Programming an Experiment Control System

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As NASA develops plans for more and more ambitious missions into space, it is the job of NASA's researchers to develop the technologies that will make those planed missions feasible. One such technology is energy conversion. Energy is all around us; it is in the light that we see, in the chemical bonds that hold compounds together, and in mass itself. Energy is the fundamental building block of our universe, yet it has always been a struggle for humans to convert this energy into useable forms, like electricity. For space-based applications, NASA requires efficient energy conversion methods that require little or no fuel.

Here at the NASA Glenn Research Center, the Photovoltaic and Space Environments branch has spent years researching one such method, solar cell (photovoltaic) arrays. This summer, I worked as an intern in this branch under Dr. Donald Chubb, who is currently researching a novel application of solar cell technology, Thermophotovoltaics (TPV). A TPV system at its core contains three parts: a heater, an emitting material, and a photovoltaic array. The heater brings the emitter material up to a high temperature. The heated emitter releases electromagnetic radiation in the infrared range. This radiation is then absorbed by the photovoltaic cells, which convert the radiation energy into electricity. In order to make the TPV system as efficient as possible, the emitter and the photovoltaic array must be synchronized, that is, the emitter must emit a large amount of radiation at wavelengths that the photovoltaic cells absorb well. The system's heater can be anything that produces heat – a traditional combustion source, a nuclear reaction, or something else. This flexibility makes the TPV system adaptable to many different applications, both space-based and terrestrial.

This summer in Dr. Chubb's lab, we have been preparing an experiment that will help determine the expected usable life of a TPV system. A major limiting factor on the life of the system is the evaporation of the emitter material and its deposition on the photovoltaic cells. As the emitter material deposits on the cells, the cells become less and less efficient. Our experiment will measure the vapor pressure of some candidate TPV emitter materials, allowing us to determine how much lifespan we can expect out of a TPV system utilizing each different material.

The experiment itself takes place inside a vacuum chamber. A sample of the emitter material is heated by a filament, which carries a current delivered by a power supply. Due to the extreme heat, emitter material will evaporate and deposit onto a detector called a quartz crystal monitor (QCM). This detector determines the rate of deposition and the thickness of the deposited material based on changes in the oscillation frequency of the crystals. The rig also contains several thermocouples to monitor the temperature and a residual gas analyzer (RGA), which analyzes the composition of the extremely low-pressure atmosphere inside the rig.

My work this summer has focused on creating the computer program that will communicate with all the experimental equipment, and therefore serve as the monitor, control, and recording system for the experiment. I have done all my programming in Microsoft's Visual Basic design environment. To create the program, I first adapted some existing programs and created some new programs that talk to each piece of equipment individually. The different components communicate with the computer through three different hardware systems: the computer's COM ports, a GPIB (General Purpose Interface Bus), and a PCI (Peripheral Component Interconnect) card. In order to communicate with the devices, I had to become familiar with the programming protocols for all three.

Right now, I am nearing completion of the first version of the experiment control program, which will display and record data from the QCM, thermocouples, power supply, and pressure gauge simultaneously. In addition, the program will allow the user to control each device. This will allow the user to set such things as the measurement units of the pressure gauge, the QCM's parameters, and the current delivered by the power supply. The program will also calculate the vapor pressure of the material being evaporated. This program will be used to monitor the initial run of the experiment, in which we will test the vapor pressure of silver. Since the vapor pressure of silver is already well known, we can compare our results to the accepted value to test the accuracy of our rig.

For subsequent runs of the experiment, in which we will be testing the unknown vapor pressures of our TPV emitter materials, I will expand the program to automatically change the current delivered by the power supply to regulate the temperature of the material. This will allow the experiment to run for days to weeks with absolutely no user input.

The data from this experiment will help us learn important information as we develop a new technology, and my program will be responsible for gathering and recording that data.