Automation of Sample-Positioning and Data-Collection for Pulsed-Laser-Melting Experiments

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Abstract:

Pulsed laser melting, a powerful technique for producing new alloy materials, is typically time-consuming and labor-intensive. A computer-controlled sample positioning and data collection system was designed and built to improve the efficiency and reproducibility of this process. Three automated stages driven by stepper motors positioned samples with micron-scale precision. Data from high-speed photodiodes tracking laser pulse duration and sample melt duration was captured by a 500 MHz oscilloscope. A high-resolution beam profiling camera recorded the uniformity of every laser pulse. These instruments were integrated by a graphical user interface developed to facilitate user operation of the system. The improvements implemented are expected to speed sample production substantially.

Introduction:

The current experimental setup is depicted in Figure 1. This setup consisted of manual calibration of the samples, storing of collected data into a floppy disk, and formatting data to see results more clearly. However, with the incorporation of new devices and implementation of new programs, a new setup would have a fast and accurate positioning system with immediate data transfer and readily available results. These enhancements were designed and built in a simpler environment for easier development and testing (see Figure 2).

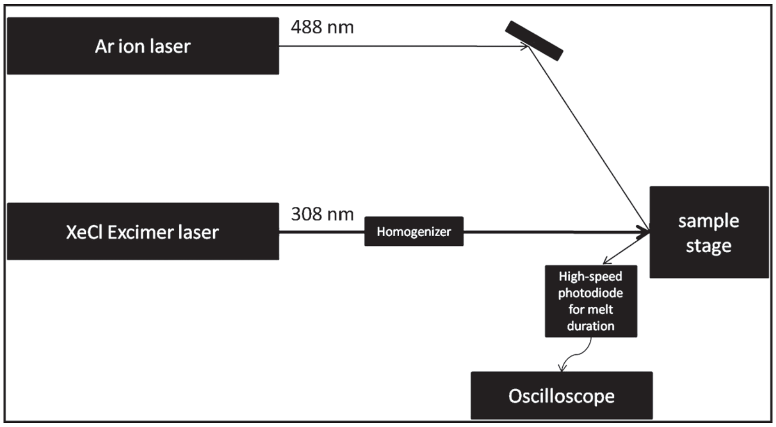

Figure 1: Top view diagram of current pulsed laser melting experimental setup.

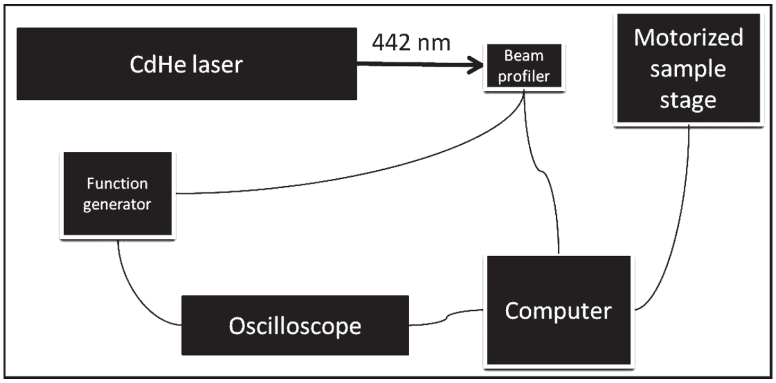

Figure 2: Top view diagram of testing setup for the data collection and sample positioning system.

Experimental Setup:

The positioning system consisted of three motorized Velmex slides with four, six, and thirty inch lengths, which were assembled into a stage as shown in Figure 3. The 4″ slide was assigned to represent the z-axis, the 6″ slide to the y-axis, and the 30″ slide to the x-axis. The stage allowed for samples to be mounted onto the y-axis and to be moved in a three-dimensional space. The slides could be moved one at a time with variable speeds up to 3 mm per second along the x and y axis, and 1.5 mm per second along the z axis. The x and y slides had a precision of 5 μm and the z slide had a precision of 2.5 μm.

The data collection devices were a Coherent attenuator and high resolution UV camera, and

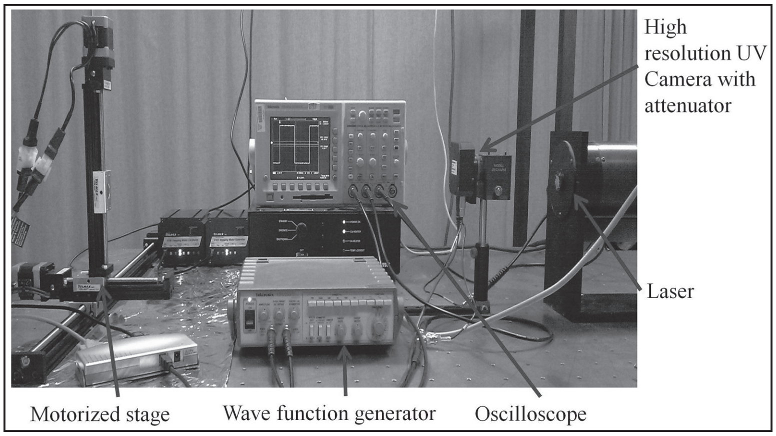

Figure 3: Testing setup for the data collection and sample positioning system.

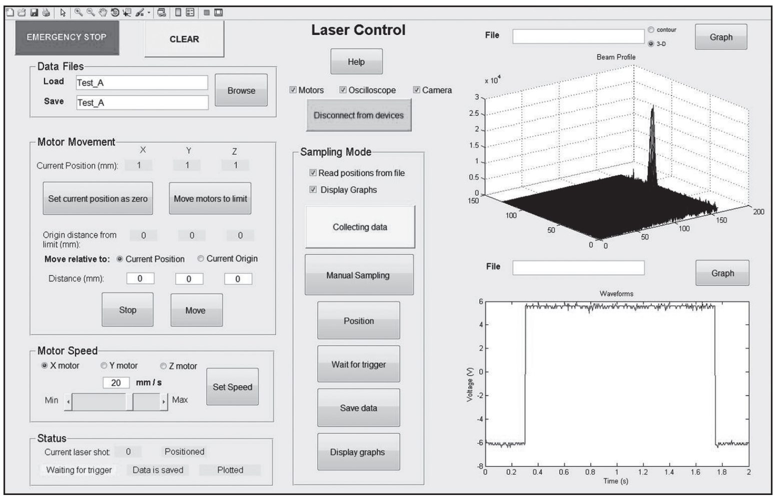

Figure 4: Graphical User Interface in continuous sampling mode.

a Tektronix oscilloscope, Figure 3. The camera captured beam profile data from the laser beam and the oscilloscope recorded trigger signals, which represented the melt and pulse duration data from two high-speed photodiodes.

The probe instruments were an Omnichrome laser and a Tektronix function generator, Figure 3. The laser emitted a constant beam onto the camera and the function generator sent pulsed triggers to the camera and oscilloscope, so that together, the laser and trigger, would simulate a pulsed laser. These trigger signals would alert both the camera and the oscilloscope to start capturing data.

Device Communication:

The slides and the oscilloscope were connected via a RS232 cable to a RS232-to-USB adapter. The adapter was connected to a USB port in a HP touch screen computer. Commands and queries were sent and received to the motor and oscilloscope by establishing a serial communication using Matlab's Instrument Control Toolbox. The camera was linked to the computer via TCP/IP. Basic commands could be sent to the camera, although its own software, BeamView, had to open in order to establish communication.

Interfacing:

A graphical user interface (GUI), Figure 4, was developed in Matlab's graphical user interface design environment. The purpose of the GUI was to create a level of abstraction that allowed the user to focus on the parameters and results of the experiment and overlook the underlying code and data manipulation. The GUI consisted of push and radio buttons, check and input boxes, and display windows that offered the user the ability to control motor movement and speed while monitoring the status of the experiments. The GUI also gave the user several options when conducting an experiment, such as graphing data on the fly, loading files containing experiment settings, and choosing the file location to save the data.

Conclusion and Future Work:

The time it takes to run an experiment is expected to decrease by having the sample move automatically from one position to the next with micron-scale precision in a matter of seconds. This same precision will also increase the reproducibility of the experiment, and subsequently decrease the production cost of the samples.

In addition, with the faster and more direct serial communication established with the oscilloscope, pulse and melt duration data can be obtained and analyzed almost instantly; this translated into having readily available data that allows the user to make more immediate and wiser decisions for subsequent experiments.

Finally, the camera allows the user, for the first time, to analyze the beam quality of each laser pulse. This is critical as measurements of beam diameter, intensity, and hot spots can potentially be used to explain new phenomena and abnormalities in the experiments.

The next step in this project is to incorporate the sample positioning and data collection system into the actual laser melting setup. As experiments are conducted, the code will be adjusted to improve the efficiency of the experiments and to fit the necessities of the users.

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