Comparing Single Piece vs. Multi-piece Laser Mounts

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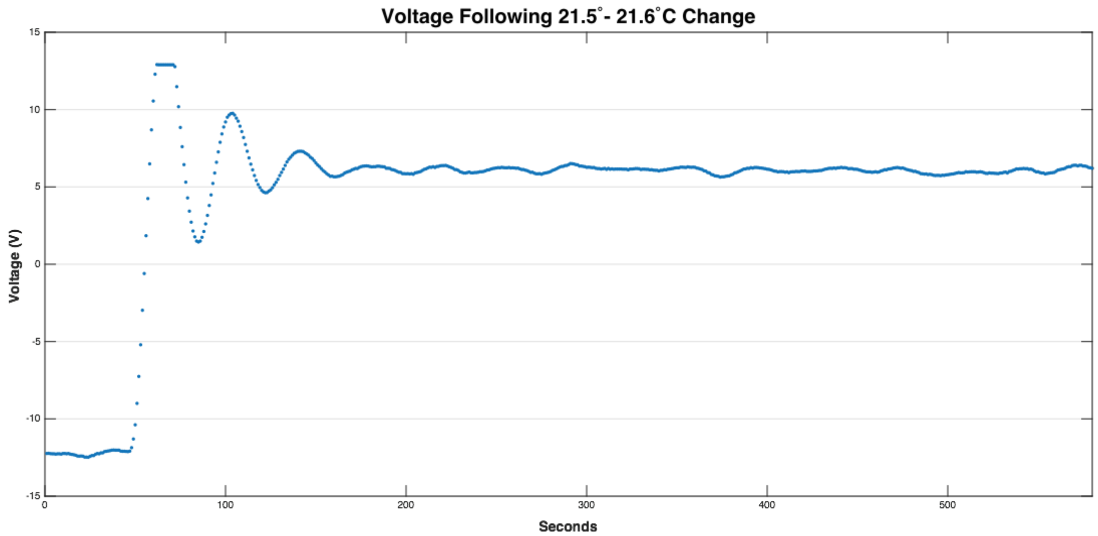
Two different diode laser mount designs were tested for thermal stability near the diode when the laser was operating with a thermoelectric cooler (TEC) as a temperature controller at the bottom of the mount. The temperature was monitored at the diode and TEC simultaneously. The laser mount composed of a single piece of aluminum proved more effective in minimizing temperature fluctuations at the diode as opposed to the multi-piece mount design.

Introduction

To monitor temperature fluctuations at various points on the laser mounts, a circuit consisting of two separate bridge circuits with one resistor in each being a thermistor was used. The difference in voltage at opposite sides of the bridge circuit are amplified through an operational amplifier which allowed small voltage changes in the bridge circuit, which correspond to temperature fluctuations, to be detected. Prior to testing, the single piece aluminum mount was expected to better stabilize the temperature at the diode when connected to the temperature control system. The thermal conductivity of the solid aluminum would allow the TEC to have more control over thermal fluctuations at the diode, whereas the multi piece mount had several interfaces between the TEC and the diode which would inhibit the effectiveness of the temperature control system.

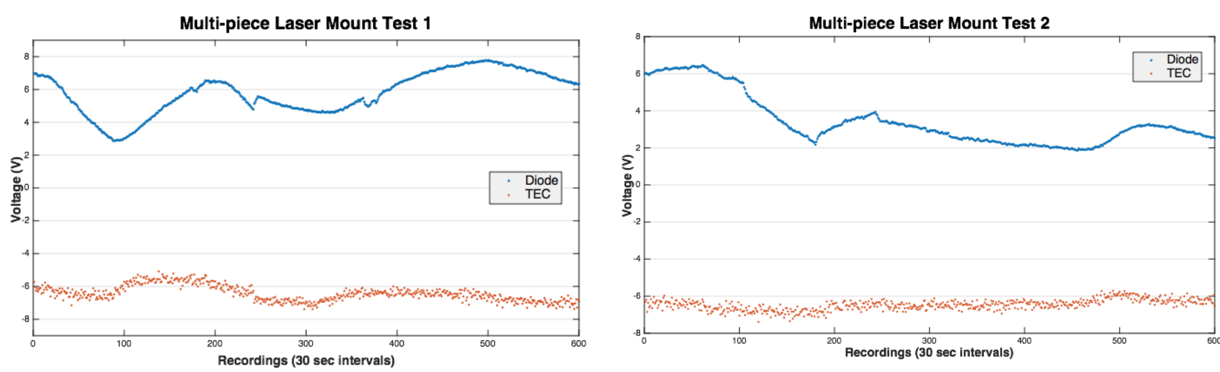
Results

Although the actual relationship between resistance and temperature of the thermistor is nonlinear, the temperature fluctuations we are investigating are so small (< 0.1˚C) that we can assume it to be linear. To obtain a scale for the voltage change in response to a certain change in temperature, a thermistor was set at the copper plate attached to the TEC and the voltage was recorded as the temperature controller was increased from 21.5˚C to 21.6˚C. Plot 1 below shows the voltage recordings shortly before the temperature was increased and several minutes afterwards. The resulting voltage increase was about 18 V, which scales to about 5 V per 0.03˚C.



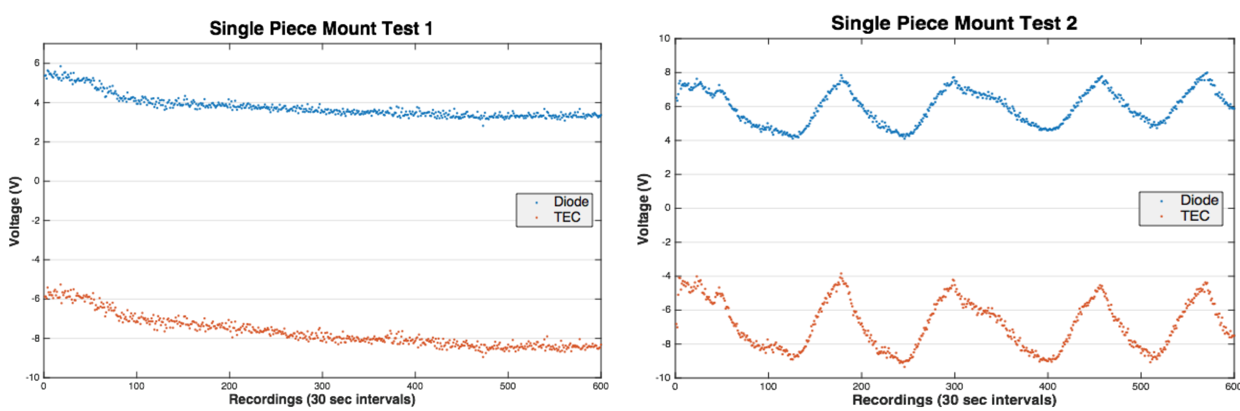
Plot1. Voltage readings with thermistor at the TEC as the temperature controller is increased by 0.1˚C

For testing the multi-piece laser mount, a thermistor was set on top of the copper plate near the thermistor for the temperature controller. The other thermistor was set in a hole in the mount and made contact with the capsule holding the diode. The voltage in both circuits were recorded simultaneously in 30 second intervals while the temperature controller was set at 21.5˚C and the laser operated at 72.7 mA. Plots 2 and 3 below show the voltage recordings of two tests taken with the multi-piece mount. The temperature near the TEC appears to remain stable over the long term. However, the temperature is more scattered at the TEC over the short term (<5 min.), which is likely due to variations in the temperature controller output. Points farther from the TEC, near the diode, are presumably less affected by the small oscillations of the temperature controller because the several interfaces between the TEC and the diode in the multi-piece mount reduces the thermal conductivity of the setup.



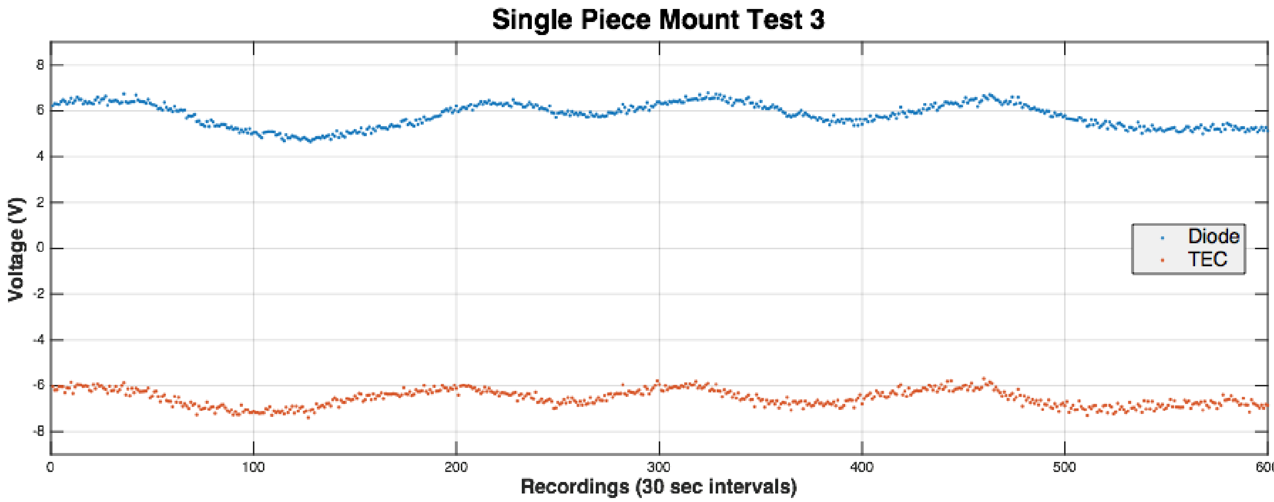
Plots 2 & 3. Voltage readings with one thermistor at the copper plate near the TEC and another at the diode using the multi-piece mount

For testing the single piece mount, several holes were drilled in the mount for testing various locations for thermal fluctuations. For one set of tests, a thermistor for the bridge circuit was set at the bottom of the mount near the TEC along with the thermistor for the temperature controller. The other thermistor was set just below the laser diode in the mount. The voltage in both bridge circuits were again recorded simultaneously in 30 second intervals while the temperature controller was set at 21.5˚C and the laser was operating at 72.7 mA. Plots 4 and 5 below show the voltage recordings of two tests taken with the single piece mount. Throughout both tests, the temperature at the diode strictly follows the temperature drifts at the TEC, clearly showing that the TEC has more influence on the diode temperature as compared to tests with the multi-piece mount. Also, the test for plot 5 was taken on a day with unusual variation in the room temperature, yet the fluctuations at the diode remained less than that of the multi-piece mount. However, the scattering observed at the TEC with the multi-piece mount now also appears at the diode on the single piece mount. This could likely be a result of the higher thermal conductivity allowing for small short term oscillations of the temperature controller to reach the diode.



Plots 4 & 5. Voltage readings using the single piece mount with one thermistor at the bottom near the TEC and another just below the diode

The thermistor setting below the diode was closer to the TEC than the setting for the multi-piece mount, so the thermistor was also set above the diode on the single piece mount to test a point farther from the TEC. As can be seen in plot 6 below, the temperature fluctuations at the diode very closely match the temperature changes close to the TEC. Examining the curves for the diode and TEC along with the vertical grid lines, a small amount of lag in response time of the temperature at the diode from temperature changes at the TEC can be seen. This is likely the result of the greater distance from the TEC and the thermistor above the diode. The corrections from the temperature controller reach the bottom thermistor first before making it to the diode. This observation suggests that the most significant temperature changes throughout this test were actually a result of some long term thermal oscillations of the temperature controller rather than fluctuations in air temperature.



Plot 6. Voltage recording using single piece mount with one thermistor near the TEC and another above the diode

Conclusion

Comparing the results of the tests on the two laser mount designs, the temperature control system works more effectively at minimizing temperature drifts when working with the single piece mount. Although it's difficult to measure exactly how much of the temperature fluctuations at the diode are from changes in the TEC output, the variations measured with the single piece mount are significantly less than the fluctuations recorded with the multi-piece mount. The minor scattering seen with the single piece mount is extremely small compared with the temperature drifts on the multi-piece mount. In addition, the variations with the multi-piece mount seem very random while the temperature with the single piece mount is mostly controlled by the TEC and seems to remain centered about a fixed temperature.