

SuNEC 2012: Entering the Solar Era Mario Pagliaro¹ and Giovanni Palmisano²

Jointly organized by the Institute of Nanostructured Materials of Italy's Research Council (CNR) and by Palermo's University Department of Electrical Engineering (Dietcam), the second "SuNEC – Sun New Energy Conference" was held in Santa Flavia, Sicily, on September 4-6, 2012 in the splendid venue of the Domina Zagarella Hotel.



On September 3rd, sponsoring company **Medielettra** offered a welcome reception based on a selection of white and red wines produced in Menfi (Sicily) by the winemaker **Tenuta dei Mille**.

The Conference scientific program opened on time on September 4th, with the welcome address of Professor **Sebastiano Tusa**, Sicily's Superintendent of the Sea Office, who also read the welcome address sent to delegates by the president of Italy's CNR, Professor **Luigi Nicolais**.

Professor Tusa emphasized the historic importance of sun's energy for Sicily where most Italy's grain is produced, as well as for making the fish-based sauce "garum" widely traded by the Romans. Today, he concluded, there is clear interest in solar energy for building-integrated photovoltaics (BIPV) in historical buildings, as well as for solar hydrogen to power boats in place of fossil fuels.

Eminent speakers at SuNEC 2012 included Aldo Steinfeld, Thomas Brown, Keith Barnham, Ruud Schropp, Bao-Lian Su and Kisuk Kang. RSC Publishing *Energy and Environmental Science*, the leading scientific journal in the field, was the conference official publication and will accept manuscripts from SuNEC 2012 for peer-review, until September 30th.

The scientific programme featured 6 plenary lectures, 14 oral presentation and 4 poster presentation that highlighted exciting innovation in widely different approaches to exploit solar energy, including concentrated solar power (CSP), thin-film photovoltaics, artificial photosynthesis and solar thermal. Helionomics, the economy of solar power, was an interesting topic addressed at the Conference

On September 4th, **Aldo Steinfeld**, chair of renewable energy carriers at Zurich's ETH, opened the conference with a lecture on a simple and most

¹Istituto per lo Studio dei Materiali Nanostrutturati, CNR, via U. La Malfa 153, 90146 Palermo, Italy; mario.pagliaro@cnr.it

²"Schiavello-Grillone" Photocatalysis Group, Dipartimento di Ingegneria Elettrica, Elettronica e delle Telecomunicazioni, di tecnologie Chimiche, Automatica e modelli Matematici (DIEETCAM), 90128 Palermo, Italy

promising method for generating solar hydrogen and carbon monoxide directly by heterogeneously catalyzed water splitting coupled to carbon dioxide reduction over ceria in a solar reactor developed by his Group in co-operation with Caltech's scientists.

The original 0.8% efficiency [*Science* 330 (2010) 1797] is now four times higher, standing at 3.2%. When the 10% efficiency threshold will be reached, this technology will find practical application.

Sustainability, he further explained, is about to close materials cycle, and not about efficiency. Efficiency concerns the economy of processes, and thus industry. Hence, the source of CO₂ for sustainable water gas generation must be CO₂ from ambient air. This requires the development of a suitable material for CO₂ adsorption and release, and Professor Steinfeld showed the remarkable results lately obtained with sol-gel aminosilica ([Climeworks](#)) as reversible CO₂ adsorber optimally working at 90 °C.

The same day, **Keith Barnham**, emeritus Professor at London's Imperial College, gave a remarkable talk on the latest developments concerning 3rd generation solar cells based on the triple-junction (III-V) concentrating PV technology using GaAs, developed in his Lab since 1990 [*J. Appl. Phys.* 67 (1990) 3490].

He briefly told the story of QuantaSol, the company spun off from his Lab recently sold to a large semiconductor US company, and explained that in order to obtain a reduction in manufacturing cost for these cells similar to that experienced by Si-based traditional cells, production must rapidly and largely grow. Such production, he emphasized, will inevitably be linked to the commercial development of the LED lighting technology.

The reactors to make LEDs or III-V solar cells are the same and basically use the same process. A number of large Chinese electronic companies recently purchased these reactors on a massive scale, which opens the door to 40% efficient solar cells.

Finally, hot water (water at 90 °C) is an useful by-product of the concentrator systems. On buildings, hot water is of course very much in need for sanitary usage, whereas another multifunctional application emerges from Professor Steinfeld's talk for extracting CO₂ from ambient air. An outcome of SuNEC 2012!

On the same day, **W.-S. Ho** from National Taiwan University, Republic of China, gave an interesting lecture on ion implanted Boron emitter n-Si solar cells. He clearly showed that implantation is a most promising alternative to diffusion to dope silicon for new generation n-Si solar cells.

Daniele Trucchi from at Italy's CNR Institute of inorganic methodologies and plasmas, described in detail the recently patented thermionic and thermoelectric conversion module concentrating sunlight to generate both electricity and heat, developed by his Group in partnership with the other members of EU-funded Ephestus consortium.

University of Zaragoza's **Francisco Collado**, a professor of mechanical engineering, showed the new code called "CAMPO" to design solar power towers with enhanced performance. In the last decade, Spain has indeed reached a leading edge in CSP plants using solar towers.

The use of biogas coupled to solar dish Stirling technology, was the topic of an insightful presentation of University of Zaragoza's **Nuria Bernal Cortes**; whereas Dr **Carmine Cancro** described the methodology developed at Italy's ENEA Labs based in Portici (Naples) for predicting and monitoring the performance of CPV plants.

Polytechnic University of Tirana's Albania **Pellumb Berberi** gave the first Helionomics presentation analyzing current trends in photovoltaics. The "breakneck" growth of PV in the world, largely based on two main markets – Germany and Italy – was described in detail. Such situation, limited to two countries only, concluded Professor Berberi, is clearly not sustainable.

On September 5th, **Ruud Schropp** described a number of ultrathin thin film silicon solar cells developed at his Labs, first at Utrecht University, and more recently to the new ECN Labs in Eindhoven, where part of his team accepted to move last Spring. The performance of hydrogenated Si solar cells deposited over Ag-coated ZnO nanorods long 25 nm only, affording close to 8% efficiency, astonished the audience. Professor Schropp's presentation addressed also tandem a-Si/nc-Si cells as well as cells based on plasmonic back reflectors.

Santiago de Compostela University's PhD student **Angela Garcia-Rivera** describe the results of the simulation of light trapping and electrical performance of thin film solar cells based on hydrogenated amorphous silicon, manufactured by Spain's company T-Solar.

The poster prize was awarded to **Orhan Özdemîr**, Yıldız Technical University, Turkey, for his poster concerning the structural analysis of the interface properties of inversed HIT solar cells

University of Namur's **Bao-Lian Su** gave an enthusing presentation on silica-entrapped biological species for solar energy conversion by photosynthesis (*Energy Environ. Sci.* 5 (2012) 5540). A number of different high value-added sugars are indeed directly obtained from sunlight, water and carbon dioxide.

These leaf-like materials currently retain their performance up to 3 consecutive months. When the threshold of 6 months first – Professor Su explained -- will be reached, a number of companies – including European and Chinese companies co-operating with his Group – will start commercialize this technology.

Professor Su, who also runs a research Group at the Wuhan University of Technology in China, insisted that for each Si atom in a traditional solar cell, 4 atoms of chlorine are released as hydrogen chloride. In China, where some 90% of solar grade silicon is nowadays manufactured, this is posing a serious threat to the environment. Hence, he concluded, we must identify alternative means to exploit solar energy that are not harmful to the environment and to human health.

Giuseppe Torzillo, from Italy's CNR based in Florence, gave a presentation on photobiological hydrogen production with microalgae *Chlamydomonas reinhardtii*. He described the strain selection and culture optimization for photobioreactors carried out at his Lab also in outdoor conditions, when H₂ evolution is considerably lower than in the laboratory. He concluded identifying routes for optimization which include sulfur-deprivation.

In the afternoon session of the same day, University of Messina's **Claudio Ampelli** described the excellent performance of newly developed sol-gel titania nanomaterials as photoelectrodes for solar hydrogen production. Comparison of this sol-gel, highly porous material with commercial titania shows performance up to twice higher in terms of H₂ evolution (*Nanosci. Nanotechnol. Lett.* 4 (2012) 142; while the solar reactor processing reactants in the gas phase to developed in his Lab can also be applied to bio-waste purification, in which organics are too dilute for other processes.

University of Palermo's economics PhD student **Marcella Giacomarra** presented an advanced statistical assessment of the PV trend in 15 EU countries using two statistical methodologies. Results show an interesting outcome by comparing Italy, where 15 GW of PV power are now installed, and Germany where 22 GW of PV power are deployed. Germany shows a very stable, slightly varying trend, while Italy, where 5 Feed-In-Tariff laws have been enforced in the last 5 years, is the most variable country in Europe.

Carmelo Albeggiani of Italy's Medielettra solar company, presented the development of PV energy in Sicily and offered a useful "real-life" insight from the market.

On September 6th, **Kisuk Kang**, Seoul National University, gave a remarkable presentation on newly developed battery materials for storage of solar energy. In particular, Professor Kang described Mn-based "olivine" materials (*Chem. Commun.* 46 (2010) 1305) and alternative phosphate-based materials for lithium rechargeable batteries (). By merging physics and chemistry, namely computation and chemical synthesis, his Group has devised new compounds, with new crystal structures, in which not only is the Li ions diffusion is improved (higher voltage), but also the need for potentially explosive Co³⁺/Co⁴⁺ is eliminated, whereas the crystal structure more resistant to degradation upon multiple recharge cycles.

Professor Kang's work was conducted in co-operation with the largest steel and electronics manufacturers in Korea, and these materials are close to be commercialized for 3rd generation Li batteries, with potential to replace Li with cheap and readily available Na (*J. Mater. Chem.* 2012 DOI: 10.1039/c0xx00000x).

Francesco Meneguzzo, Institute of Biometeorology, CNR, Italy, reported the first results of using heating systems for buildings and greenhouses using PV electricity to heat water at temperatures up to 90 °C through cavitation based on Baurov theory of buyons. Such easily assembled systems, recently patented along with Professor Baurov, do not use coils or traditional resistance, but

rather employ cavitation of water bubbles that going through a cycle path, including a vertical part, release a considerable amount of energy.

Dr Meneguzzo, the father of Italy's FiT scheme, showed the results of both experimentation and simulation concerning the application of this PV-powered thermal system in greenhouses, where some 1,100 liters of diesel fuel are currently needed to grow valued vegetable. The system is capable to conveniently provide all the heat needed to replace diesel fuel in both southern, central and northern Italy.

The last plenary lecture was given by **Thomas Brown**, from Lazio's CHOSE Center at the University of Rome Tor Vergata, Italy. Professor Brown described in detail the design and development of the first large area dye solar cell modules, addressing the requirements of both the device and the manufacturing processes (*Prog. Photovolt: Res. Appl.* 2012 DOI: 10.1002/pip.2261).

He reported the last data on flexible modules based on plastic substrates covered with the DSC cells, showing a remarkable 4,2% efficiency in outdoor testing. The CHOSE Group has developed considerable proprietary knowledge on scale-up of the technology, including laser sintering for glass cells, and UV irradiation for plastic devices. The technology is ready for the several market applications of organic photovoltaics.

Given by **Hyung-Man Kim**, INJE University, South Korea, the last talk addressed simulation and comparison with experiments of a solar hydrogen electrolyzer using a proton exchange membrane. The optimum working temperature for this system is 80 °C.

Finally, the social program organized on the afternoon and evening of September 5th was, to quote the wife of Professor Schropp, "unforgettable". With assistance of a guide, delegates first explored the ancient Norman town of **Cefalù**. One of the better kept examples of Norman architecture, this town is famous for its two storey Cathedral whose building's interior decorated with splendid gold mosaics date back to 1138.

On the evening of the same day a banquet dinner based on time-honoured Sicilian recipes was served at the **Abbazia Santa Anastasia**, a luxury resort next to a large winery. Delegates first visited the *cantina* and then enjoyed Sicilian specialties matched with the excellent wines from the very same winemaker.

Scientific exchange and networking was certainly eased by the informal style of the Conference along with the unique *milieu* of both the Conference location in front of Sicily' sea and the Abbazia Santa Anastasia, in a proper balance between science, networking and entertainment.

The 3rd edition of the SuNEC Conference will be held in Sicily again, on September 2013.