Stepping Up to the Flat-Panel Challenge

Steve Gardner, Vice President, Azores Corp

Step-and-repeat photolithography system picked for fast, precise display production.

Like all companies looking for production equipment, PerkinElmer Inc. wanted a fast, accurate system for making its large-area X-ray detectors. But with features as small as 2 µm in stacks of thin glass layers, the flat-panel detectors posed a formidable manufacturing challenge. Photolithography offered the necessary precision, but could such a precise system work fast enough for display production lines?

PerkinElmer got the answer it sought from Azores Corp, manufacturer of the Model 5200 PanelPrinter. The 5200 is an advanced photolithography device for large-area substrate applications that require 0.8-4 µm resolution. Key subsystems include a precision X-Y stage, a high-fidelity projection lens, an automated substrate-alignment system, and a sophisticated set of metrology sensors. Working together, these components and others manufacture displays that meet exacting accuracy requirements on high-volume production schedules.

Image Making

Designed for the medical industry, PerkinElmer's detectors feature flat panels consisting of an array of amorphous silicon photodiodes that convert X-rays into high-resolution digital images. The flat panels are made a layer at a time in a photolithography process run by the 5200, a device known as a step-and-repeat system. A stepper creates images by exposing only a portion of the substrate at a time to light from a mercury arc lamp. A series of filters and mirrors projects the light toward a mask, or reticle, that contains circuit patterns. A lens focuses the light through the mask, which strikes photoresist material deposited on the substrate. Then most steppers move

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(or step) the substrate to another position to expose an adjacent area. The process repeats until the entire pattern has been created on the substrate.

To form a complete layer, steppers like the 5200 “stitch” together the smaller pattern segments made during the step-and-repeat process. In the production of X-ray detectors, the stitching process has undergone extensive FDA testing. One cause for concern: stitching errors at the joints between segments. These errors must be limited to no more than 1 µm to prevent performance problems and undesirable visual effects such as a “checkerboard” display appearance.

The 5200 easily meets this requirement, holding image-field stitching errors to less than ±0.3 µm. The device’s stitching success is due to several features, including built-in metrology, laser-metered stages, low-distortion optics, and a closed-loop reticle positioning system with six degrees of freedom.

Accurate Alignment

Besides stitching panel layers together, steppers must align each layer with the one beneath it. Alignment is complicated by the use of glass, an amorphous material that changes dimensions during the thermal cycling of high-temperature processing. The resulting substrate compaction can cause significant overlay errors. Errors as large as 10 µm per 300 mm have been found during testing of glass substrates used to fabricate thin-film transistors.

An industry rule of thumb states that alignment error shouldn’t exceed 30% of the panel’s minimum feature size. So steppers should maintain a layer-to-layer registration tolerance of 0.3 µm or better when producing a panel with a 1 µm minimum feature size.

To meet strict overlay requirements, the 5200 relies on the precision of its stages, which are controlled by a laser interferometer. Also playing a key role is the lens, which provides

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±100 ppm real-time magnification adjustment. Before a new layer is printed, the system uses alignment marks to determine the location of the previous layer on the substrate. Then the stage receives the necessary grid corrections, while the lens makes corresponding magnification changes. By compensating for each substrate based on alignment results, the stepper ensures high overlay accuracy.

Speedier Setup

No matter what advantages it offers, a stepper won’t satisfy display manufacturers if setup takes a long time. But isn’t this unavoidable? After all, steppers are complex machines that must be adjusted to extremely-tight tolerances. In addition, these adjustments do not remain in tolerance for long.

Users of conventional steppers check settings by making special test substrates on a regular basis. After fabrication, manufacturers check the test substrates and then make the necessary adjustments to the photolithography system. The whole process can take hours or even days.

This won’t do in the display industry, where throughput rates demand lithography devices with computer-controlled automatic calibration systems. In the 5200, calibration procedures for the lens, reticle, and platform proceed automatically in a sequential process. Calibration can be completed in as little as five minutes, thanks in part to a set of sophisticated metrology sensors. The sensor set includes:

- Transmission Alignment: detects positioning of the lens grid.
- Modulation Transfer Function: detects lens focus.
- Illumination Intensity: detects illumination uniformity.
- Reflective Alignment: detects the position of the alignment system relative to the center of the lens.

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These sensors and the stepper’s automatic calibration routines combine for fast and accurate system tuning. As a result, optimum process conditions are maintained without the downtime required by adjustment methods based on test substrates.

Yield-enhancing Features

To give production an additional boost, the 5200 includes a number of other time-saving, yield-enhancing features. These include:

- *Auto focus and compensation*. The 5200 employs real-time auto focus measurement and compensation for focusing at each exposure site. Instead of moving the platform, the stepper moves the lens system using fast, precise voice-coil technology. The result: less processing time and higher throughput than systems with a moving platform. Focus compensation is completed in less than 0.05 second — within the X-Y stage settle time for each step — so there’s no adverse impact on production.

- *Dual-lens option*. With the stepper’s dual-lens configuration, users can employ two lenses of the same type, which will double production-line throughput. Alternatively, two different lens types can be used to produce different-size features on the same plate. For example, the high-throughput Azores 80 mm 8015 gT lens can be combined with the company’s high-resolution 33 mm 3333 g lens.

- *Job-setup software*. Display layouts are often very complex, with many different display patterns on each substrate layer. Conventional step-and-repeat lithography systems require users to enter precise coordinate positions of each subpattern on every layer, a process that can take days. Not so with the 5200, which includes Azores’ PanelCAD graphical software for rapid job setup. With a point-and-click interface, PanelCAD minimizes keyboard entry, shortening programming jobs from days to hours.

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Reticle-handling and storage system. To print multiple image types per layer, reticle changing must be much faster than the mask changes in IC production. With a special reticle wheel, the 5200 ensures faster and more accurate reticle exchanges than those of competing systems. The key: a reticle handler with two-axis rotation instead of the normal three-axis movement.

More Advantages

On the production line, the 5200 can be part of a “mix and match” setup that includes steppers and aligners made by other manufacturers. As part of such a setup, the 5200 can image critical layers on substrates, while ensuring grid registration and alignment with other systems imaging resists for less critical layers in the same process line. This arrangement can produce significant savings in capital and operating costs.

With an impressive suite of features for precision imaging, the 5200 produces highly accurate circuitry patterns with a wide process margin on critical dimensions. The device also offers 10 µm depth of focus and ±10% critical dimension control, another reason PerkinElmer decided to use the system.

The company also chose the 5200 because of the resolution capability of its high-performance lenses, which allow imaging below 1 µm under actual manufacturing conditions. Other lenses are available for feature sizes greater than 1 µm.

During production, the stacked X-Y stage moves on frictionless air bearings that prevent contact between moving parts, which virtually eliminates particle contamination. Should the stage or some other component need service or maintenance, the 5200 includes advanced system diagnostics that can be accessed remotely by Azores technicians.

At a customer’s request, an anti-reflective coating can be applied to the stage. Other optional features include a 38-reticle storage library, an automatic cassette-handling system, an edge

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exposure system for bulk resist removal, and a full complement of supporting equipment, including loaders and unloaders.

Conclusion

The Model 5200 PanelPrinter is step-and-repeat photolithography device that precisely manufactures layers with features smaller than 1 µm. As layers are manufactured, the device’s alignment system ensures superior overlay accuracy. During the manufacturing process, an automated calibration system maintains optimal conditions without halting production. This boosts throughput, as do features such as special job-setup software and a dual-lens configuration. Offering both high yield and great accuracy, the 5200 is a compelling choice for the production of large-area x-ray sensors.

16 Jonspin Road • Wilmington, MA, 01887 • Tel: (978) 253-6200 • Fax: (978) 658-6349
sales@azorescorp.com • www.azorescorp.com