Multi-axis system handles silicon wafers for solar industry

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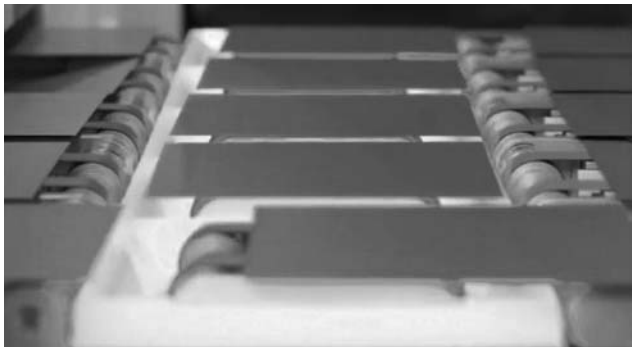

It is really fun to watch the two carbon-fiber jib axes working „hand in hand“ without interfering with each other. In order to take care of their sensitive freight, they work with a steady acceleration curve without jerks. Nevertheless their velocity can make oneself getting dizzy.

The article describes the new plant of a well-known manufacturer of photovoltaic cells and the observing of a so-called wafer transfer system at its work in the manufacturing line. The described handling system may also be used in many other applications where high throughput, jerk-free motion, minimized downtimes and maintainability are required. The complete wafer transfer system has an overall axis number of 15. As network system between the drive units and the higher-level NC controller CANopen is used.

Wafer transfer system

The task of the wafer transfer system is to bundle the wafers (156 mm x 156 mm), which are coming in multiple tracks from the cleaning system to one track. Subsequently, the wafers are fed into the inspection system. Broken wafers or wafers lying partly and/or completely upon each other have to be fed aside carefully.

Regarding the handling in a manufacturing line the silicon wafers used in photovoltaic cells are rather challenging because the material is brittle and may easily break if handled roughly. In the described wafer handling application a double xyz-axis system of Jenaer Antriebstechnik with two jib axes made of carbon-fiber material replaces a robot with delta kinematics. The integration of the system into the manufacturing line has been carried out by SIM Automatisierungssysteme and Rex & Schley Automatisierungtechnik.

In five tracks the wafers run continuously through an optical image evaluation where the geometry is checked and defective wafers are sorted out. The double xyz-axis system takes over the wafer transfer from five tracks to one track (see Figure 1) and the automatic buffering. Currently a maximum throughput of 4800 wafers per hour can be reached, i.e. a complete handling sequence is carried out in only 0,75 s.

Compared to the single picker unit of the robot with delta kinematics the two picker units of the double xyz-axis system can run ▷

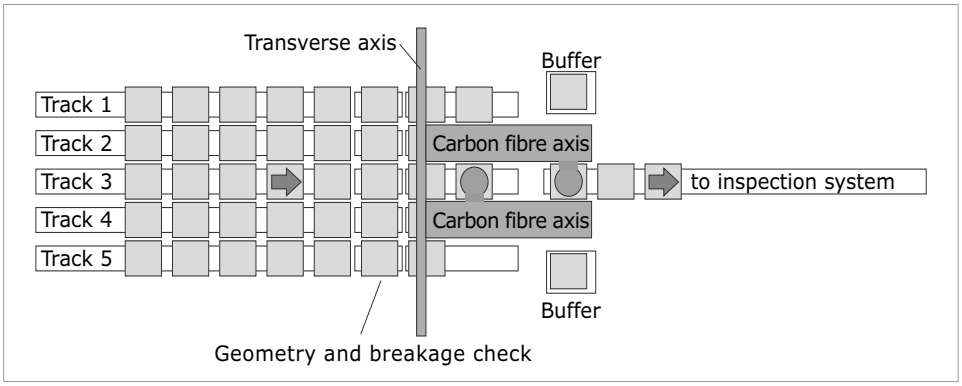

Figure 1: Wafer transfer system with incoming and outgoing wafers

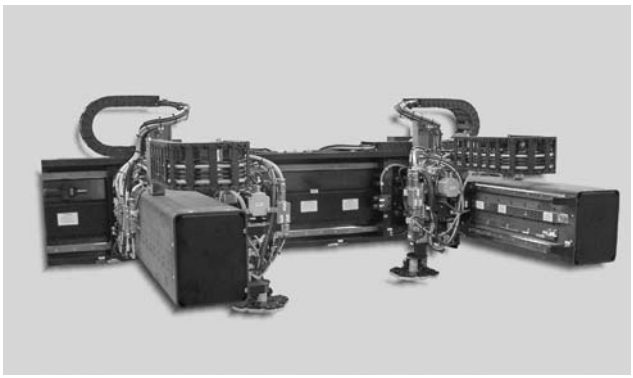

Figure 2: Double xyz-positioning system

Figure 3: Wafer pick-up unit

a steady acceleration curve and have a higher wafer throughput. The advantage of avoiding jerks is the significantly lower breakage rate of the wafers. Moreover, the reduction of vibrations has the additional effect that a disturbance of the measurements in the subsequent wafer inspection system is avoided.

Jib axes for positioning

The axis system consists of a direct linear axis where two jib axes, also direct linear, with carbon-fiber profiles as carrier, are mounted. In z direction (vertical) each jib is equipped with a toothed belt axis with linear measuring system. At the wafer pick-up unit additionally rotational axes are mounted because the wafers can arrive with up to ± 7° deviation related to the center axis and have to be fed aligned (with a maximal deviation of ± 0,5°) to the inspection system.

The wafers are picked up by suction. During the transport the wafers are held by under-pressure, for laying down the wafers the under-pressure is reduced.

By using the carbon-fiber jib axes the positioning dynamic is increased compared to steel or aluminum axes. Reasons are the reduction of the masses and the higher structural stiffness of the material. In order to achieve precise positioning, robust linear measuring systems are used; the repeatability is less than ±10 μm. The wafers may be transported with velocities of up to 2,7 m/s, at maximal accelerations of 13 m/s^2. Thus, the axis system is suited for fast pick-and-place applications like this one.

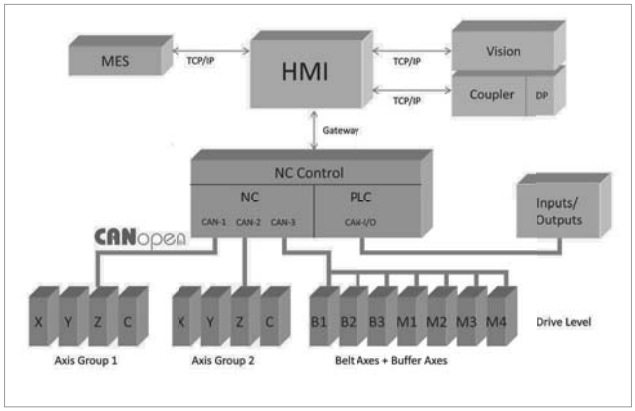

Figure 4: Networking structure

CANopen communication

All axes of the wafer transfer system are driven by servo amplifiers Ecovario by Jenaer Antriebstechnik. As controller interface for the setpoint setting CANopen is used. The drive supports the CiA 301 (CANopen application layer and communication profile) and CiA 402 (CANopen device profile for drives) specifications. As higher-level NC controller the ENC66 by Eckelmann is implemented. This manages the track and ramp generation. For a steady, jerk-less motion of the axis system a jerk filter is implemented.

The networking structure is shown in Figure 4. Because of the high number of axes, four independent CAN interfaces of the ENC66 are used. The NC controller manages the synchronization between the axes. Two interfaces are responsible for the eight axes of the double xyz-axis system. The drives for the belts and the buffers are connected to the third CAN interface. The CANopen communication is handled in the interpolated mode (as specified in CiA 402) with a cycle time of 4 ms. The CAN bit-rate is 1 Mbit/s. After initialization via SDOs (service data objects), the fast data transfer is handled via PDOs (process data objects). The fourth CAN interface is used for digital and analog I/Os and valve blocks. Because of the standardization, further CANopen devices can be easily integrated into an existing network structure.

Plant visualization

The wafer transfer system is connected to a production control system to which all wafer information is handed over. For backtracking each wafer is assigned a unique wafer-ID, which is retained throughout the wafer transfer system.

Rex & Schley Automatisierungstechnik developped a user interface software for the manufacturing line. Included are functions for the operation of the axis system and for plant visualization. Statistics functions help optimizing the manufacturing line. ◀

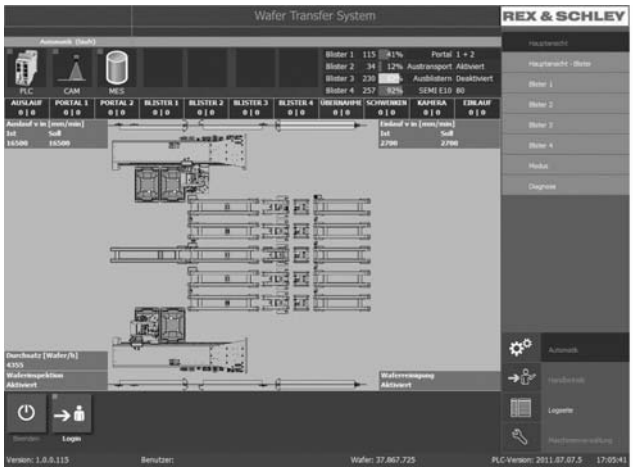

Figure 5: Plant visualization