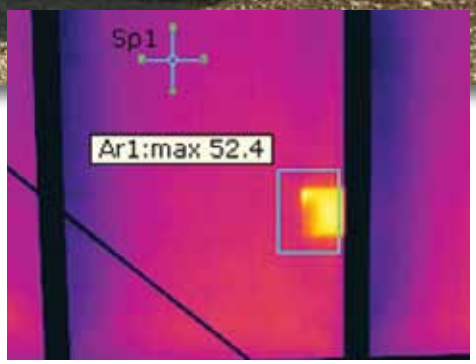
FLIR thermal imaging cameras help ensure the impeccable quality of SOLON solar modules

'Thermal imaging is a great tool both for quality control during production and for field inspections'



This thermal image shows a hot spot due to cell breakage in a standard 60 cell module.

With a solar power plant on your roof you can convert the sun's energy into electricity. And into hard cash – solar power plants are a lucrative investment. To receive maximum returns and high yields for decades however, high quality is key. The solar module, the most important part of a solar system, must be reliable and continue producing electricity for years at an end. To ensure good quality during the full lifetime cycle of a solar module, FLIR thermal imaging cameras can play an important role.

One of the companies that realized the potential thermal imaging technology has for solar module quality control and inspection is the German company SOLON. "We use FLIR thermal imaging cameras intensively both in our R&D department and in the field", explains Oliver Frank, Team Manager R&D at SOLON.

The SOLON headquarters in Berlin.

Founded in Berlin in 1997, SOLON SE is a globally active solar system supplier. SOLON's portfolio includes photovoltaic systems, project planning for and construction of large-scale roof-mounted systems and turnkey solar power plants as well as the production of solar modules. The SOLON Group has subsidiaries in Germany, Italy, France and the U.S.

A solar module is a long term investment. Generally a solar system will earn the investment costs back after 11 to 13 years, depending on solar system price, energy prices and the amount of sunlight. "We design our modules to operate for at least 30 to 40 years or more", adds Frank. "A quick sum learns that a module will actually be earning the owner money for decades."

Thermal imaging in quality tests

A solar module manufacturer needs to produce reliably and sturdy modules that are capable of withstanding decades of operation. SOLON does not manufacture its own solar cells. This means that quality controls are a necessity for SOLON. "SOLON is a premium producer", explains Frank. "So to ensure that our solar modules live up to the high standards we have set ourselves we first have all solar cells and module materials undergo stringent quality tests. We test our solar module materials for their capability to withstand pressure, temperature, moisture and such. But for shunt detection and general solar cell quality testing, our FLIR thermal imaging camera is crucial."

"To detect shunts in solar cells before lamination we apply a reverse bias to a single cell and use the thermal imaging camera from FLIR Systems to look at the thermographic pattern", continues Frank. "Hot spots indicate local shunts due to manufacturing flaws in the cell's semi-conductor material. Simply put this test allows us to make sure that the quality of the cell is above a certain grade."

Oliver Frank, Team Manager R&D at SOLON, performs a shunt check using a FLIR thermal imaging camera.

FLIR SC660: a perfect tool for shunt detection tests

- 640 x 480 pixels resolution
- <30 mK sensitivity, accuracy +/- 1% of reading
- Wide range of lenses
- Extended measurement functions
- Sequence recording in camera
- Contrast Optimizer

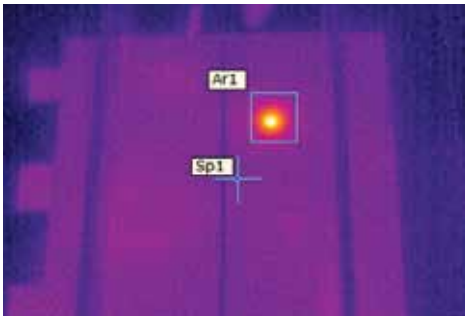
Thermal imaging camera is crucial

The thermal imaging camera currently used for this purpose at the research and development (R&D) department of SOLON in Berlin is the FLIR P65. Frank is very pleased with it. "We bought this thermal imaging camera in 2006 and today it still operates flawlessly. The thermal imaging shunt detection test is a crucial quality test for new solar cells."

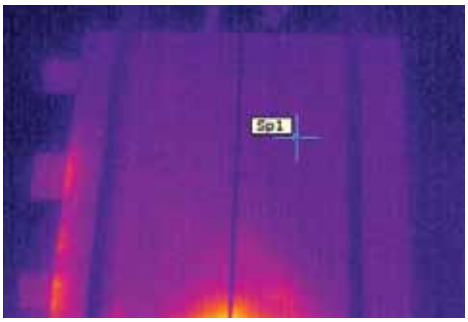
The model currently on the market for this type of application is the FLIR SC660 thermal imaging camera. Its uncooled microbolometer detector provides thermal images at a resolution of 640 x 480 pixels at a thermal sensitivity below 30 mK. It contains automatic contrast optimizing algorithms that make it easier to make thermal analyzes of detailed objects. Combined with exchangeable lenses and the most advanced camera features this makes the FLIR SC660 a perfect tool for solar cell shunt detection tests.

Thermal imaging in the field

"The success in the R&D department led to the purchase of two new FLIR T-Series thermal imaging cameras for field inspections", continues Frank. "The fact that these cameras are compact, lightweight and ergonomically designed makes them perfect for inspections in the field."



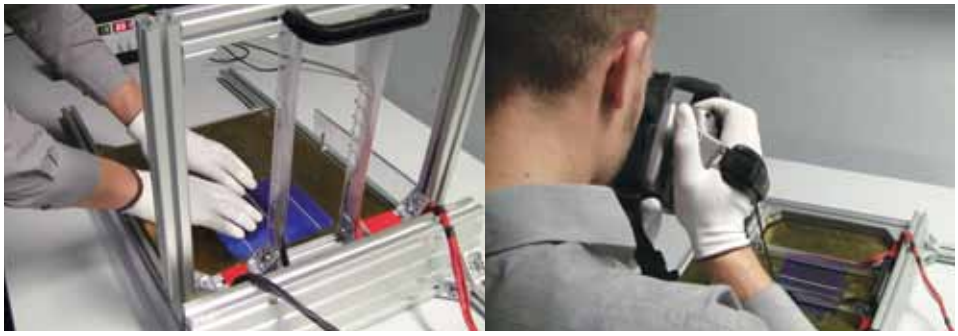
This thermal image of a cell under reversed bias shows a hot spot that indicates a local shunt due to silicon material defects



This thermal image shows that this cell has flaws in the edge isolation, which causes local shunts.

The field inspections are performed by the maintenance department, explains Volker Denzler, thermography expert at the after sales services department of SOLON. "We use these cameras to check a solar power plant before handover to the customer to make sure everything is in order. But we also perform monitoring, operation and maintenance services for plant owners that purchased their solar plant from SOLON."

"Thermal imaging cameras really are a wonderful addition to our field inspection



In the SOLON labs the cell is placed under reversed bias and inspected using a FLIR thermal imaging camera to detect shunts.

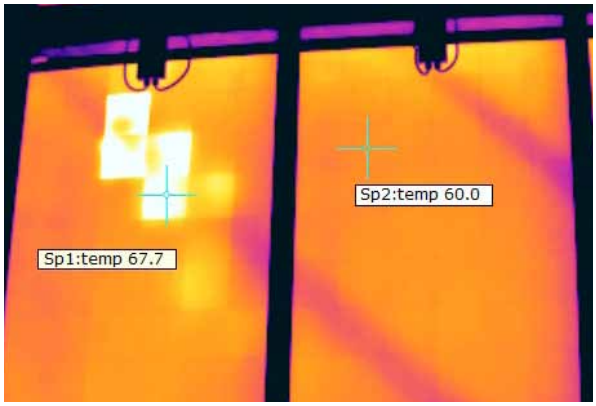
methods", continues Denzler. "Before we had these thermal imaging cameras from FLIR we had to measure each string by hand. As you can probably imagine this is very time consuming, especially in large installations. And even when you found the string where the problem was located, you would still have to guess in which cell or cells the cause of the problem is located."

Volker Denzler, thermography expert at SOLON's after sales services department, takes thermal images from the back of a module to avoid reflections.

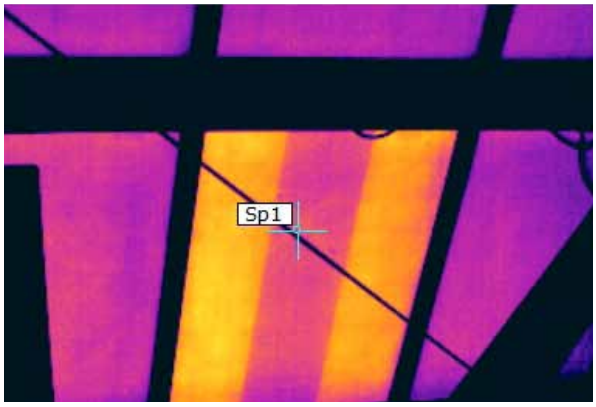
Immediately see the problem

"With thermal imaging cameras from FLIR Systems we can immediately detect where in the module the problem is located and usually we can immediately see on the thermal image what the problem actually is. For there are many different possible causes for issues with solar modules and each different problem requires a different approach in solving the problem."

The hot spots in the thermal images indicate the cause of the problem. Usually thermal anomalies indicate loss of yield from the solar module in question and in some cases hot spots reach such high temperatures that it is considered a security risk. Usually these problems can be solved. "We often find that the cause of the problem lies in connection issues. Electrical connections can sometimes degenerate slightly over time and often these problems can be solved quite easily."



A shadow caused by an overhead power line causes a reversed current. The problem area clearly shows up as a hot spot in the thermal image.



Two strings of cells show up hot in the thermal image, which indicates broken bypass diodes.

Thermal imaging helps find the cause

Other possible causes for defects are breakage in cells, breakage in the protective glass layer, defective bypass diodes, shadowing, to name just a few. "FLIR thermal imaging cameras are the best tool currently available on the market to find out what's wrong, why a module shows a decrease in yield", explains Denzler. "Especially in the case of defective bypass diodes – caused by a thunderstorm for instance – it was very difficult to detect the problem. Defective diodes show up very clearly in the thermal image, however. And the list goes on and on. For all of the possible causes for solar module defects, determining the temperature pattern on the solar module is a very important step towards finding out what's wrong."

And Denzler is not just looking at the module itself. "We inspect the entire installation, including cables, connectors, fuse boxes and inverters. These thermal imaging cameras from FLIR are also a great tool for maintenance of electrical systems in general."

Ergonomic design

The FLIR T-Series thermal imaging cameras currently used for field inspections all contain an uncooled microbolometer detector with 320x240 pixels resolution that produce crisp thermal images at a thermal sensitivity of below 50 mK. Especially developed for maintenance inspections these cameras have been designed for maximum usability. They are compact, lightweight and ergonomically designed.

"Especially the tiltable lens unit is very practical", explains Denzler. "When we're inspecting a module in the field we usually try to look at the back, if the installation allows it. With the tiltable lens unit we can effortlessly capture the back of a solar module without having to crawl on the ground. Due to this ergonomic design feature we can effortlessly point the

T-Series: perfect for field inspections

Developed for maintenance inspections these cameras have been designed for maximum usability. Especially the tiltable lens unit makes them very practical.

thermal imaging camera at the module in every possible angle."

Instant reporting

The FLIR T-Series used by SOLON for field inspections also include some very useful features, such as Thermal Fusion and Instant Report. "We've used the Thermal Fusion several times, showing a combination of visible image and thermal image in one picture, but the instant reporting feature is especially useful. When we conduct a survey of a solar installation we can immediately show the owner or manager some preliminary results."

Of course that initial report is followed by an official report. "We use FLIR Reporter software for producing our reports. This software allows us to adjust level and span to show the relevant temperature differences and because it is Microsoft Word compatible it allows us to easily create reports using Microsoft Office Word."

Common mistakes

Thermal cameras are easy to use. Still you need to know what you are doing. "One very common mistake is to look at a solar module without the required amount of sunlight shining onto it. Here at SOLON we use the guideline that we only perform thermal inspections if the solar irradiance is 700 W/m^2 or higher. This amount of light is needed for the solar modules to operate in an optimum range for detecting defects", says Denzler.

This Picture in Picture image shows a hot cell due to a shadow from the nearby alarm system.

Another mistake Denzler often comes across is relevance of temperature differences. "Not all thermal effects are an indication of a defect. The temperature difference needs to be above a critical difference in order to be sufficient cause for repairs."

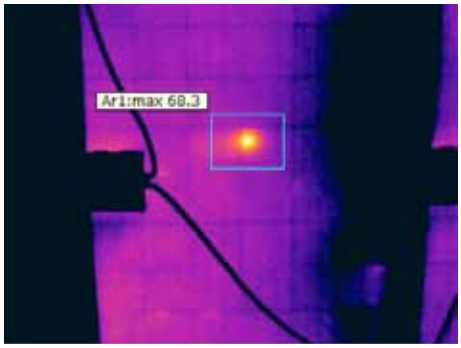
Maintenance contract

According to Denzler these mistakes are sometimes made by new users. "When we sell a solar installation we also offer to take care of the maintenance, which includes inspections with thermal imaging cameras. But some of our clients decide not to opt for SOLON maintenance and have an external thermographer do the inspections."

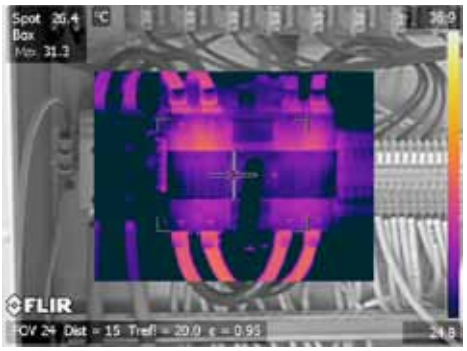
"More than once we received a complaint from a customer with a non-SOLON thermographic report showing 'hot spots', saying something should be done immediately", continues Denzler. "But then we find that the temperature differences are so low that this is not an indication of defects, but a normal variation between cell temperatures that doesn't impact the yield of the module at all."

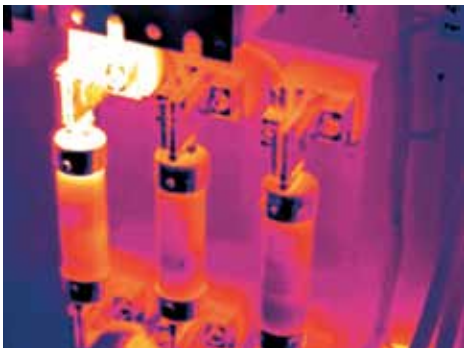
The importance of good training

"Luckily FLIR Systems offers good training that helps prevent SOLON employees from making such mistakes", continues Denzler. FLIR Systems co-operates with the Infrared Training Centre (ITC) to organize regular training courses specifically designed for these applications. "We are continually growing and new people start using the thermal imaging cameras we bought, but we make sure that all of our thermal imaging camera operators have had at least the basic thermography training from the ITC and additional internal training specialized in SOLON solar installations."



This thermal image shows damage within a single cell.





The FLIR T-Series thermal imaging cameras can be used for more than solar module inspections alone; at SOLON these cameras are used to inspect the entire solar installation, including cables, connectors, fuse boxes and inverters, in other words: the entire system.

FLIR Systems: a good long term partner

Whether for quality control during the production process, or for the maintenance inspections of modules and the installation infrastructure, FLIR thermal imaging cameras are a great tool to obtain vital information, according to Denzler. But that's not all; FLIR is also a good long term partner.

"The combination of good service, excellent training and of course unparalleled thermal imaging camera quality makes FLIR Systems a perfect partner for us", concludes Denzler. "When we will need to buy a new thermal imaging camera it will doubtlessly be again a FLIR camera."

For more information about thermal imaging cameras or about this application, please contact:

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