German Researchers striving for Excellence

German PV researchers challenge US-American technology leadership. This strong industry is pushing scientists over here to present top performance: innovations are developing fast, efficiency records are constantly being broken. But with Obama ambition has returned to US laboratories. .

In the field of the most efficient thin-film technology the Swabian company Würth Solar is striving for excellence. It has recently increased the efficiency of its modules based on copper, indium, gallium and selenium (CIS) to 12% and intends to increase efficiency even further in the short term. “We can achieve 14% on average by improved semi-conductor quality, for example,” says Head of Development, Bernhard Dimmler. This would allow Würth to clearly “lose” their competitors: Solibro, the efficiency record-holder for CIS, currently achieves as much as 12.3 % with its mass-produced panels while most other CIS producers reach only about 10% efficiency.

The way for Würth’s success was paved by the Centre for Solar Energy and Hydrogen Research (ZSW) in Stuttgart, which developed the modules for this company and provides it with a continuous input of fresh expertise. ZSW researchers enjoy a worldwide reputation: In a pre-industrial scale production they are already achieving efficiencies as high as 19.6% with CIS-cells and are planning to even surpass the 20 % mark soon, says Michael Powalla, Head of the PV Unit at ZSW. This means the Institute would outperform the previous world record-holder, the National Renewable Energy Laboratory of the USA (NREL). It achieves 19.9 % under the same conditions.

The achievements of the Swabian thin-film cooperative confirm that solar research and innovations in Germany are on the advance. So far thin-film technologies were considered an absolute US domain. Over there a great deal of research funding was pumped into the

Messe Düsseldorf GmbH
Postfach 10 10 06
40001 Düsseldorf
Messeplatz
40474 Düsseldorf
Germany

Telefon +49 (0) 2 11/45 60-01
InfoTel +49 (0) 2 11/45 60-9 00
Telefax +49 (0) 2 11/45 60-6 68
Internet www.messe-duesseldorf.de
E-Mail info@messe-duesseldorf.de

Geschäftsführung:
Werner M. Dornscheidt (Vorsitzender)
Wilfried E. Moog
Wilhelm Niedergöker
Joachim Schäfer
Herbert Vogt
Vorsitzender des Aufsichtsrates:
Dirk Elbers

Amtsgericht Düsseldorf HRB 63
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development of “slim” power generators. The Department of Energy (DOE), the US energy ministry, thinks silicon-based cells are not suitable for broad-based use due to their costs, explains Tonio Buonassisi of the Massachusetts Institute of Technology in Cambridge. This is also why this institute primarily focused on thin-film technology. Nevertheless, the Americans’ leading edge in this field is melting away.

NREL hot on their tails

The situation is similar in other PV segments. Since the 70s the NREL has done research on so-called multi-junctions from III-V-semi-conductors to supply space stations and satellites with solar energy. 1980 saw the DOE spend $ 400 million, i.e. the biggest injection into solar research in the history of the US, establishing the country at the very leading edge of solar science. Companies such as semi-conductor specialist Emcore later brought back those Multi Junctions from space to earth thereby developing the first concentrator systems that capture light with special optics and bundle, and project it to the high-efficiency cells. Here, too, the Americans have lost their role as pioneers now: The Fraunhofer-Institute for Solar Energy Systems (ISE) now achieves 41.1 % efficiency with a multi-junction – 0.3 percentage points more than the previous record-holder NREL.

In the field of crystalline technology, that still dominates the market, US scientists have never been able to catch up with their German colleagues: many institutes and universities – ISE and the Institute for Solar Energy Research in Hameln (ISFH), in particular, – are working on new concepts for silicon-based cells and developing suitable manufacturing processes for them in cooperation with producers. However, the efficiency record for cells from this semi-conductor is held by Australian rather than German researchers – who have reached 24.7 %. However, in contrast to various German concepts the cell from “down-under” is far from commercial implementation: Stiebel-Eltron plans to produce a so-called back-contact cell

developed by the ISFH from mono-crystalline silicon, where all contacts are moved from the front to the back. This way more light enters the cells allowing more power to be generated.

The Federal Government promotes crystalline specialisation in Germany: every year almost two thirds of state PV research funds are earmarked for silicon wafer technology – unlike in the US where Buonassisi says: “There are no state funds for applications-oriented research in the area of crystalline silicon.” Amsterdam-based publishing house Elsevier, which analysed the performance of 3,000 research facilities in the field of renewable energies by way of a study, therefore says: “A certain degree of US leadership becomes visible across all sub-segments of regenerative energies. But in terms of solar energy Germany can indeed steal a march on the USA,” adds Elsevier analyst Kevin Boyack.

Closely dovetailed with industry

Policy-makers have paved the way for science in Germany: The Renewable Energies Law (EEG) with its guaranteed tariffs for solar power fed into the grid ensures sustained, strong growth of the local PV market. This also benefits the institutes that now receive the majority of their work from expanding PV producers. At ISE, for example, the proportion of industrial projects is already as high as 40%. Thanks to the avid demand for research and development (R&D) services the headcount of the institutes has gone up quickly while the quality and intensity of both institutional and university research is increasing. This in turn helps the German solar industry to stand its ground in international competition. It therefore depends on close cooperations with those facilities. Solarworld, a group of companies from Bonn, is currently building a state-of-the-art research and development centre at its principal production site in Freiberg, where it intends to make new technologies ready for mass-production in cooperation with the Freiberg Mining University. German machinery and plant builders play a crucial role in translating the

achievements of researchers and engineers into standard applications. Firms such as Applied Materials, VON ARDENNE and Centrotherm are among the leading global outfitters that supply solar factories around the globe with their production equipment. These production specialists will present their innovations from 28 September to 1 October at the solarpeq – International Trade Fair for Solar Production Equipment and the concurrently held world's leading trade fair for the glass industry, glasstec, in Düsseldorf

Both the German Government and the European Union (EU) keep the dual innovation motor of science and business "running" by heavily subsidising industry-related research. The Federal Ministry of the Environment (BMU) co-funds cooperation projects in 2010 with nearly EUR 25 million. The lion's share of the money goes to the development of new processes for silicon, wafer and cell production. The Federal Research Ministry safeguards the basic funding for the facilities and complements the applications-oriented project-funding of the BMU: EUR 42 million will be made available this year alone – four million more than in 2009 and three times the amount in 2008. Add to this funds from the 7th Research Framework Programme of the EU for the period 2007 to 2013.

Obama fills the budget line

In contrast to this, US solar researchers have faced budget cuts over the past few years. While they still boasted the highest solar funding of all times in the early 80s standing at $ 400 million, they only received scarcely one third of this sum from the DOE in 2007 and 2008. In 2006, the year of the lowest PV research budget in US solar history, the sum was even as low as $ 50 million – too little for carrying out cutting-edge research in a country three times bigger than Germany and employing a correspondingly higher number of scientists. However, the USA may regain its old strength. President Barack Obama intends to expand regenerative energies and has therefore increased the research budget of the DOE massively. This

is why $ 213 million rather than the previously budgeted 149 million are now available for PV in 2010. Obama has not only boosted the budget but also prompted a new mode of thinking at both the DOE and NREL: “With the help of solar technology we can vigorously fight climate change and win back our top position in the field of renewable energies,” says Secretary of State for Energy and previous solar sceptic Steven Chu today.

Venture capital makes for innovations

Chu’s change of heart is also reflected in the new research objectives of his department: in future science is to better serve industry. “Thanks to the additional funds we can now strike a better balance in subsidies,” says JoAnn Milliken, Manager of the Solar Technology Programme at the DOE. The applications-related area “PV Systems Development” is particularly to be promoted: with just under $90 million the DOE intends to primarily promote joint ventures by research and industry in 2010 that are geared to the development of PV systems and components. Not only institutes rejoice – but also the many young start-ups in the US that are only waiting for their opportunity. Fed with venture capital they were able to develop their ideas also without state aid. Some of their innovations are ready for the market. Just recently, the Californian firm Solaria started producing novel flat solar modules where the captured light is directed to the cells in double concentration. Experts praise the technology since it saves expensive silicon thereby bringing down costs. In 2007 Q-Cells therefore invested $ 50 million in their production and ensured Solaria’s survival in so doing. With a budget of $ 2.6 million the funding from the DOE was comparatively modest; it supports ambitious young firms as part of its so-called “PV Incubator Project”, a start-up programme. “Without investors prepared to take risks and venture capital, innovations in the US would be nipped in the bud,” explains Solaria’s German boss Philipp Kunze.

Backed by a strong research branch the American solar sector may now develop into a real industry. And they can sell their modules basically in their own backyard: solar radiation conditions in the US are ideal, funding has improved with Obama, power is very expensive in some regions and the power plant pool is obsolete. Which is why energy groups are investing in PV on a large scale, planning giant solar power plants. The consequences of a US solar boom are evident: the expanding industry will call for more scientific input thereby pushing researchers to render top performance. It remains to be seen whether German PV research will then still be able to keep pace.

Photos

Photo 1:
Research focus: At the ISFH solar cells are characterised with the help of cameras. This enhances the understanding of this technology. (Foto: ISFH)

Photo 2:
View into a light cabinet: A scientist at the Fraunhofer-ISE researches new methods for applying cell contacts. (Foto: Fraunhofer-ISE)

Photo 3:
Wearing gloves is a rule: In multi-junction production the absorber materials are separated in a reactor. Not a speck of dust shall interfere. (Photo: Fraunhofer-ISE)

Photo 4:
Power check: At the lab the grid fingers of a solar cell are tapped into for electrical measurements. (Photo: HZB)

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Photo 5:
No modules without machines: PV upstream suppliers make sure with their equipment that innovations find their way from the lab to commercial production. (Photo: aleo)

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Press Contact solarpeq 2010
Sebastian Pflügge/Corinna Kuhn
Phone: +49-(0)211-4560-464 or -598
Fax: +49-(0)211-4560-87 464
Email: PflueggeS@messe-duesseldorf.de or
KuhnC@messe-duesseldorf.de