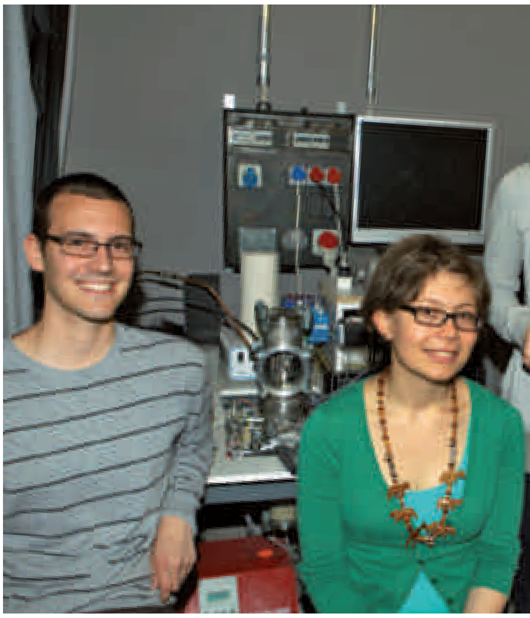
The midget sun

It all started with a high-school graduation project dealing with solar energy. What actually resulted was a sunlight simulator developed and built by three graduating students from Aargau together with Empa scientists – and which today is being used to measure the efficiency of solar cells.

TEXT: Martina Peter / PHOTOS: Kevin Schmid; Empa



1
The sunlight simulator generates the spectrum of the sun. With this device you can determine how efficiently a solar panel converts sunlight into electricity.

2
Fabian Pianezzi, Kathrin Ernst, Debora Bachmann and Miriam Marti (left to right) built a portable sunlight simulator.

Kathrin Ernst has long been interested in how solar energy can be used. When she was just 15, she got involved in the Greenpeace "Solar Generation" campaign and volunteered to help build systems which allow solar energy to be converted into other forms of energy. Later on, in the summer of 2009 the high-school student suggested to two of her classmates in Zofingen that they get involved with solar cells for their graduation project. Because her central area of study was "Physics and Applications of Mathematics", Miriam Marti wanted to write a technical paper and was on board in an instant, and it didn't take long to get Debora Bachmann interested either.

But how to get started? It was soon clear to them that in order to move ahead, they would need a mentor from the university environment. On the homepage of the Swiss Academy of Sciences they ran across Empa and Fabian Pianezzi, who has been working as a PhD student since 2009 in the Thin Films and Photovoltaics Laboratory. At the start, though, he wasn't overly enthusiastic. "Way too complicated", thought Pianezzi after a first meeting, during which the students suggested they wanted to develop an organic solar cell.

While they were talking, though, the four of them came across another idea. During the development of solar cells, it's important to determine how efficient a cell is in converting solar energy into electricity. When conducting these tests in the lab, Empa uses a sunlight simulator. Pianezzi, however, was interested in a new system which ideally would be mobile, could be set up quickly and was inexpensive. Commercial systems are not only expensive, they also need as long as half an hour to warm up. "The very idea of developing a product for Empa which the researchers could then actually use motivated us even more", recalls Kathrin.

The search for a low-cost material

To simulate sunlight inexpensively, the students decided to work with a low-cost raw material: light-emitting diodes (LEDs). In order to cover the entire solar spectrum in the wavelengths from 350 to 1100 nanometres, they needed a large number of lamps of various colours. But which were the right ones? Using calculations alone they would have never found the optimal combination of LEDs according to Miriam, the maths specialist in the team. "Instead, we tried various combinations by varying the number and the type of LEDs." After numerous tests they found a selection of LEDs, which matched sunlight in terms of colour spectrum and brightness.

For technical drawings and fabricating the aluminium dome that would hold the LEDs, the school technician came to their aid. "We were mounting the LEDs in the dome largely by ourselves, as well as doing the soldering and connecting up the controls", relates Miriam. Her classmate Kathrin took on the task of programming the controls which supply the LEDs with the necessary voltage and which can turn each individual lamp on and off, and to do so she had to learn a new programming language.

Useful test results

"In contrast to many of our classmates, we never got bored", says Kathrin. "For months, we were in constant contact with the experts and were even able to carry out tests ourselves in the laboratory at Empa." They received a continual stream of new tips on how to further improve their self-built simulator. That was necessary because although the first design did work, it had too little output power. To increase that, Kathrin and her group built in additional white power LEDs along with a lens that would bundle their light, in other words, concentrate it. The easiest solution would have been to simply opt for LEDs with a higher light intensity. The problem, according to the students, is that such devices are not yet available on the market or – if so – are very expensive. They are convinced, though, that in a few years it will be possible to build an affordable sunlight simulator with the desired output power using commercially available LEDs.

"Although in the end, the sunlight simulator built with standard LEDs didn't achieve the desired output power, we can still make very good use of it at Empa", says their Empa mentor Pianezzi. "We already use it to measure the quantum efficiency of solar cells." Because it's possible to turn each of the 64 LEDs on and off individually, researchers can calculate the percentage of light of a certain wavelength a solar cell can convert into electric current.

Success with "Swiss Youth in Science"

At this point the story could come to a close, but it doesn't. Even before submitting their graduation project, the young women had sent a preliminary version to the Swiss Youth in Science competition. "To our surprise, the jury immediately waved us into the final, without us having to make even the smallest change", recalls Kathrin with pride. Even so, they took the optional recommendations of the jury to heart and worked them into the final version.

Then, on 30 April at ETH Zurich, their work was awarded the rating "excellent" along with a cash prize of 800 Swiss francs by the Swiss Youth in Science Foundation. On top of that, the three of them received a special award – they were invited to attend the International Summer Science Camp in Aalborg, Denmark. What's more, they also had the opportunity to show a short film describing their project at the annual meeting of the Swissmem trade association. And finally, their graduation project also impressed their high school, which praised it as one of the 24 best in the canton of Aargau.

So what conclusions do the young women draw? "In doing this work, we got a pretty good impression of how research in the lab is done", comments Debora. "At the lunch table, we sometimes sat together with scientists from around the world and learned a lot about what they are involved in." Even before entering university they had the chance to experience the daily life of a researcher. After their summer holidays, all three plan to enrol at university. Kathrin would like to study microtechnology, Miriam is beginning her physics courses, and Debora is starting to study educational science so that she perhaps one day could teach natural science to high school students.

Link

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