Ion Beam Deposition Automation

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Category: R&D/Lab Automation

Products Used:

PCI-6052E MIO DAQ card

SCXI-1001 SCXI Chassis

SCXI-1125 8 channel analog input signal-conditioning unit

SCXI-1180 feed through panel

SCXI-1124 6 channel analog output unit

SCXI-1161 8 channel relay unit.

PCI-GPIB

PCI-232/8

The Challenge: Automate an ion beam deposition system with a price-tag of close to 1 million dollars, that was being under-utilized due to the complexity of operating it.

The Solution: Using new features in LabVIEW 6i, such as the tab-control and data-socket connections of the front-panel controls, we were able to fully automate the deposition system so that it can now be controlled using a simple script.

Abstract: The Naval Research Laboratory expressed a desire to automate an ion beam deposition system. Because of the manual nature of every control, operating the system required the presence of highly qualified personnel during the entire deposition process. Using LabVIEW to control the Ion-Beam power supplies, the Kepco power supply, the gas controllers, and all the valves, while monitoring the pressures and flows in the system allowed us to fully automate the system and control it using a script language.

The Ion-Beam deposition system Before the system was automated, personnel was needed to control the power supplies to the two ion beam sources for each of the targets as well as a third ion beam source used for cleaning and assisting during deposition, the shutters for both targets and the shutter for the substrate. There was no PID setup to control the substrate temperature. Additionally, the operator had to manually monitor the deposition rate using the two Inficon Crystal Monitors, one for each target. There was no feedback mechanism in place, and the deposition process was not logged. Furthermore, any inadvertent errors, such as depositing for too long or too short went unnoticed, invalidating any further research performed on the sample deposited.

Data Science Automation was contracted to provide a turnkey solution that would operate the ion-beam deposition system using a simple script, such that even personnel with a minimal technical background would be able to operate the system.

Data Science Automation installed a Pentium III PC running Windows 2000 with a National Instruments GPIB card, an 8 port serial card, and a DAQ-card. The serial ports and GPIB controller provide communications to the Ion-Beam and heater power supplies, and the crystal oscillator controller. The DAQ-card controls and SCXI-chassis with SCXI-1124, SCXI 1125, SCXI-1161, and SCXI-1180 modules. The modules provide the analog and digital IO to control 4 pneumatic valves, 4 electromagnetic valves, 4 flow controllers, the substrate temperature, and give the capability to monitor the gas flows and pressures at various locations in the system.

Fig 1: The Ion-Beam deposition system that is now completely automated

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Using new features of the LabView 6i Environment, such as the tab-control, Data Socket Connections and control references, Data Science Automation was able to develop an application which only requires user interaction during the creation of the script, and requiring little to no user interaction during execution of the script. This reduced the risk of operator errors significantly, and most importantly, because the system logs all operations, the exact deposition procedure can be verified for as long as the log files are kept. The program also allows the same script to be executed multiple times, thus enabling the experimenter to repeat the same procedure, removing the variability inherent in manual operation of the equipment.

The application was developed using a fairly complex queued-state machine, which allowed for the execution of the script, and still allow for user interaction. Twenty different commands were implemented in the script language, including variables and the ability to execute a 'FOR – NEXT' loop.

Four additional loops execute in the background, each of which has access to several front panel controls using control-references. The first loops communicates over RS-232 with the Gauge controller and continuously updates the pressure readings from the Ion Gauge, the Baratron Manometer Gauge and the two Convectron Gauges on the front panel. The second loop monitors all the Ion Gun controls, and communicates any changes to one of the three Ion-Beam power supplies over RS-232. The third loop monitors the substrate temperature and controls a kepco power supply over GPIB using PID. The last loop monitors for any errors in the system and logs all relevant parameters to a file each time a step is executed in the script.

Not only can the system now run automatically with little user intervention, as an added benefit, the operator can even monitor and control the system from his or her desk, requiring far fewer entries into the clean-room where the deposition chamber is located!

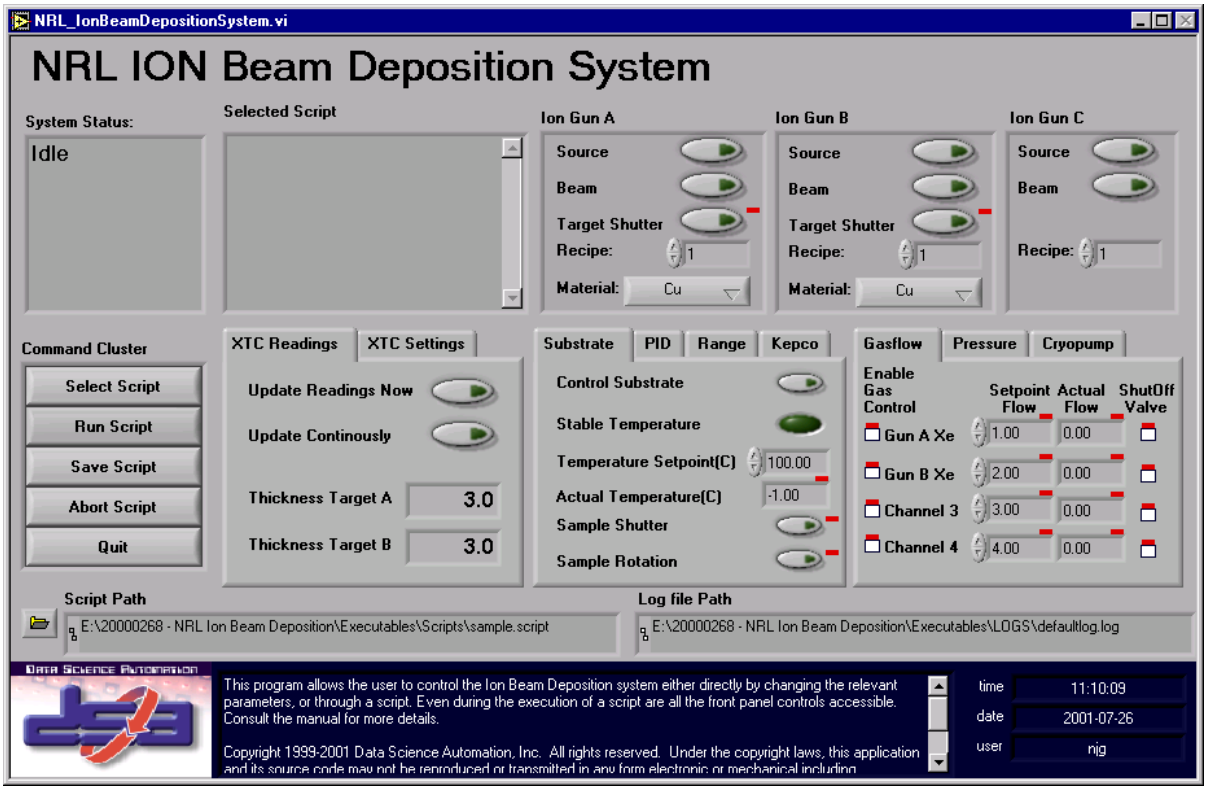

Fig2: The user interface, allowing full control of the system from just a single window.

In conclusion, LabVIEW provided an easy to use development environment which allowed us to easily develop high level instrument drivers for each of the ten instruments being controlled (four power supplies, a crystal monitor, a flow controller, a Baratron gauge monitor, an ion-gauge controller, a stepper-motor controller and several valves). Using the NI-DAQ OPC server and VISA allowed for easy connectivity to the hardware.

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