# Microtester Facility at The Ohio State University

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Summary of Findings

This finding details the development of a miniature mechanical test facility we have developed to study materials issues associated with electronic packaging. A small test machine (Microtester) was designed in conjunction with a commercial vendor, and then manufactured. A thermal chamber was designed and fabricated in-house which permits testing to temperatures as high as 150°C. The facility is completed with microscopic video capability so that test specimens may be continuously observed. We are currently using the facility to gather fracture toughness data on molding compounds using small compact tension specimens.

## Technical Results and Data

### Description of Microtester and Associated Facility

The microtester was developed in collaboration with EnduraTEC Systems Corporation of Minnetonka, MN after an extensive inquiry in which all known vendors of mechanical testing machines were contacted and given the opportunity to participate in the development of such a device. In addition to tentative specifications as to the size, maximum load capacity, and precision of the machine, it was deemed essential that the device should have two moving cross-heads in order that the center of a symmetrical specimen not move during testing; this facilitates microscopic observation of, e.g., a centrally located crack during loading.

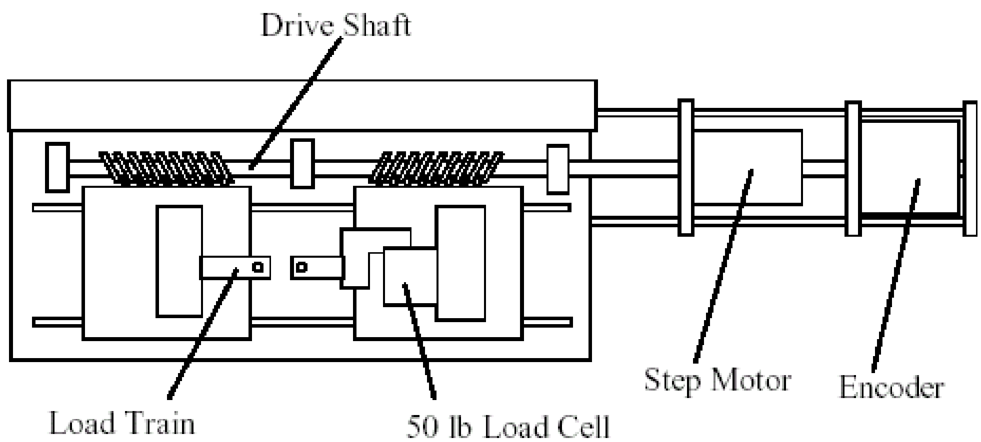



**Figure 1** Schematic of Microtester

Figure 1 presents the elements of the microtester. A drive shaft which incorporates both a right and a left-hand thread is driven by a step motor. A rotary encoder monitors the rotary position of the shaft and consequently its axial position as well. Two stages, which comprise the two ends of the load train, are driven in opposition by the two threads on the drive shaft. A 50 lb capacity load cell is included in the load train.

The control system for the microtester is illustrated in Figure 2 for the case of displacement control. The displacement, as sensed by the rotary encoder, provides the feedback signal for closed loop control of displacement through a step motor controller card (supplied with the microtester) which is incorporated into a personal computer. The output of the controller drives an amplifier, which in turn powers the step motor. Load control, based on a feedback signal from the load cell, is also provided for in the software and hardware provided with the microtester.

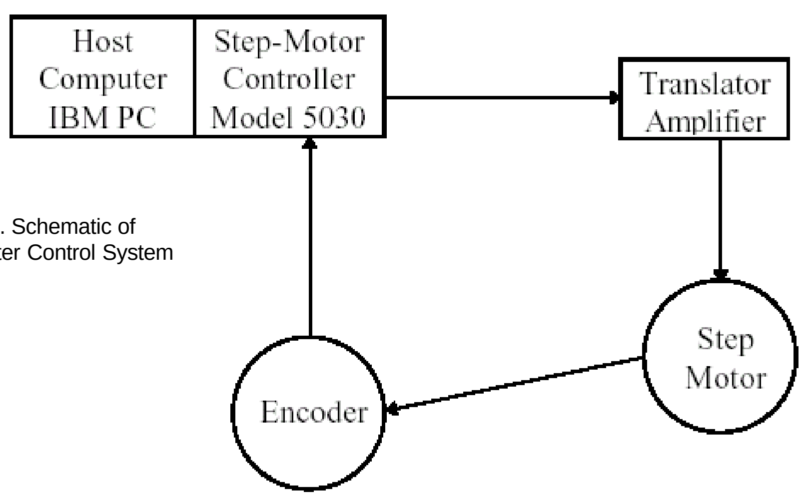



**Figure 2**. Schematic of Microtester Control System

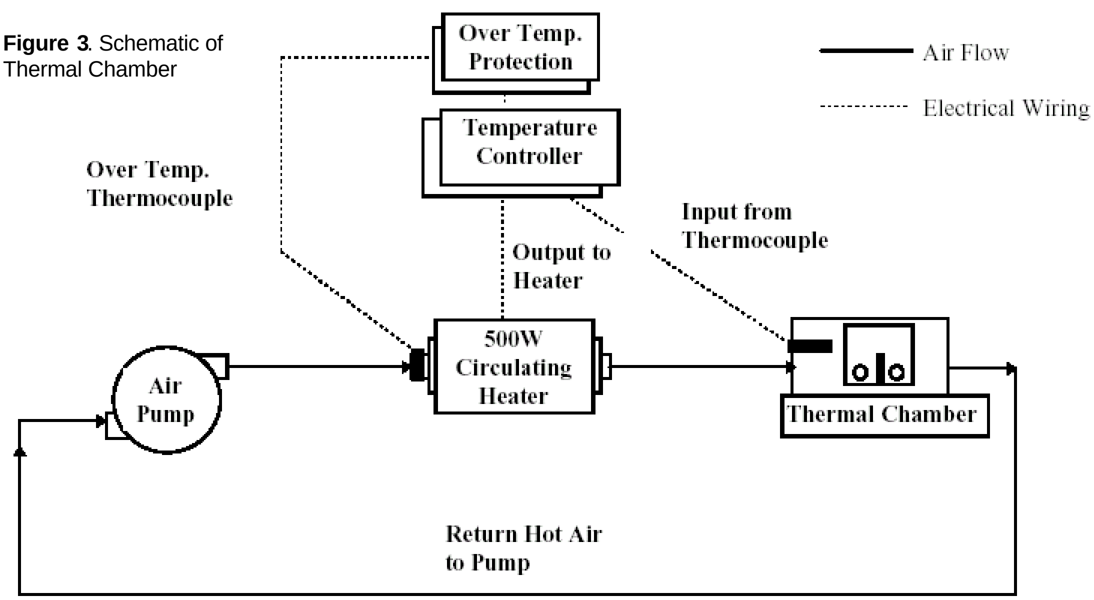
The control of the microtester is through the computer noted above and is menu driven. The format for control and terminology used is largely that used with traditional servohydraulic closed loop test machines. The software provided with the microtester provides the usual control functions, namely, ramps, square waves, and sinusoids. A summary of both the microtester specifications and control characteristics is provided in Table 1. The system software also provide for data logging.

Table 1. Microtester Specifications

| | |
|---|---|
| Least Count on Load | 0.0244 lbs |
| Least Count on Stroke | 0.06 mils |
| Load Cell Capacity | +/- 50 lbs |
| Stoke Displacement | 0 to 4182 mils |
| Displacement Rate Range | 0.00001 to ~800 mils/sec |
| Wave Functions | Sine, Triangular, Square, Ramp, Dual |
| Heater Capacity | rm. temp to 150 deg Celsius |

A thermal chamber was designed and fabricated for use with the microtester. This box-like structure is approximately 4-inches on a side. The exterior of the chamber is sheet aluminum. The interior is lined with 1/4-inch-thick sheet insulation. Fittings for circulating air and a thermocouple are provided, as well as two ports to accommodate the load train. The top of the thermal chamber is made of Lexan® clear plastic; this allows for continuous examination of tests. Hot air is supplied in a circulating system incorporating a 17 CFM blower and a 500 watt heater, as presented in Figure 3. A temperature controller and an over-temperature shut-off circuit are also part of this system.

**Figure 3**. Schematic of Thermal Chamber




The thermal chamber may also be used for cold testing. Simply replacing the pump and heater with a liquid nitrogen bottle, and venting instead of recycling gas exiting the chamber, produces a capability (demonstrated) for generating temperatures as low as negative 93°C. The addition of a servovalve actuated by the temperature controller will permit closed-loop control of these subambient temperatures.

The facility also includes the capability for microscopic examination and video recording of tests. A microscope equipped with a video camera is mounted on a boom support for ease in positioning over the test chamber. Fiber-optic light sources are present which may be positioned for favorable lighting within the chamber. The output of the video camera is both recorded by a VCR and displayed on a monitor. A second computer associated with the facility incorporates image analysis software for digitizing images from the video monitoring and processing data from the microtester. Figure 4 summarizes the integrated facility.

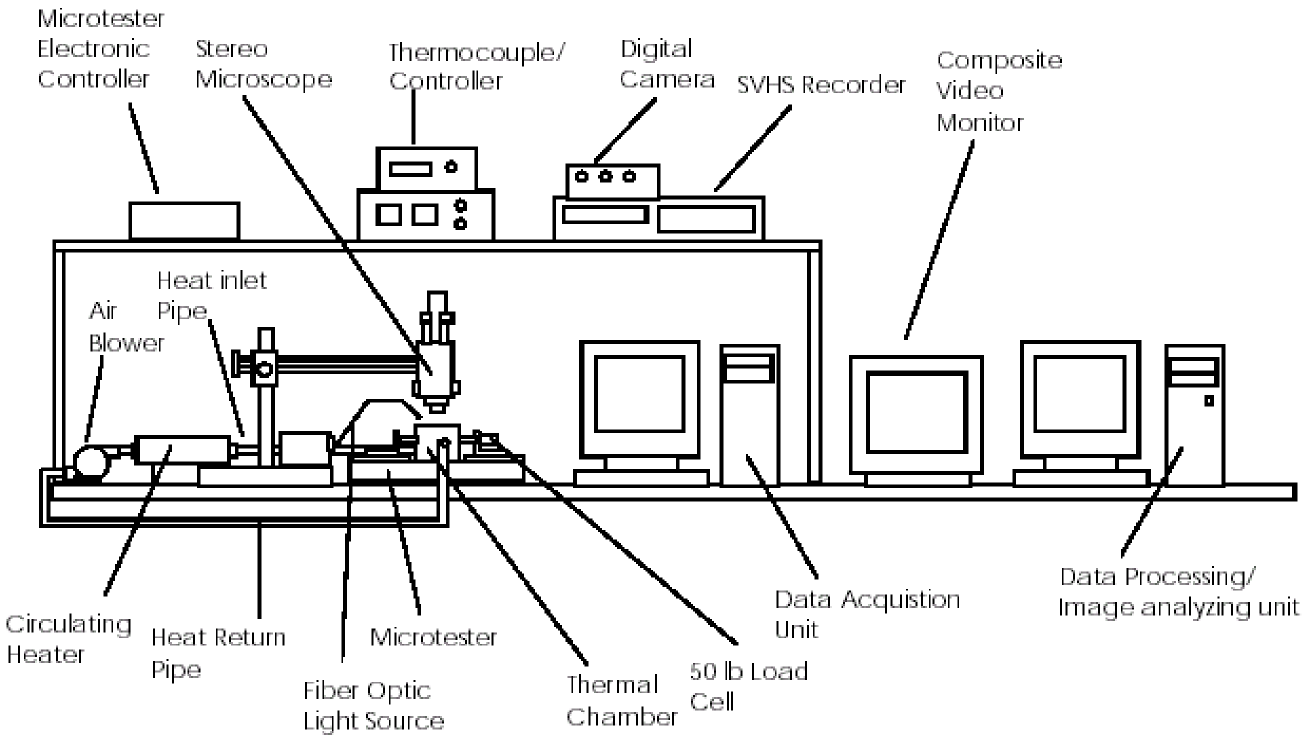



Figure 4. Schematic of Microtester Facility

**Evaluation of Microtester**

The microtester has been tested through its use in a series of fracture toughness tests of molding compound ( Sumitomo EME7320) compact tension specimens. These specimens are nominally 1.25 x 1 x 0.1 inches with a molded central notch which is subsequently both sharpened and then precracked. The specimens fail at loads ranging from approximately 30 lbs at ambient temperature down to approximately 4 lbs at 150°C. Displacements at failure are in the neighborhood of 10 mils. Temperatures have ranged from -93°C to 150°C.

We have found that the general quality of the experimental data acquired under these conditions has been superior to that which we have obtained from conventional servohydraulic test machines in our laboratory. This is evidently the consequence of the greater precision in displacement control available with the microtester. The thermal chamber maintains constant temperature to within 0.1°C for all elevated test temperatures utilized to date, i.e., 50°C to 150°C. 150°C represents a maximum available temperature for the thermal chamber. While this could easily be increased by increasing the wattage of the heater, greater temperatures would also require more insulation for the thermal chamber. Since exterior space is fixed by the microtester dimensions, this would entail a reduction of working space inside the chamber. Microscopic videography has been readily accomplished at ambient or elevated temperatures. At significantly subambient temperatures, condensation or frost on the transparent top of the chamber prevents observation.

Several features not directly associated with the quality of data acquisition are noteworthy. Relative to conventional test machines, the microtester is user friendly in that it is considerably cooler (thermal chamber excluded), quieter and cleaner than servohydraulic machines, for which a hydraulic power supply is necessary. The small maximum load generated by the machine makes it obviously safer than traditional machines which, even in small versions, often generate peak loads of 10,000 lbs or more. Finally, the microtester is significantly less expensive than a servohydraulic machine.

The load limitation of the present device (50 lbs nominal) may be too severe, depending on particular application. In the present case, this is set by the torque capability of the stepping motor. A second consideration which may be important in certain fracture testing applications is the relatively high compliance of the microtester as compared to larger machines. While measurements of this machine parameter were not made, it seems clear that this difference exists.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