AGENCE NATIONALE DE LA RECHERCHE

Presentation of funded projects in 2008 for Smart Buildings and Solar Photovoltaic Programme

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	AMMIS - Multicriteria analysis and inversion techniques with energy simulation for building
Abstract	This project is the creation of calculus model, which will be able to determine the performance needs of a building (enveloppe, inertia…) using sketch, comfort will and maximal heating needs. This method will be inclued in a software for architects in order to facilitate the power problematic in the earliest stages of conception. The strenght of the project is to use the existant inverse methods to offer a new approch on decision aid for architects and project manager. We use the comfort will and maximal heating needs to deduct the good construction parameters. In the first time, the work will be the construction of the inversion calculus model. Mathematicaly. it will be an infinity of solution, but physic, regulations and technology allow to find borders for building designing. This inverse method will be able to evaluate the liberty space for the architects in order to design a low consuming building. The method will be constructed on a simple case, with just one thermal zone. Secondly, the methode will allow to use different thermal zone to refine the design. The other question will be to give solutions to choose easyly between different building habits to have the wanted performance. An optimisation on cost will be a solution. The details level will be fixed with the selected criteria and accuracy needs.
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ANR funding	497 712 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-001

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	ASYSCOL - Systemic approach of dye cells with ZnO based material

Abstract

The goal of the project is to demonstrate that dye sensitized solar cells (DSSC) constitute a promising and realistic solution for several applications (either nomadic or building-integrated applications). Indeed, the development and the fabrication of solar cells at low cost, low thermal budget, on solid or flexible substrates, exhibiting a possible semi-transparency (to the detriment of efficiency) with an efficiency target of 7% with a liquid electrolyte and 5% with a solid electrolyte would open tremendous scientific, environmental and economical perspectives. For this purpose, and also for addressing the issue of dye cell lifetime, the most promising solution consists of performing a systemic study using a synergistic network of laboratories which represent most of the state of the art in France.
A DSSC consists of several components which all play a fundamental role: the conductive and transparent front electrode, the nano-structured semiconductor of large band gap (generally TiO2 or ZnO), the dye and finally the solid or liquid electrolyte or the hole

transporting materail (used to regenerate the dye). The efficiency of the cell corresponds to the cumulative efficiency, in series, of the individual components. Therefore, focusing on only one of these components would hardly optimize the global cell efficiency. Meanwhile, working on the components as a whole is, for all practical purposes, out of reach of a single laboratory. Therefore a strong and efficient partnership between different actors appears to be the only solution for the proposed task.
The idea of the ASYSCOL project is to address in parallel the limiting points of a dye-sensitized solar cell with innovative approaches. The semiconductor will be essentially the nanostructured zinc oxide prepared in order to provide a very high surface area (allowing the adsorbed dye at its surface to absorb incident photons more efficiently), with non-interrupted electron paths

(to enable the transport of the electrons injected by the dye up to the anode) and an opened internal surface (to allow for an easy penetration of the hole transporting material inside the pores). A dye cell solely composed of nanoparticles can fulfil the first condition, but hardly the others. An original and promising strategy consists in exploiting the different ways to elaborate the ZnO-based material: by growing branched nanowires, by forming nano-porous ZnO or by elaborating a composite with both nanowires and nanoparticles of the same material. Regarding the latter method, the first results, very recently published, are highly encouraging. Such an approach requires a detailed investigation of the elaboration of the material as well as its physical and structural characterisations.
The interaction with the other components (electrode, dye and electrolyte or hole transporting material) will also be studied with great attention. The choice of the dye and its regenerating partner (redox electrolyte or hole transporting polymer) should also deserve thorough reflection. New dyes will be prepared and special attention will be paid to sensitizers exhibiting high molar absorptivity

and large electron injection quantum yield. Replacing the liquid electrolyte, which at the moment is the most important technological challenge of dye-sensitized solar cells, constitutes one of the main scientific and technological goal of the present project ASYSCOL. Several alternative solutions will be tested in parallel, such as dry polymers, a gel polymers and hole transporting polymers chemically bounded to the sensitizers. Some prototypes of dye cells will be fabricated. Their photovoltaic characteristics will help in choosing the optimal implementation of the different constituents of the dye cell. Finally, investigations will be conducted on the mechanisms that govern the degradation of the photovoltaic properties over time.

Partners

Grenoble INP - LMGP (coordinator)
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ANR funding

854 359 €

Start- duration

December 2008 - 48 months

Contract

ANR-08-HABISOL-002

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	BATIMETRE - Methodology for measurement of BBC building energy efficiency
Abstract	This project proposes to develop a methodology to measure and monitor the energy performance of the building throughout its life. This methodology will lead to understand and analyze the gaps that might occur compared to the initial design. This method of the energy performance determination of the building will be based on the measuring outcome of some sensors and use in real-time of simplified simulation software. The performance evaluated in real time would be compared to the simulation and the gaps would be detected. For each building, we will have an "energy counter" like a car speed meter. The only difference is that the "limit permitted" will fluctuate depending on weather conditions. This project will be divided into 5 tasks taking place practically in parallel throughout the project: - Development of the methodology - Implementation and verification on experimental buildings - Development of an innovative temperature measuring methodology through the use of optic fibre - Implementation of the methodology on buildings in vivo - Management and data fusion. This upstream research project must lead to supply scientific knowledge and provide assessment and diagnosis methods in the field of energy measurement of building throughout its existence.
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ANR funding	707 691 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-003

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	INFIME - Back surface optimisation for ultrathin silicon solar cell: efficiency improvement and module encapsulation

Abstract

The photovoltaic industry (PV) exhibits a high growth rate since 1995 (30 to 50 %/year). The silicon used for the production originally comes from the microelectronics of-spec material and wastes, but since 2005 the PV needs more silicon than the microelectronic industry. Nowadays, many research and industrial programs are involved in the increase of the silicon production capacities. Due to the lack of material, the cost share of the silicon in solar cell manufacturing has increased to reach 50% of the final price. It appears thus of great importance to decrease the quantity of silicon used in one solar cell, to reduce the price of solar electricity. In this purpose the silicon wafer thickness for solar cell has been reduced along the years from 350 µm to 220 µm at an industrial level. Recent studies show that a further decrease of the thickness from 220 to 120 µm could lead to a 17%-saving on the final cost of the PV module, providing the solar cell efficiency is kept constant.

Nevertheless, a problem occurs when reducing the solar cell thickness. With the actual technology the rear side of the cell is covered with screen-printing aluminum. This layer diffuses and alloys itself with silicon during a high temperature step, to create P+ doped layer on the back side. This leads to the formation of an electrical back surface field (BSF), which repels the minority carriers, and thus limits photogenerated-carriers recombination. But this aluminum-based process is not suitable for thin-wafer cell, due to two reasons. Firstly, the allied Al/Si layer generates mechanical constraints within the wafer, that can lead to the rupture of the thin wafer. Then, the quality of the surface passivation obtained with Al-BSF is unsatisfactory. The rear surface passivation is indeed of greater importance when the thickness of the wafer decreases, since more carriers will be generated near the backside of the cell.

The objective of the project is thus to develop a process suitable for the rear-side design of thin silicon wafers solar cells. Three different structures of solar cell are to be evaluated in the project. The solution has to limit the mechanical constraints to prevent the wafer from breaking down, and has to lead to an efficient surface (and volume) passivation. The integration of the cell into PV module has to be taken into account, in particular on the perspective of solar cells metallic interconnection for current collection. The optimization of thin wafer cell should lead at term to a cost saving regarding the decrease of silicon consumption for the same power output.

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ANR funding	872 982 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-004

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	PACAir+PV - Heat Pump System + Building Integrated Photovoltaic Collector

Abstract

The number of buildings equipped with Heat Pump Systems and Photovoltaic Systems is increasing. But the design of these systems is not completely optimal, because the interaction between both systems are not considered. The maximal electrical efficiency of photovoltaic collectors is about 20 %, meaning 80 % of the incident solar energy is transformed into heat, and this heat can be used by the Heat Pump. Moreover, the efficiency of many photovoltaic modules increases if the temperatures decreases, and the Heat Pump could be used to refresh these modules.

The aim of this project is to study, both in an experimental and theoretical way, a technological innovation which consists in :
- recovering the heat produced by the PV collector to increase the temperature of the low temperature source, and therefore to improve the Coefficient of Performance, and possibly avoid the freezing of the evaporator,
- using the fresh air coming from the evaporator to improve the electrical efficiency of the photovoltaic collector
- controlling the air flows according to external conditions and the thermal needs of the building
- optimizing the choice of the photovoltaic modules and the type of the heat pump to lower the global environmental impact of the system

The partnership consists of two research organizations (ARMINES and INES), a company (CIAT), and a consultant (CYTHELIA). The association of experts in photovoltaic and heat pump systems is relevant regarding the objectives concerning the global optimization and the energy needs of the building.
The project will consists in selecting one kind of system among a preliminary set of different configurations. An experimental setup will be designed and produced, and a model will be developed and implemented in a building simulation tool. The experimental setup will be tested and characterized, and then installed in a low energy building. The analysis of experimental results and othe results given by simulated case studies will generate precious information about the potential of the concept.

Partners

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ANR funding

455 164 €

Start- duration

December 2008 - 36 months

Contract

ANR-08-HABISOL-005

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	Performance BIPV
Abstract	This project is dedicated to identify the best practise for BIPV electrical yield prediction. This work is based physical model, RD mok-up and full scale BIPV installation. Accuracy will be quantified as a function of approach deepness : individual component characterisation or not, meteorological data input, more or less detailled physical interaction with building envelop (mainly thermal interaction), more or less detailled BOS component model . Long term ageing is not covered by this work.
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ANR funding	735 124 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-006

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	QUAD - BBC - Indoor air quality and ventilation systems in low energy buildings

Abstract

Ventilation in Low-Energy Buildings shall be considered through specific considerations, in order to assume both low consumption and good indoor air quality.
Design of these buildings is based on insulation, thermal inertia, low air permeability, and therefore has an influence on the design of ventilation systems. In fact ventilation systems should assume the whole air renewal for good air indoor quality, since there's quite no air flow through leakage and opening the windows is not recommended considering heating strategy. In the other hand the energy consumption of the system shall be reduced.

The QUAD-BBC Project intends to determine the minimum level of air flow to have good indoor air quality in low energy buildings, and what is the strategy of regulation of those flows to ensure in the same time low energy consumption.
Nowadays in France, ventilation systems are designed regarding permanent minimum air flows. The project will propose a performance requirement approach (good indoor air quality), to analyse new innovative systems and their strategy of regulation.
State of the art of new innovative systems, of health risks in low energy buildings, of indoor air quality indicators, and the analyse of standards and regulations is the first step of this new approach. The objectives of this phase is to propose indoor air quality indicators and health level for air pollutants concentrations.

After that, for 6 typical rooms, and different ventilation systems, calculations will determine ventilation efficiency (air renewal + pollutant elimination), and energy consumption. The result should be a proposal of referent systems which ensure both air quality and low energy consumption, and equivalent principles in order to qualify other systems regarding those references.
Finally a list of referent ventilation systems for each type of room, and innovative systems who answer to minimum same value of indoor air quality and energy consumption will be establish for low energy buildings.

Partners

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ANR funding

291 872 €

Start- duration

December 2008 - 30 months

Contract

ANR-08-HABISOL-007

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	REPLIIC - Innovative multifuntionnal wallboard system coupling isolation and heating capability for energy efficient and confortable renovated buildings

Abstract

Energy performance of existing buildings is one of the challenges identified by the Group 1 of the French "Grenelle de l'Environment" working meeting. The target of existing building energy consumption, 80 kWh/m².year, has been defined for retrofitting operations. Moreover, a national regulation for existing buildings will be applied very soon in France.
Today, there is no industrial product adapted to building retrofitting for insulating the wall with the following characteristics: efficient insulation layer in contact with the wall, with and heating capability, and optionally cooling capability, with a plaster material containing a phase change material, with 2 different temperature of phase change, and a protecting and decorative layer.
This industrial R&D project aims at studying, developing and optimising a novel wallboard device, which is an assembly of a plaster containing MCP and a radiating emitter of heat and cold.

This novel device industrialization and commercialization are planned in the coming years to satisfy the building retrofitting market demand. In order to fulfil the objectives, the first actions to be performed are:
• The market target specifications and the product technical specifications,
• The feasibility study of the material assembly and of the active air gap. A first validation mock-up will be built and to test the natural air convection effectiveness,
Then, numeric modelling works will be performed to optimize the device components and the coupling with the building environment.
A Computational Fluid Dynamics modelling of the air gap will be made, with the objective to generate a simplified model (type) for the TRNSYS simulation tool.

Consequently, it will be possible to evaluate the annual performances of a building or an apartment after a retrofitting operated with the novel device. An optimization study will be then performed with the energy consumption and the internal comfort indicators (PMV, PPD) as criteria of choice of the device control strategy. The simulation results will be also used to validate the technical and the economical feasibility of the novel device.
Finally, a prototype of the novel device will we studied and build to be tested in a PASSYS test cell at the French Solar Energy Institute INES. The components will be studied and purchased to equip on PASSYS cell with the adapted instrumentation and energetic equipment (heat, cooling and venting). Another PASSYS cell will be equipped with a referential technology "insulating + gypsum" with a standard heating / cooling device and monitored as well.

The test campaign will last 12 months respecting a specific test protocol. The test will have to check the positive impact of the innovative device and to validate the developed numerical models: CFD model for the air gap, and simplified TRNSYS component.

The performances of this novel wallboard device will be evaluated for the potential of energy consumption and greenhouse gas emission reduction. The level of comfort will be quantified thanks to the PMV and PPD indicator. The optimization of the device will be made by accommodating energy consumption and energy consumption in comparison with the referential technology (insulation + gypsum).

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ANR funding 532 504 €

Start- duration December 2008 - 36 months

Contract ANR-08-HABISOL-008

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	RTUSolarCrucible - Ready To Use Crucible for the crystallization of Multicrystallized Silicon ingots

Abstract

An important challenge over the coming year is to reduce the cost of solar energy in order to make it competitive against the fossil energy. The main part of the solar cells are manufactured from wafers cut from Multi crystalline silicon Ingot.
Multicrystalline silicon is solidified in silica crucibles coated with silicon nitride. The aims of the coating are to prevent a chemical reaction between the silica crucible and the silicon, which may cause cracking of the solidified ingot and also crucible failure, and to reduce the diffusion of impurities from the crucible into the silicon. The crucibles are fired before use to remove organic compounds in the coating. The coating will then become brittle and easily cracks when the surface is scratched, making the charging of the crucibles difficult and impossible to automatize. Most of the ingot producers are doing this operation internally and are facing significant rejects due to damage or adhesion loss of the coating .
So crucible and coating technologies have a significant impact on cell cost and consequently on PV energy cost .

Producer are looking for a more reliable solution which will require a more mechanically resistant coating surface without affecting the photovoltaic properties of the ingot.
Consequently an innovative Ready To Use crucible solution with a hard coating couldbe very benificial to this industry if it is proved to be reliable and performing well in term of :
- Releasing properties
- Reliability
- Durability
- Minimum contamination

The main stake of the proposed study is to demonstrate within one year that a suitable solution of a RTU crucible can be proved to work on a laboratory scale.
If this first step is successful the solution could be further developed on an industrial scale with an ingot producer .

The main stake of the proposed study is to demonstrate within one year time that a suitable solution of a RTU crucible can be proved to work on a pilot scale .
This project is an industrial research project that gather the know how and competencies' of :
An industry leader for crucible production Vesuvius
A Norwegian University laboratory expert in Silicon Crystallization (NTNU)
A French cell manufacturing expert institute (INES).
Purpose is to contribute to the automation and improve cell performance of this industry
The first year of this Research collaboration is supported by the French Norway foundation that offers to support half of the Norwegian research cost.

If successfull, this project could require a second year for industrial validation that is not described in the present application.

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ANR funding	106 585 €
Start- duration	December 2008 - 24 months
Contract	ANR-08-HABISOL-009

Year 2008

Title	SiFlex - Photovoltaic silicon cells on flexible substrate
Abstract	The objective of this project is to develop photovoltaic cells based on silicon nanowires, for use on flexible substrates. The nanowires will be grown by the VLS peocess (Vapor, Liquid, Solid). The growth of nanowires will be first developped on single crystal silcion wafers, in order to determine the conditions allowing to form a high density of nanowires, with controlled dimensions, and next, it will be developped on metallic substrates. A thin silicon film will be deposited on the metallic substate, which allows to increase the collect of photons, and to simplify the cell technology. The cell technology will use an heterojunction, with an emitter done with deposited amorphous silicon, and a transparent conductive oxide for electrical conduction. The nanowire cells have the potentiel to reach 12% efficiency, similar to those obtained with the CIGS technology on flexible substrates, without using rare and expensive materials (indium and selenium).
Partners	CEA/LITEN (coordinator) SUPELEC - LGEP CNRS - LPICM PV alliance
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ANR funding	1 024 106 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-010

Year 2008

Title	SIMINTHEC - Simulation and coupled software tools for thermal and electrical energy management in buildings

Abstract

The progress of simulation in each fields involved in design of buildings (thermic, electricity, ligthning, acoustic, control) were very important during the last years and are at the origin of very efficient software in the field they address. Environnements like TRNSYS, EnergyPlus have achieved a remarkable progress models developpement that it sounds very difficult to develop them again in new environments starting from scratch. That is why the goal of this project is to develop solution so that these software can inter-operate with their equivalent software in the area of thermal energy, electricity and control.

Two solutions for inter-operability will be explored:
• An approach by exchange of standardized files. In this perspective, we will more particularly explore the Modelica standard. By this way, we will explore the question of inter-operability in terms of exchange of models by standardized files.
• An approach by exchange of standardized software components: black boxes that can contain data and solving algorithms for simulating a component or a system. By this way, we will explore the question of inter-operability thanks to simulator that are able to connect to each others fo making co-simulations.

The experience of the partners in thermal simulation (model generation of reduction) and controls (dynamic) allows the definition of new control strategies and anticipating management.These approaches will be validated on real platforms: the INCAS platform implemented at INES - Chambery and a positive energy building implemented at Grenoble.

Partners

CNRS - LOCIE (coordinator)
CNRS - TREFLE
ARMINES-CEP-Paris
Grenoble INP - G2ELab
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ANR funding

865 656 €

Start- duration

December 2008 - 36 months

Contract

ANR-08-HABISOL-011

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	Si-X - Characterisation and understanding of the crystallisation of photovoltaic Silicon: X-ray synchrotron imaging

Abstract

Photovoltaic (PV) cells will become an essential element of ecologic buildings of the future. In this respect, an important issue is that the integration of PV sources in buildings takes place as the Si-PV market suffers strong evolutions. As a matter of fact, the growth of the Si-PV market is currently limited by the availability at a reasonable cost of a solar grade silicon source. In order to solve this problem, a number of teams across the world work on alternatives to the distillation process used by the microelectronics industry for the purification of metallurgical grade silicon, which is a cheap and abundant source. Such a source material should be considered as new for the purposes of ingot and cell elaboration.

As a consequence, a number of issues linked to the solidification of these materials will have to be carefully considered again even for processes well-established when using materials coming from the microelectronics industry. Such is the case of the crystalline structure of the ingots. In multi-crystalline silicon, which presently constitutes the main proportion of silicon used for the fabrication of PV cells, the PV properties are totally different as a function of the grains structure obtained after the elaboration process. The question is especially acute for the process developed by the company EMIX, which is based on an original technique for the growth of ingots using continuous pulling in a cold crucible.

This process presents several advantages in particular concerning the productivity but, the unavoidable existence of strong radial temperature gradients leads to a fine grained solidification structure with a high density of extended defects. As a consequence, it is essential to control the grain structure obtained for the different silicon grades used for the fabrication of PV cells. In this frame, the objective of Si-X project is to deepen significantly the understanding of the dynamical mechanisms present during the formation of the crystalline structure of multi-crystalline PV silicon. With this objective, we propose an experimental validation including various scale experiments with innovative characterisation methods coupled with 3D simulations of the processes and associated structures.

In particular, we will develop a unique device using X-ray imaging system for X-ray radiography (dynamics, growth kinetics and nucleation) and X-ray topography (crystallographic orientation, strains) to characterise in situ and in real time silicon solidification. Other experiments in the project are going from wafer moulding to industrial ingots solidification and will allow linking the experiments using X-rays which are limited to small dimensions to the industrial process. Si-X project also comprises a thorough study of the link between the crystallographic structure and the PV properties. At the end of this project, benchmark data concerning the formation and development of the grain structure in multi-crystalline Si will be available as well as a 3D simulation model of these structures. The ultimate objective is to control the solidification process in order to obtain more performing materials from the PV point of view and to reduce the production costs.

Partners	CNRS - IM2NP (coordinator) CEA/LITEN/Ines GRENOBLE INP - SIMAP ARMINES EMIX ESRF SINTEF
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ANR funding	1 070 042 €
Start- duration	December 2008 - 48 months
Contract	ANR-08-HABISOL-012

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	Solhypin - P-I-N transparent high lifetime hybrid solar cells

Abstract

Organic solar cells, and particularly those made from polymer, constitute an emerging technology which is extremely attractive due to the ease of process provided by organics and offers large possibility of integration due to its intrinsic light- weight and flexibility. Nevertheless their main drawback is due to a considerably reduced lifetime compared to their inorganic counterparts. This is without any doubt their Achille heal toward any industrial production targeting more demanding application than short term, mobile or indoor ones. Electrode materials and organic-electrode interfaces are particularly sensitive to degradation and are the main cause to the observed fast ageing. The project Solhypin proposes a very innovative way in order to completely modify the internal structure of polymer cells which allows the substitution of the more fragile parts. In fact, insertion of semiconducting transparent metallic oxides in both sides of the organic photoactive layer leads to a P-I-N structure, which has not been developed yet for polymeric cells,

In such a structure, the organic-metal interfaces do not exist anymore and are substituted by more organic-semiconductor and semiconductor-metal interfaces. Beyond the expected improvement of lifetime, the insertion of nanometer thin layers of inorganic wide bandgap semiconductors offers the opportunity to develop transparent devices, with large possibility of integration in window applications. The aim of this project is to develop a new architecture with improved intrinsic stability compared to the classical M-I-M structure, and not to develop new active materials with promising properties. Then, standard organic materials P3HT and PCBM, which are fairly stable, will be used. Solhypin will focus on the preparation of semiconducting oxides which are n or p doped, and their deposition process under conditions which are fully compatible with the presence of organics in the structure and also with the absolute necessity to maintain the production cost as low as possible.

Two different deposition techniques will be explored in order to find for every layer the best way to produce the material of highest quality (at the more reasonable cost). A wet process based on sol-gel chemistry which will be adapted for ink-jet printing and more traditional, less challenging vapour deposition techniques which will be adapted to satisfy the requirement of mild conditions. Then, the right deposition technique will be used at the right place in the elaboration process of the multilayer P-I-N structure. The objective of Solhypin is to produce P-I-N modules of 100 cm² active area which demonstrates a degradation less than 20% over 5000 hours under continuous illumination (STC conditions), starting with a power conversion efficiency as high as 3.5%.

Partners

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ANR funding

1 010 430 €

Start- duration

December 2008 - 36 months

Contract

ANR-08-HABISOL-013

Title	SPIR-Wind - Stable polymer photovoltaic devices with infra-red photon harvesting capacity: toward photovoltaic windows applications.

Abstract

Polymer based photovoltaic (PV) devices have seen their performances increase continuously over the last decade. With power conversion efficiencies reaching those of amorphous silicon devices, low temperature high through-put and therefore low-cost production processes, together with an expected small module weight, possible device semi-transparency and flexibility, polymer photovoltaics do have already a strong potential for applications in large-scale renewable energy production. However, several important technological issues need still to be addressed and leave significant room for improvements. In particular, device stability has to be enhanced in order to meet the prerequisites for commercialization and the mismatch between the photon absorption and the solar spectrum can be reduced, opening a route towards still higher efficiencies.

Preliminary device degradation can originate either from chemical degradation of the molecular components, electrode failures or unstable active layer morphologies.

The latter is particularly important for devices based on blends of electron-donor and electron-acceptor materials. The efficiency of such donor-acceptor bulk heterojunctions (BHJ) depends strongly on domain size and distribution.
Yet, the crucial thin film morphology is kinetically quenched and phase separation that occurs during device operation will irremediably
reduce the device efficiency. Equally, the device external quantum yield is mainly limited by the reduced active layer absorption band,
which, for the currently most investigated BHJ devices, is bounded to wavelengths lower than 700 nm.

The present project intends to circumvent both limitations of BHJ devices mentioned above, by a molecular engineering approach. Block-copolymers including chemical moieties that allow selective interactions with the photovoltaic blend components will be designed and used as surfactant thereby enhancing both, the control and the stability of the blend thin film morphology.

To additionally improve photon harvesting, metal-organic small molecules with high electron affinity, strong near-infrared (IR) absorption and specific self-assembling functionalities, which make them compatible with the compatibilizer approach, will be designed and used as electron acceptor. Devices with chemically stable, electrodes will be elaborated that, combined with an enhanced active layer morphological stability, will lead to long lifetime devices. Combined with an enhanced active layer morphological stability, this will lead to long lifetime devices. In addition, with industrial participation, we propose to make the first steps toward the development of industrial-scale materials methodologies and processes and processes, that will include development of improved encapsulation and protection package, and of processing technology for large area devices. The targeted device IR response is the first step towards photovoltaic windows with integrated heat screening capacity.

The general research strategy that will be pursued relies on the joined expertises of the consortium which cover the fields of advanced chemistry, material structural, analytical and electrical characterizations, photovoltaic device physics and engineering, and industrial development. It addresses both, fundamental aspects such as molecular engineering, ternary phase diagrams, structure–property relationships, and application-oriented studies, such as device lifetime measurements, and industrial processes.

Partners

CNRS - LIPHT (coordinator)
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ANR funding

998 227 €

Start- duration

December 2008 - 36 months

Contract

ANR-08-HABISOL-014

Title	ULTRACIS - Ultrathin and Efficient Copper Indium Gallium Diselenide Thin Film Solar Cells

Abstract

Copper indium gallium diselenide (CIGS) thin film solar cells present the highest efficiency ever reported with thin film polycrystalline solar cells, up to a record value of 19.9 % achieved recently.High efficiency modules start to be produced at the industrial level based on the same approach, with 12-14% efficient modules. This makes the CIGS thin film solar cell technology extremely promising. Reducing the thickness of the CIGS absorber is a short/medium term strategic issue in the CIGS technology associated to the minimization of indium utilization.
The aim of this project is thus to explore the possibility of reducing down to the sub-micron level the thickness of the absorber layer in CIGS solar cells while maintaining, or even increasing, the high efficiency level. Layer thicknesses down to 0.5 micron are the first objective and 0.1 micron the ultimate objective .

These aspects will involve high level basic research, with strong potential impact on industrial developments on two main CIGS technologies : coevaporation (higher efficiencies but higher costs) and electrodeposition (lower efficiencies but lower costs). In the case of coevaporation, efficiency goals of > 15%- 0.5 micron CIGS cells and > 10% for 0.1 micron CIGS are proposed. The project will also be strategically directed to prepare future innovations of the large scale electrodeposition proprietary technology developed at IRDEP, which is a cutting edge second generation of lower cost CIGS technologies. Cells (up to 11.5 % record efficiency) and large area prototypes (about 7 % efficiency) are presently based on 1.5 to 2 micron thick layers. The use of sub micron thick layers, with cell efficiency goals at 10% for 0.5 micron and 6% for 0.1 micron,will also represent an important breakthrough for this non vacuum technology, making it even more competitive.

Partners

CNRS - IRDEP (coordinator)
EDF-IRDEP
CNRS - ILV
SUPELEC - LGEP
CNRS - LPN
Institut d'Optique - LCFIO
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ANR funding

1 057 936 €

Start- duration

December 2008 - 42 months

Contract

ANR-08-HABISOL-015

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	VABAT - Very low energy building, indoor climate and ventilation: numerical, experimental and architectural approach.
Abstract	The project is part of VABAT the prospect of rehabilitation energy dwelling with a very low energy consumption. In this context, the feasibility of potential vector air to replace the heating system classic an integrated system of ventilation and air treatment is to be searched. Considering that the potential energy savings lies mainly in the existing housing stock, the technology proposed under this project should contribute to achieving the objective of "factor 4" for a large part of the housing stock and this therefore an environmental impact in relation to the conclusions of the workshops Grenelle of the Environment. The project involving 4 partners including 2 research laboratories, an industrial company and an architectural office, is based on a theoretical and experimental laboratory for the development of a specification of an innovative concept ventilation buildings. The vector air as an energy carrier in the building should be further studies on its distribution plan and its dissemination in the premises. That is the purpose of this project. It is considered an integrated system "2 to 1" ventilation and heat treatment of air associated with types of ducts and broadcasters specific particularly suited to the renovation of housing, use for new buildings being also possible. The ventilation should therefore no longer seen as an adjustment variable economic or energy, but as an element contributing to the design and renovation of buildings at low or very low energy consumption. The project falls within the scope of the theme No. 2 "Concepts to break on a few key technological bricks for a drastic reduction of energy consumption", theme 2.3 "ventilation system and aerodynamics" following an upstream approach therefore type basic research.
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ANR funding	413 345 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-016

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	VALERIE - Increasing the value of energy resources available around the building thanks to the building envelope
Abstract	This project aims the design and the appraisal of building envelope concepts which are able to exploit energy which is available in their surroundings. It is organized as a three main steps program which will result in : the definition and the estimation of the available energy potential, the quantization of the energy potential exploitation by present buildings and advanced technologies, the specification of new concepts defined by their physical properties. A fourth step will be dedicated to the identification and the description of potential practical problems which may hinder the development of the new concepts on site and to find the ways for limiting their negative impacts. This project is supported by simulation tools, developed or used by the partners, which allow the study of a wide range of actual or virtual technical solutions. The consortium gathers three university laboratories, one industrial research department and an ingeneering society which are all concerned, for a long time, by the energy modelling of building and by the use of such models for the design of very efficient buildings. Thanks to the variety of the studies carried out in time, every partner has developed its tools and skills, integrating innovative systems and components dedicated to the improvement of energy efficient buildings. All the tools available for the project allow to cover a very wide variety of existing or emerging solutions. Each partner can be distinguiched by its specific skill due to its main interest in energy efficiency : the development of new energy services; the development of new simulation tools for research needs or for design of efficient buildings; the development of new technical solutions for the enhancement of solar energy use in France. Many recent projects aim a similar target, but they are often restricted to the design of a specific technical solution, to the exploitation of a part of the energy potential or to the optimization of a part of the building envelope. This project is different as its global approach permits to cover all the possibilities and to determine which of them are the most promising.
Partners	EDF R&D / EnerBAT (coordinator) ARMINES - CEP - Paris CNRS - CETHIL CNRS - LOCIE OASIIS SAS
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ANR funding	707 617 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-017

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	VISTASOLOR - STRATEGIES TO ENHANCE SOLAR CELLS STABILITY FOR WINDOWS INCLUSION
Abstract	New strategies to improve the lifetime of organic solar cells are considered with the aim to include these latter in buildings, more accurately into double-pane windows surfaces. The first relates to the use of solar cell designs specially adapted to: - the use of the solar cell cathode as a protective layer of the device, following a new concept validated by a 10 time lifetime increase for solar cells working in open air and under illimination (patent deposited by XLIM) - decrease the current densities crossing the electrodes, in order to limit the device dissipation, and to support the setting in module of the cells. Second strategy is dedicated to organic solar cell elaboration following the modelised designs by technologies which increase device satbility or lower the production cost: - cathode realization by ion beam assisted deposition, which increase the barrier layer effect of the aluminum cathode, by thickening of the deposit, and increase the lifetime (patent deposited by XLIM) - to carry out the anodes by direct writing (serigraphy, ink jet printing) with the aim of saving transparent conducting oxide quantity and if possible replacing the ITO material. Finally the cells elaborated with these technologies will be sealed under inert glove box atmosphere between two layers of glass (one being used as substrate and the other as protective layer), under conditions of inclusion in surfaces of double-pane glazing. Device lifetime will be evaluated by the study in open air and versus time of the cells photovoltaic parameters, and by the photodegradation and trap generation mechanisms studies in these cells under operation or in devices specifically adapted to the study of the interfaces. These physical studies follow as directing topic the multi-scale (from the material to the device) and multi-physics (photo-ageing, generation of the traps under operation) approach, with the long term objective to connect the molecular level (material) to macroscopic (solar cell) level.
Partners	Université de Limoges - XLIM (coordinator) CNRS - IMN CNRS - LPMM
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ANR funding	575 848 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-018

Year 2008

Title

4C - Comfort in Hot Climates without HVAC Systems

Abstract

The present project named 4C –acronym for "Confort Control in hot Climate without air-Conditioning" concerns the study of natural ventilation and its impact during the summer season in the South of France and in the French overseas territories. The use of natural ventilation has not been seen for a long time as an energy efficiency solution to avoid air conditioning. This time is over and because of the issues are increasing in term of energy cost management and low energy buildings, natural ventilation is back on the stage. The objective of the project is to treat different aspects from the modelling to the control and the optimization of natural ventilation to reduce the use of "active" air conditioning systems. The project will deal with the issues of the modelling of indoor convective transfers in buildings and the modelling of passive air components ranging from simplified to detailed models (section 2.3 of the call for projects).
The methodology aims to have a major technical "break from the past" technology and to radically change our way of thinking in terms of air-conditioning design which is so far to install systematically air-conditioning units either in t without thinking of the possibility to avoid them.

Different laboratories from very complementary fields of research will gather around this project to treat various problems such as :
- detailed modeling of airflows to improve the accuracy of numerical simulation tools for passive building components.
- the study of steady or unsteady airflows within passive components and the improvement of these components thanks to the sensitivity analysis and the determination of the most significant key parameters
- the experimental validation of the models thanks to small and real scale tests under natural and controlled conditions.
The control of the natural cooling is a key stage of the project, as well as the intermediate level of modelling to allow the easy implementation into some design programs used by people from the industrial field. This method will allow the implementation of the reduced models developed thanks to the experimental stage and the CFD modeling while guarantying the optimisation of the overall coupling within a global complex system : the building itself.

Natural passive cooling is a complex subject which can only be dealt with the taking into account of a theorical study linked with experimental results. For these reasons the project is divided into three main steps :
1. The first step will rely on the background of the different partners involved in the project.
2. the second step will focus on the airflow patterns thanks to CFD modeling
3. The last step will concern the experimental part of the project.
As the weather conditions are of a strong influence in terms of natural cooling, the experimental validation will be conducted on three real scale buildings located in three different regions : Guadeloupe, Reunion Island and Corsica.
The weathers conditions are really hot in summer in these islands where the environmental issues are quite similar : the CO2 emissions from the electricity yield are around 800 g/kWh whereas in mainland France, the index is only around 150 g/kWh. These figures themselves point out the strong environmental impact of the reduction of air-conditioning in these islands.

The final aim of the project is :
- to list the existing solutions in terms of natural cooling and to develop new techniques adapted to naturel ventilation
- to model and optimize each technical solutions thanks to numerical tools
-to conduct an experimental validation of some components in different real scale buildings
This fundamental and practical approach will allow the industrial partners involved in the project to apply directly the results and the numerical tools to develop themselves new passive solutions for hot climates.
Finally, a design guideline of different natural ventilation solutions will be proposed for buildings in hot climates function of the type of climate and the energy context of each region.

Partners

Université de La Réunion - LPBS (coordinator)
CNRS - LOCIE
Ecole Nationale Supérieure de Mécanique et d'Aéronautique - LET
Université des Antilles et de La Guyane - GRER
Université de La Rochelle - LEPTIAB
INSA - CETHIL
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ANR funding

909 649 €

Start- duration

December 2008 - 36 months

Contract

ANR-08-HABISOL-019

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	NewPVonGlass - III-V nitrides deposited on glass for one watt, integrated, low cost, and very high efficiency photovoltaics

Abstract

We propose to demonstrate thin film single-junction InGaN solar cells on increasingly cheaper substrates, beginning with sapphire, then proceeding to silicon, and finally to glass. While the development of this materials system for photovoltaics is in its infancy, InGaN possesses great potential. An optimized InGaN single-junction cell may have ~20% efficiency, comparable to CIGS, but without the risks posed by required cadmium, a notorious cumulative poison. Because the bandgap can be tuned from 0.7 eV to 3.4 eV by increasing the gallium content, with multi-junction cells it is in theory possible to achieve record efficiency (70%) in a single materials system and thus surpass GaAs multi-junction technology with a maximum theoretical efficiency of less than 50%.

InGaN technology is scalable to industrial development. For example, GaN and related compounds have become commonplace and inexpensive, and are used in blue and white LEDs. This proposal offers an opportunity for France to become a global leader in an important emerging technology, with one American and one Chinese group having already produced the first demonstration solar cells.

This collaboration combines unique resources in an ambitious project. The key technical idea of this proposal is the use of a thin ZnO interface layer that permits hetero-epitaxy by greatly by reducing dislocation density of III-N compounds grown on the ZnO. An active collaboration between Nanovation (the world leader in ZnO for hetero-epitaxy) and GT-CNRS UMI used this technique to demonstrate orders of magnitude improvement in GaN quality grown on ZnO on sapphire substrate. Nanovation also has experience growing ZnO on silicon. The collaboration also includes Dr. Ian Ferguson, the world leader in InGaN solar cells, who is part of the project through his membership in GT-CNRS UMI. The partnership is completed with expert modeling and state-of-the-art solar cell characterization to be performed by LGEP and the etching, complementary characterization, and contact optimization to be provided by LPN.

The project will result in both scientific knowledge and a strong potential to commercialize the InGaN technology. Much is to be learned about the growth of InGaN. Much is to be learned about the physics of depositing ZnO on silicon and glass and of InGaN on ZnO. Much is to be learned about optimization of cell design and electrical contacts. It is anticipated that solutions to these problems will generate important patents, articles, and conference communications. To help fulfill its potential, the project is well organized with a plan for regular communication between partners and accountability to the leader of the project. It proceeds systematically from lower risk activities to the more ambitious and allows knowledge gained to be used in the next step. Given current energy and environmental problems, the development of new photovoltaics having a high potential for alleviating these problems seems to be a wise choice.

Partners	CNRS - UMI Georgia Tech (coordinator) SUPELEC - LGEP Nanovation CNRS - LPN
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ANR funding	849 361 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-020

Smart Buildings and Solar Photovoltaic Programme

Year 2008

Title	Inxilicium - Ink-jet printed amorphous silicon photovoltaics
Abstract	Inxilicium aims at demonstrating the feasibiliy of a printed solar cell based on amorphous silicon nanoparticles. The nanoparticles are synthesized by a facile chemical route involving a room temperature redox process in solution. As a consequence, the particles are size controlled with easy chemical routes to doped nanostructures. The solar cell process will be based on ink-jet printing, the particles dispersion has be to be stable over the process. Inxilicium will develop two parallel routes: (i) formulate the nanoparticles as a stable ink (ii) optimize a new printer head dedicated to non stable fluids. The thin films will be investigated by all characterization techniques and electro-optical measurements. The optimized process will give the best compromise between the optical and electrical properties. The multilayered junction will then be tested on a photo-electric bench to give photovoltaic yields of the solar cells. Inxilicium is an innovative project that takes into account the sustainable growth all over the solar cell fabrication. Both the chemical synthesis and the thin film deposition by ink jet allow a drastic decrease of the chemical waste and equipment needed.
Partners	Université Montpellier II - ICG (coordinator) Ecole des Mines de St-Etienne - CMP IMPIKA Université Montpellier II - IES CNRS - IRDEP Quantum Solar EDF - IRDEP
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ANR funding	979 651 €
Start- duration	December 2008 - 36 months
Contract	ANR-08-HABISOL-021