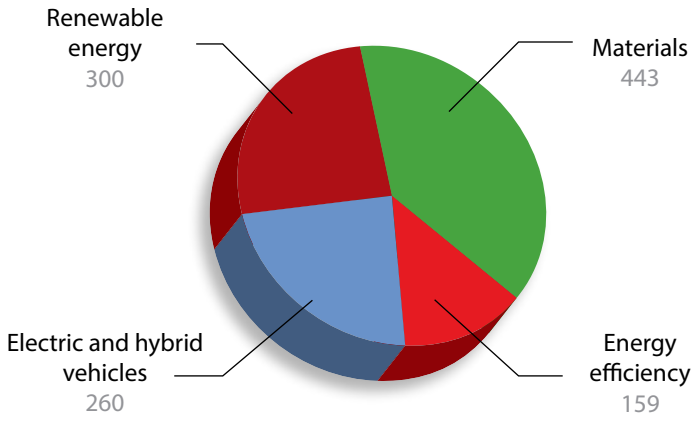


R&D staff by program



Breakdown of intellectual property

a total of 1162 patents in portfolio as of end-2014



Budget

Operating budget : €155 million

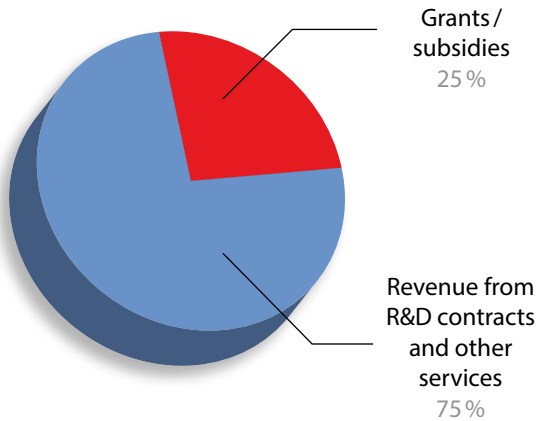


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PHOTO CREDITS

D. Guillaudin, P. Avavian, D. Meunier, J.M. Francillon, utopikphoto, CEA Grenoble, L.Godart/CEA-Leti, P.Y Thoulon/Crosslux