Brookhaven National Laboratory

Galil Controller Aids Development of Multilayer Laue Lens Designed for Directing Synchrotron Light

What can one find in something as small as one-billionth of a meter? Apparently, quite a bit, which is why over 2,000 scientists and physicists on average make the trek annually to the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory located in Upton, NY. They come to probe nanostructures as small as a few atoms using the powerful, fast and bright infrared, UV and x-ray light produced by a synchrotron.

The NSLS produces such light by accelerating electrons inside one of two football-field sized rings at close to the speed of light. When the light is focused on a specific sample—like a human cell or a speck of interplanetary dust—it produces an image of its most minute properties on a detector for analysis.

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The NSLS-II electron storage ring delivers photons with a spectral brightness that peaks in the 2–10 keV range.

The findings are leading to significant advances in such areas as Alzheimer's disease, HIV/AIDs, breast cancer, osteoarthritis, hard drives, catalytic converters, corrosion, space travel and environmental cleanup.

To further aid this research, Brookhaven is building a new synchrotron, the NSLS-II which, when completed, will be capable of producing X-rays more than 10,000 times brighter than its cousin. To achieve this, a specially coated Multilayer Laue Lens (MLL) is used for precise steering and focusing of the X-rays to about 1 nm of the item being analyzed.

Working with CVD Equipment Corporation of Ronkonkoma, NY, and Galil Motion Control of Rocklin, CA, Brookhaven developed a magnetron sputtering system that deposits thousands of ultra-thin layers of two different materials (i.e., WSi2 and Si) onto silicon substrates to create the MLL. Coating thicknesses range to 100 micrometers with up to 62,000 layers in a stack, with the thinnest layer less than 1 nm.

During production, the substrates are loaded onto a linear-translation stage or "transport car" that rides on a stationary base and rail assembly, and is controlled by Galil's DMC-4020 motion controller.

The standalone, 2-axis controller sends signals to a Trust Linear Amplifier and receives feedback from a high resolution encoder to move the car one-dimensionally back and forth throughout the 23-foot, ultra-high vacuum chamber that contains nine magnetron sputtering guns and four cryogenic pumps. The car travels at defined speeds from .01"/second to 9"/second, with maximum acceleration reaching and maintaining no less than 5"/second.

Typically, the coating process involves the deposition of several thousands of layers over as many as 100,000 non-stop cycles over a period of six days. A critical specification of the MLL deposition system called for a smooth, reliable and repeatable velocity stability with less than .01% ripple. The Galil controller beat the specification by four times.

It did so with its sinusoidal commutation mode which assured that a smooth sinusoidal signal (resolved into a full 16-bits) was sent to the amplifier. This, plus the incorporation of a linear amplifier instead of a switching one, enabled the DMC-4020 to reduce the velocity ripple to 0.0025%.

The engineers at Brookhaven appreciated the position mode of the Galil controller which allowed for easy programming of the back and forth linear motion of the transport car.

Another key feature is that all communication between the DMC-4020 and the host computer is via Ethernet. This enabled the host computer to send commands to the controller to commence a new cycle the moment after receiving signals from the controller announcing the completion of a cycle.

To ensure accuracy and repeatability, the DMC-4020 recorded actual position, position error, velocity and torque every twenty seconds of each cycle to provide data logging and check for system errors. ■

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