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Lasers are making solar cells competitive

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The laser beam is guided and focused by means of a process adapted manufacturing system. This allows thousands of holes to be burned into a silicon wafer in one second. Image: Fraunhofer ILT

At "Laser 2009" in Munich, Germany, June 15 to 18, Fraunhofer researchers will be demonstrating how laser technology can contribute to optimizing the manufacturing costs and efficiency of solar cells.

Cell phones, computers, MP3 players, kitchen stoves, and irons all have one thing in common: They need electricity. And in the future, more and more cars will also be fuelled by electric power. If the latest forecast from the World Energy Council WEC can be believed, global electricity requirements will double in the next 40 years. At the same time, prices for the dwindling resources of petroleum and natural gas are climbing.

"Rising energy prices are making alternative energy sources increasingly cost-effective. Sometime in the coming years, renewable energy sources, such as solar energy, will be competitive, even without subsidization," explains Dr. Arnold Gillner, head of the microtechnology department at the Fraunhofer Institute for Laser Technology in Aachen, Germany. "Experts predict that grid parity will be achieved in a few years. This means that the costs and opportunities in the grid will be equal for solar electricity and conventionally generated household electricity."

Together with his team at the Fraunhofer Institute for Laser Technology ILT in Aachen, this researcher is developing technologies now that will allow faster, better, and cheaper production of solar cells in the future. "Lasers work quickly, precisely, and without contact. In other words, they are an ideal tool for manufacturing fragile solar cells. In fact, lasers are already being used in production today, but there is still considerable room for process optimization." In addition to gradually improving the manufacturing technology, the physicists and engineers in Aachen are working with solar cell developers - for example, at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg - on new engineering and design alternatives.

New production technologies allow new design alternatives

At "Laser 2009" in Munich, the researchers will be demonstrating how lasers can drill holes into silicon cells at breathtaking speed: The ILT laser system drills more than 3,000 holes within one second. Because it is not possible to move the laser source at this speed, the experts have developed optimized manufacturing systems which guide and focuses the light beam at the required points. "We are currently experimenting with various laser sources and optical systems," Gillner explains. "Our goal is to increase the performance to 10,000 holes a second. This is the speed that must be reached in order to drill 10,000 to 20,000 holes into a wafer within the cycle time of the production machines."

The tiny holes in the wafer - their diameter is only 50 micrometers - open up undreamt-of possibilities for the solar cell developers. "Previously, the electrical contacts were arranged on the top of the cells. The holes make it possible to move the contacts to the back, with the advantage that the electrodes, which currently act as a dark grid to absorb light, disappear. And so the energy yield increases. The goal is a degree of efficiency of 20 percent% in industrially-produced emitter wrap-through (EWT) cells, with a yield of one-third more than classic silicon cells," Gillner explains. The design principle itself remains unchanged: In the semi-conductor layer, light particles, or photons, produce negative electrons and positive holes, each of which then wanders to the oppositely poled electrodes. The contacts for anodes and cathodes in the EWT cells are all on the back, there is no shading caused by the electrodes, and the degree of efficiency increases. With this technique, it may one day be possible to use unpurified "dirty" silicon to manufacture solar cells that have poorer electrical properties, but that are cheaper.

Drilling holes into silicon cells is only one of many laser applications in solar cell manufacturing. In the EU project Solasys - Next Generation Solar Cell and Module Laser Processing Systems - an international research team is currently developing new technologies that will allow production to be optimized in the future. ILT in Aachen is coordinating the six million euro project. "We are working on new methods that make the doping of semiconductors, the drilling and the surface structuring of silicon, the edge isolation of the cells, and the soldering of the modules more economical," project coordinator Gillner explains. For example, "selective laser soldering" makes it possible to improve the rejection rates and quality of the contacting, and so reduce manufacturing costs. Until now, the electrodes were mechanically pressed onto the cells, and then heated in an oven. "But silicon cells often break during this process," Gillner knows. "Breakage is a primary cost factor in production." On the other hand, however, with "selective laser soldering" the contacts are pressed on to the cells with compressed air and then soldered with the laser. The mechanical stress approaches zero and the temperature can be precisely regulated. The result: Optimal contacts and almost no rejects.

Laser technology means more efficient thin film cells

Laser technology is also helping to optimize the manufacture of thin film solar cells. The extremely thin film packages made of semiconducting oxide, amorphous silicon, and metal that are deposited onto the glass panels still have a market share of only ten percent. But as Gillner knows, "This could be higher, because thin film solar cells can be used anywhere that non-transparent glass panels can be mounted, for example, on house facades or sound-insulating walls. But the degrees of efficiency are comparable low at five to eight percent, and the production costs are comparatively high." The laser researchers are working to improve these costs. Until now, the manufacturers have used mechanical methods or solid-state lasers in the nanosecond range in order to structure the active layers on the glass panels. In order to produce electric connections between the semiconductor and the metal, grooves only a few micrometers wide must be created.

At the Fraunhofer-Gesellschaft booth at "Laser 2009" the ILT researchers will be demonstrating a 400-watt ultrashort pulse laser that processes thin-film solar modules ten times faster than conventional diode-pumped solid-state lasers. "The ultrashort pulse laser is an ideal tool for ablating thin layers: It works very precisely, does not heat the material and, working with a pulse frequency of 80 MHz, can process a 2-by-3 meter glass panel in under two minutes," Gillner reports. "The technology is still very new, and high-performance scanning systems and optical systems adapted to the process must be developed first. In the medium term, however, this technology will be able to reduce production costs."

The rise of laser technology in solar technology is just taking off, and it still has a long way to go. "Lasers simplify and optimize the manufacture of classic silicon and thin-film cells, and they allow the development of new design alternatives," Gillner continues. "And so laser technology is making an important contribution towards allowing renewable energy sources to penetrate further into the energy market."

Source: Fraunhofer-Gesellschaft (news : web)