RHONE-ALPES REGION: A STRONG RESEARCH POLE ON ENERGY AND PHOTOVOLTAIC SILICON

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Rezumat. Regiunea Rhone-Alpes (RRA) este una din cele mai imporatnte zone de cercetare din Franţa. RRA reuneşte 1300 de cercetători implicaţi în domeniul energiei şi aplicatiilor sale. RRA a lansat un plan de acţiune în ordine să promoveze dezvoltarea activităţilor de cercetare în energiilor regenerabile. Energia solară este unul dintre subiectele principale promovate de grup după creearea Centrului Naţional pentru Energie Solara (INES) din Chambery. Dintre diverse teme legate de energia solară, prelucrarea siliciului pentru proiectarea eficientă a celulelor fotovoltaice reprezintă o prioritate. Cercetările asigură întreg procesul de elaborare a siliconului pur, construirea de plachete de silicon cu performanţă ridicată pentru integrarea acestora în celule.
Cuvinte Cheie: energie, captarea energiei, celule, celule fotovoltaice, eficienţa clădirilor.

Abstract. Region Rhone-Alpes (RRA) is one of the major research poles in France. RRA gathers around 1300 researchers involved in the field of energy and its applications. RRA has launched a plan of action in order to promote the development of the research activities on renewable energies. Solar energy is one the main topics supported by the cluster following the creation of the National Centre for Solar Energy (INES) in Chambery. Among the various topics related to solar energy, silicon processing for the design of efficient photovoltaic cells is one of the priorities. Researches cover the all chain from the elaboration of pure silicon, the building of silicon wafers with high performances to the final integration into the cells.
Keywords. Energy, energy harvesting, fuel cells, photovoltaic cells, building efficiency.

1. INTRODUCTION

Region Rhone-Alpes (RRA) is one of the major research poles in France. RRA gathers around 1300 researchers working in 46 research laboratories involved in the field of renewable energy and its applications including social and economical issues. In 2005 RRA has launched a plan of action in order to promote the development of the research activities on renewable energies [1]. The strategy is focused on :

- the will to promote cooperation between research teams working on the same subjects,
- the promotion of interdisciplinary project including various aspects like electrical engineering, materials sciences, economy,
- the coherence with other types of structures devoted to energy like "competitiveness poles", Carnot institutes etc.
- to foster scientific cooperation between university and industry.

Four main priorities corresponding to the main activities existing in RRA were defined:

- materials for energy
- energy and building
- storage and energy management
- renewable energy sources.

The research activities are concentrated in four main geographic poles: Grenoble, Lyon, Annecy- Chambéry and Saint Etienne (see Fig. 1).

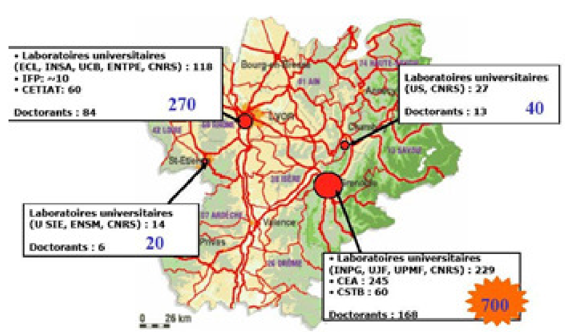

Fig. 1. Location of the research poles and corresponding number of researchers involved in the field of energy

A special recent thrust has been given to solar energy and its various applications. It is one of the main topics supported by the cluster supporting the creation of the National Centre for Solar Energy (INES) in Chambery which gathers about 200 researchers. The support mainly consists of PhD grants completed with funding. In the period 2005-2010 the cluster Energy distributed 22 PhD grants and 1.5 MEuros.

2. THE VARIOUS CHALLENGES

The main priorities contain the actual challenge linked to renewable energies.

2.1. Materials for energy

The various processes producing energy are limited by the properties of the materials issues as well as their cost. There are various examples. As far as solar cells are concerned, the challenge consists in :
- using high efficiency silicon materials ;
- capturing the largest part of solar radiation as possible without heating to much the cell itself,
- reducing the amount of silicon in each cell to reduce the cost by developing thin film techniques.

As far as fuel cells are concerned, one of the main issues is linked to catalysis. The reduction of the amount of platinum which is used as a catalyser, could lead to a drastic reduction of the cell cost. An area of research (in CEA-Grenoble for example) consists in applying nano-technology concept in order to maximize the ratio surface- to- volume for the active platinum particles by developing nano-powder coating for example. Another key issue is the storage of hydrogen. Only some metals are able to store a significant amount of hydrogen, like magnesium or aluminium-nickel alloys. Furthermore, in order to increase the storage capacities researches are focused on the production of powders having porous micro-nano-structures. Materials issues are present also in generators, storage systems, batteries, electrolysers, building walls etc. Nanotechnologies are also of interest.

2.2. Energy and building

The global goal is to achieve positive consumption buildings. This is multidisciplinary fields involving once again material issues. As far the structure materials are concerned, it becomes necessary to work on the assembly of various different items involved in the energy budget such as glasses, lighting, heating and refrigeration. The researches performed in RRA are related to materials related to buildings like glass design, especially active glasses, sustainable insulating materials like vacuum panels, whose lifetime is often an issue. A research area also concerns the design of heat storage in walls by means of phase change materials. Coupled technico- and socio-economical issues are also taken into account, especially concerning the renovation purposes.

Fig. 2. Example of positive energy building : “Caserne de Bonne” in Grenoble (France)

2.3. Energy management

The energy consumption in RRA represents approximately 15% of the total French consumption. The electric energy comes from different sources, namely hydraulics, fossil fuel and nuclear plants, solar and wind intermittent energy. The issue is to couple different distributed and intermittent (sometimes dispersed) energy sources into a single reliable network. This leads to the concept of smart grids able to regulate the different electricity supplies and able to exploit and couple the various renewable sources of energy efficiently (e.g. sun, wind, water, biomass, fuel cells)

2.4. Storage and renewable sources

Storage of energy is complementary to the management issues, which result from the coupling of various types of electricity sources. The method and type of storage depend on the device used to produce energy. In the case of battery for example, attention is focused on the durability. Different types of storage are investigated. In the case of fuel cells, one important issue is related to the storage of hydrogen. This combines both a material issue, i.e., the nature of the metal able to catch the maximum amount of hydrogen via hydride formation on the surface of the metal particles. Here again it is necessary to increase the surface-to-volume parameter.

However, the overall process must ne analyzed in order to control and limit the temperature of the storage cell since the hydride reaction is strongly exothermic. The reliability of fuel cells is also of importance, especially for system able to work during several thousands hours.

Another interesting topic concerns the energy harvesting concept applied for micro- systems like watch, cell phones etc. The range of required electric power is illustrated in figure 3.

It covers at least 5 decades, meaning that several types of adapted sources must be invented. For example according to the consumption of the system, one may use various principles, namely vibration of piezo-electric materials, direct electromagnetic or electrostatic excitation, thermo-electric conversion etc.

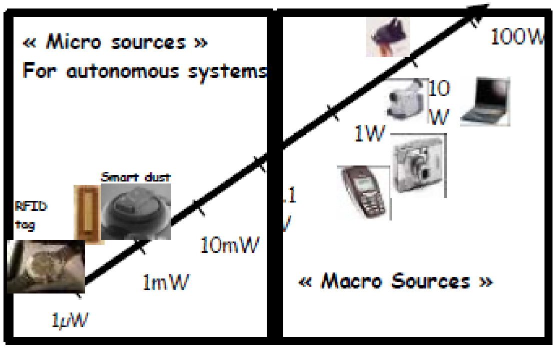

Fig. 3. Scale of consumption of different micro-macro-systems (from A. Bsiesy, Intercluster Seminar, Grenoble, 2008)

3. SILICON PROCESSING

An important activity in RRA is related to the photovoltaic industry. There exists many SMI involved in the field, like Photowatts Ind., Ferro-Pem, Apollon Solar. The photovoltaic industry has to face with an exponentially growing world demand on silicon as shown in figure 4. The same trend is observed in France (see figure 5). It is not surprising to find many active research groups working in that area.

The research topics cover the whole production chain, from the elaboration of the silicon raw materials, the production of wafers, their integration in global systems. The overall objective is to reduce the cost- per-produced Watt, which one of the main criteria.

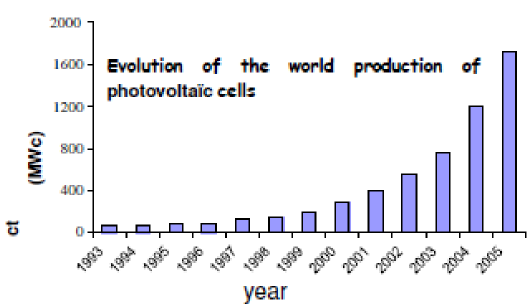

Fig. 4. Evolution of the world production of photovoltaic silicon

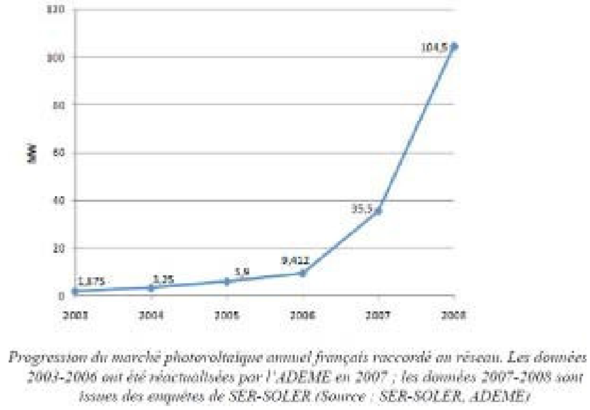

Fig. 5. Evolution of the photovoltaic market in France

3.1. Silicon wafer production

The cost of silicon is continuously increasing on the market. It is of important to reduce the amount of silicon by using layer deposit techniques on metallic substrates (aluminium, iron etc.) in order to decrease the thickness from 300 mm to 150 mm.

Various routes are explored. The most common routes start from the reduction of silica to obtain raw silicon containing many impurities, the so-called metallurgical silicon. Then, the MG silicon is purified by removing undesirable species, like iron, boron, phosphorous. A recent promising device consists in using induction plasma torches impinging a silicon bath (figure 6) to remove the impurities at a high rate [5].

The silicon ingot is then solidified in batch furnaces then sliced into thin wafers. The thickness of the silicon wafers is around 300 µm whilst its efficiency may reach 15%. One major drawback of the process is the loss of materials (50% approximately) during the cutting.

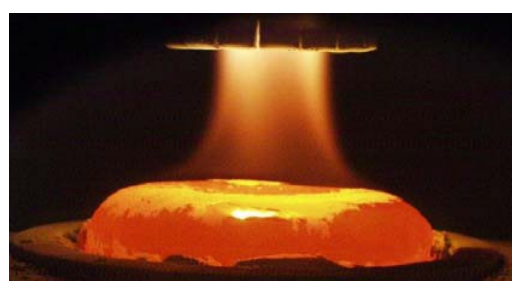

Fig. 6. View of the purification process by means of an induction plasma impinging the free surface of a silicon bath

3.2. New trends for photovoltaic cells

An alternative route consists in thin layer deposit by epitaxy on substrates. The advantages are the following:

(i) the layer thickness may be significantly smaller than with the previous system,
(ii) it is possible to increase the efficiency of the cell by multi-layer deposit, each layer being able to absorb a particular range of solar radiation spectrum (hetero-junction cells, nano-thread surfaces).

The future aim is to produce cells with a coating of 100 mm thick having efficiency around 30%. However, mass production for those types of quite sophisticated cells is still an issue, and further researches are ongoing.

4. CONCLUSION

Many other types of researches are undertaken in the various laboratories, and it was not possible to review all of them. For example Grenoble is very active as far as the development of superconducting flexible conductors with YBCO-based alloys using CVD techniques. This topic is of great importance for the transport of electricity. Social sciences are also present through various projects, for example on the promotion of the use of renewable energies in the city.

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