Chapter 5: Suggestions for Future Work

The work presented in this thesis helps to further the goal of developing a real-time fiber sensor that can measure displacements of up to 6.35 millimeters with a resolution of 10 microns at temperatures of 1500 degrees Celsius, but much work remains before the final product can be fabricated. It is the ultimate goal of this work to develop a sensor system that is portable and can be operated by those having little familiarity with optical fiber. This development requires both finding better techniques to use in configuring the modified WSFMI system, and locating and developing higher quality system components. It is also mandatory that the system become computer automated.

The results of this work will be greatly improved when several key components are replaced by those of higher quality. With the acquisition of a more perfect sapphire fiber, the signal returned by the sensing arm will be greater in amplitude and will suffer less from the effects of mode mixing and scattering losses. This will result in the fundamental mode fringe groups having a higher signal to noise ratio. This will enable the zero order fringes to be identified more accurately. The incorporation of a custom-designed alignment tube in the sensing head will act to boost the amplitude of the signal returned by the sensing fiber endface by prohibiting lateral or angular movement of the sensing fiber endface. It would also be advantageous to acquire a higher power source. One possibility is a fiber-based amplified stimulated emission source, another is the use of the combined power of several semiconductor sources.

The power coupling between the singlemode fiber and the GRIN lens in both the measurement and the sensing arms will benefit by the physical coupling being better executed. The assembly used in the measurement arm to collimate the light from the singlemode fiber was fabricated carefully, but using limited precision alignment devices. The quality of the collimator will be improved if every step the fabrication process is precisely controlled. If this is not possible, commercially available collimators have good quality. The singlemode fiber and the GRIN lens in the sensing arm are joined together by a bead of index matching fluid. While the fluid is useful in a research environment, it becomes dirty, evaporates, degrades in light, and is difficult to handle. It will be useful to develop a method for coupling from the singlemode fiber into the GRIN lens that allows the fiber to move freely with respect to the lens, but that allows for optimal power coupling between the two elements.

Currently, much of the electrically-based equipment, such as the preamplifier and the actuator that drives the mirror in the sensing arm, contribute electrical noise to the signal displayed on the oscilloscope. The addition of a low bandpass filter to eliminate this noise is highly recommended. Electronics should also be developed to allow the mirror to track the changes in the optical path length (OPL) of the sensing arm due to changes in temperature. This is currently done manually. The difference in the optical path length that the measurement arm must match differs by tens of millimeters between room temperature and elevated temperature testing environments. It is recommended that the OPL of the measurement arm be adjusted by altering the distance between the GRIN lens and the average position of the actuator-mounted mirror. Because the speed of data acquisition depends on the rate at which the mirror scans back and forth, it is inadvisable to alter the movement of the mirror to allow it to scan over a wider range.

If a portable sensor system is to be designed, it will benefit by the flexibility resulting in the use of longer lengths of singlemode fiber in the measurement and sensing arms. The length of singlemode fiber is currently limited to 1 meter because of polarization mode fading. While no simple solutions to the problem of polarization mode fading are obvious, it may benefit the development of this sensor if a combative method is implemented. Reducing polarization mode fading will also help to increase the signal to noise ratio at the output of the sensor.

The sensitivity of this system to perturbations of the surrounding environment, such as normal room vibrations limit the usefulness of the sensor. It is anticipated that the sensor will find use in test and measurement laboratories, where heavy industrial test apparatus will produce pronounced vibrations. Immobilizing the reference and sensing fiber endfaces in a custom-designed alignment tube will reduce the sensitivity to vibrations. It is also anticipated that the use of a more perfect sapphire reference fiber will reduce the opportunities for mode-mixing that are introduced by vibrations. With this reduced sensitivity, it may become easier to maintain the dominance of the fundamental fringe group. Some mode mixing will always occur in response to vibrations, regardless of how perfect the multimode fiber is, because the vibrations perturb the ideal geometry of the waveguide. If the sensitivity of the multimode sapphire reference fiber to vibrations cannot be reduced to acceptable levels, the development of the sensor may depend on the availability of a singlemode sapphire fiber.

Any final version of this sensor requires the use of a computer and specialized software to control the sensor system and to acquire and analyze the data. Ideally, the factor limiting the speed with which the sensor determines the value of the displacement of interest will be the speed with which the actuator-mounted mirror scans. The speed with which a computer is able to access data, determine the position of the zero order fringes, and tabulate the data make this a possibility. The computer could find use in automatically aligning the modified WSFMI system to make the fundamental mode fringe groups dominant, ensuring that they stay dominant throughout the test, and adjusting the optical path length of the measurement arm as the temperature of the test environment changes.