Solar modules designed to face a rough mission

Industrial image processing components for the targeted optimization of the solar modules manufacturing

Limited fossil fuel resources are leading to a global change of attitude, from which the renewable energy sector in particular will profit. Due to that, a high level of efficiency and a long persistence are regarded as the central challenges in the development and manufacturing of solar modules already today.

The quality of solar modules is now, and will be in the future, a subject to utmost standards, in order to ensure their stable and efficient functionality during a prolonged use. Industrial image processing components can make a major contribution to this – going way beyond the control of assembly robots supported by image processing.

Using the power of the sun – an attractive alternative for many in the area of renewable energies. Image processing components can make a decisive contribution to the optimization of production processes in the highly competitive manufacturers' market.

A small leak will sink a great ship

The manufacturers of photovoltaic modules have to guarantee consistently high quality throughout the entire manufacturing process, from the incoming wafer to the point of delivery-ready solar modules. Even the tiniest fractures in the semiconductor material may cause cracks during the production process. This leads to expensive machine down times. During their operation time the solar panels are exposed to enormous temperature variations and other extreme environmental factors. Under these conditions, undetected microscopic defects may quickly lead to cell malfunctioning, causing a reduction in efficiency or shorten the durability of the modules. That is reason enough to support manufacturers in this highly competitive market in finding solutions that not only reduce processing costs and manufacturing times, but also increase the quality. More and more often this solution is found in automated optical inspection systems. Image processing components, such as industrial cameras or vision sensors, can be used throughout the entire manufacturing process and contribute significantly to the reduction of costs.

How wafers become a solar module

The wafers are manufactured from a monocrystalline or poly-crystalline semiconductor blank which is normally in block form. Usually this block is cut into razor-thin wafers that form the substrate for the electronic components. After the wafer has become a conductive solar cell, several cells are connected and laminated in a series of layers with tempered glass and foils to form a weather-proof unit. When the unit has been fitted in a frame, the solar module is ready to be taken in operation.

Early identification of production defects in wafers

Along their path to becoming a solar cell, the wafers pass several production steps. It is essential for the cost-optimized manufacturing process to identify defective products as soon as possible, before they enter the next cost-incurring step. The inspection has to begin with the examination of the wafer blanks. Are there contour defects? Are edges damaged? Is the wafer soiled? These questions can be answered using optical image processing. The exact dimensions are also significant for further processing as well. By using a vision sensor of the *VeriSens*® XC series, for example, the answers can be given by length validation of the edges. Whether the edges are at the required angle to each other can be determined with these easy-to-use vision sensors in the same inspection step.

Industrial image processing components, such as the XC series VeriSens® Vision Sensors and the HXG or SXG series cameras, can help to reduce costs when manufacturing solar modules.

In order to achieve a high precision in the image evaluation they provide a resolution up to 2 megapixels, a fully integrated flash controller and a C-mount interface. The patented *FEXLoc*® technology ensures 360° part location – this means that now it is also possible to monitor those wafers that are not aligned on the assembly line in the right way by correcting the position virtually inside the vision sensor.

Checking the crystal structure for stable long-term use

The quality of the crystal structure has a major and direct impact on the efficiency and duration of the operating life. Because of this it is even more important to identify defective components in the manufacturing process immediately. Fractures or structure irregularities may be detected by electro- and photo-luminescence measurement. Induced by electricity (electro-luminescence) or by irradiation of the semiconductors with short-wave light (photo-luminescence), the silicon emits light near the infrared spectrum. Material defects, such as microscopic fractures or cracks, glow stronger, while defective contacts between the cells do not emit any light at all. By analyzing the images, conclusions regarding the integrity and efficiency of every single wafer can be drawn. The wavelength of the emitted light (from 900 nanometers upwards) is not only invisible to the human eye; it also challenges the camera sensors being used. Industrial cameras that are especially optimized for the near-infrared range (NIR) are a cost-efficient alternative to the usually high-cost and low-resolution cameras using indium gallium arsenide or deep depletion sensors. For example, the Baumer HX series camera models, which are optimized for the NIR spectrum, are clearly more sensitive at a wavelength above 900 nanometers than the previously available models with silicon sensors. The 1:1 aspect ratio of the 4 megapixel HXG40NIR is particularly suitable for examining square cells that can be inspected in only one single image.

Taking a very close look at glass and coatings

In addition to the solar cells themselves, the glass and coatings also significantly influence the efficiency of the solar modules. The thickness of the coating, scratches or foreign material on the surface and saw marks – these are defects that must be avoided. It is necessary to install high resolution cameras to detect even the slightest deviation in the applied structures. For example, the SX series 8 megapixel cameras from Baumer are able to provide high image accuracy thanks to low readout noise and a high dynamic range. In addition, with Baumer's dynamic tap balancing, the differences in brightness in the four sectors of the CCD sensors can be equalized. This will generate a stable and homogeneous image which simplifies further evaluations. Using the 12-bit mode instead of the 8-bit mode, up to 4,096 shades of grey can be distinguished. Even finer details can be checked in the image with this fine gradation and tiny imperfections can be identified.

The final fitting

Before solar cells can deliver electricity in a sustainable manner, they must be fitted into a stable aluminum frame. For this action not only a precise alignment, but also an exact inspection of the frame is important. Here, too, Baumer *VeriSens*® XC series Vision Sensors can be utilized as a reliable all-in-one solution. The existence of drilled holes and or solder joints and their correct position as well as their arrangement on the frame can be monitored. Furthermore it is not necessary to program a whole image processing application before using the Baumer Vision Sensors. The required parameters for those tasks can be set with the supplied software within just a few minutes. In most cases, the final fitting is followed by a last inspection of the attached codes and serial numbers that guarantee the solar modules traceability. At that point the verification should be as simple as possible. As a compact image processing system in sensor format, the *VeriSens*® ID-110 is already equipped with all the necessary hardware and software. In addition to reading 1D and 2D codes, it can also be used without any preliminary font training to read any texts and numbers (OCR), and evaluate the print quality (OCV) – even when dot matrix printing is used. The easy generation of solar power and its high level of public acceptance, together with decreasing purchase and implementation costs, will most likely result in an increase of solar energy's share in the power mix of the future. Cost-efficient image processing components can make a decisive contribution to this, because the foundation for long-term energy efficiency is laid in the beginning of a solar cells life.

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