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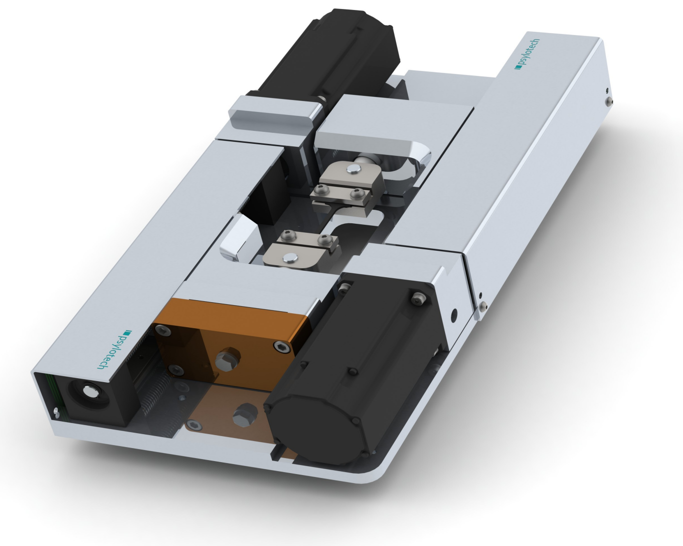
µTS
Under-microscope Test System

The µTS is a 2000 N meso-scale universal test system with 25 nm resolution and 140 mm stroke. The system is bundled with an Olympus BXFM microscope and digital image correlation software to offer a unique platform for:

1. **continuum model validation** of finite element analysis through multi-scale testing
2. **miniature sample testing** to facilitate novel material development where yields can be low
3. **unprecedented versatility** enables implementation of new techniques for the enterprising experimentalist



The system was designed specifically for digital image correlation and optical microscopy. The complete package is tuned to offer 0.1 pixel resolution.

1. Continuum Model Validation

In finite element analysis (FEA), material mechanical properties are presumed uniform to limit the size of elements for reasonable computation times. Psylotech's µTS is a tool to validate continuum models over 6 length scales. Through digital image correlation (DIC) and optimized microscope optics, the full displacement field can be monitored down to 0.1 pixel resolution during a mechanical test. This means up to 25 nm resolution in the displacement field and 0.01% resolution in the strain field, depending on camera resolution.

Consider the example of a composite layup. Typically, FEA presumes uniform, anisotropic material behavior. Tests on a given layup must be experimentally determined in multiple directions. If the layup is modified or the matrix material is changed, new tests should be conducted to re-define material properties. Multi-scale testing offers a vehicle to better understand the interaction between fibers as well as between fibers and the matrix. With test data on smaller scales, continuum properties for any layup can be modeled, skipping an extra experimentation step and accelerating component development time. Moreover, better understanding of small scale interactions and small scale failure mechanisms can lead to fundamentally improved materials.

2. Miniature Sample Testing

In novel materials' research and development, sample yields can be too small to produce full scale ASTM samples. Consider the case of high cost nano-particle reinforced composites. Presuming five specimens are tested to produce statistically relevant data, machined dog-bone samples could prove cost prohibitive. With local strain measurement from the DIC, The µTS can perform accurate tests on significantly smaller samples, offering quality data when less material is available for testing.

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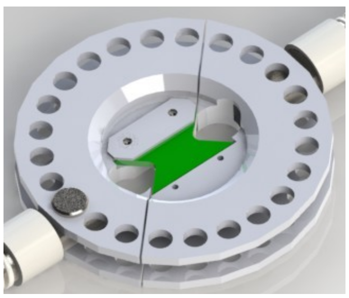
3. Unprecedented Versatility

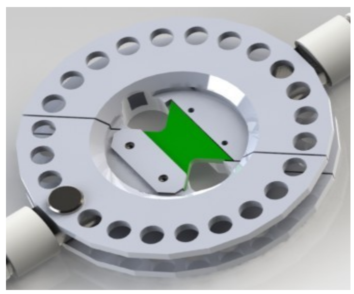
Advanced motion control significantly differentiates the µTS among alternative instruments. Psylotech innovation can help scientists and engineers develop new experimental techniques. Examples of such techniques are detailed in the following feature descriptions.

3.1. Grip Options

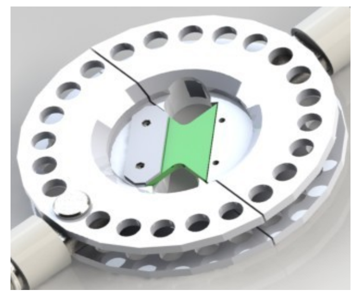
As a versatile universal testing system, the µTS can accommodate many mechanical tests. Experimental grip options include: Arcan, tension, compression and beam bending. These grips also accommodate fracture mechanics testing.



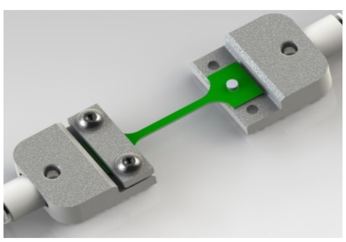
Arcan - Pure Shear



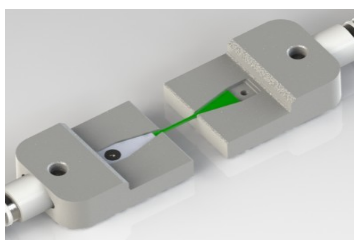
Arcan - Pure Tension



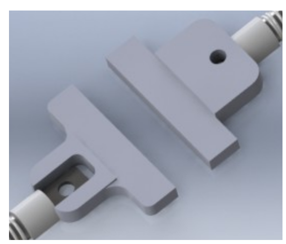
Arcan - Mixed Mode



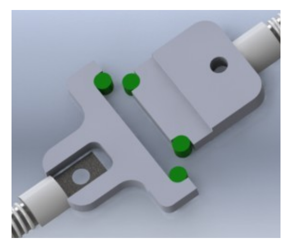
Pinned Tension



Wedged Tension



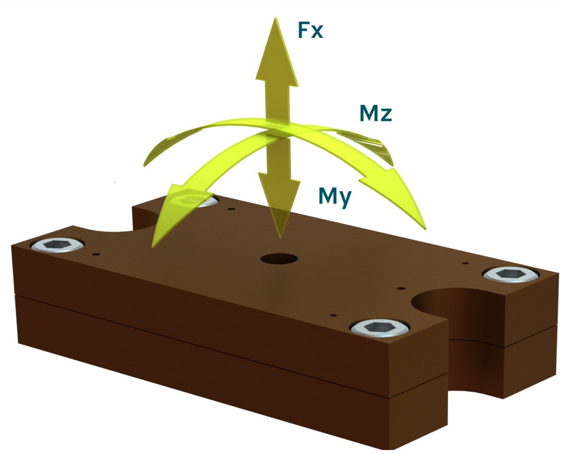
Compression



Four Point Bend

3.2. High Resolution 3-Axis Load Cell

Psylotech uses a capacitive load cell with 200x higher sensitivity compared to strain gauged sensors. With higher sensitivity and a similar signal to noise ratio, the proprietary sensor technology has 100x higher resolution, such that a 2000 N cell can offer 1 mN resolution. High resolution reduces the need to install smaller range load cells for low force tests. Moreover, keeping the load cell installed improves lab efficiency, eliminating installation and load train realignment time.



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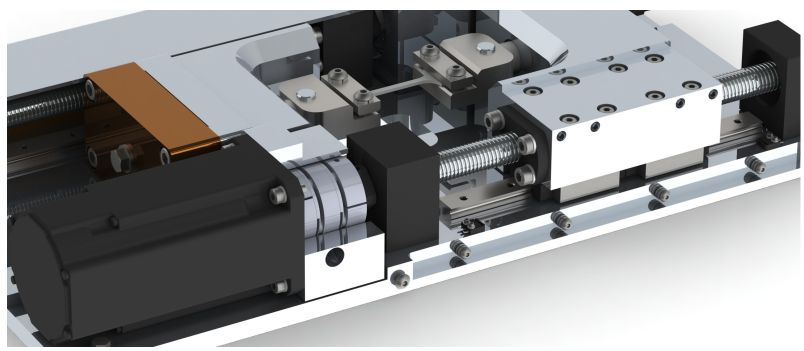
In addition, Psylotech's 3-axis load cell measures bending moments perpendicular to the loading axis, indicating any possible misalignment during a test. Moment information represents an avenue for developing new experimental techniques. High resolution and moment measurements enable a novel experimental technique for testing foam in compression. One could sense individual ligament collapse and estimate the location of the collapse, while monitoring the process over digital image capture.

3.3. Closed Loop Control

The µTS is controllable on force, displacement or speed via a 5kHz closed loop. A novel experimental technique is strain control over DIC. Smooth motion is maintained by nesting the 5kHz displacement control loop inside a slower rate DIC strain data acquisition loop.

3.4. Direct-Drive Ball Screw Actuator



Ball screws offer significantly reduced friction compared to lead screw designs, enabling more precise actuator control. Directly coupling the screw to a servo motor eliminates backlash, contributing to exceptional control over 8 orders of magnitude in speed. Direct coupling also eliminates gear box friction and thereby reduced system maintenance.

High resolution displacement control and fast actuation enables an novel, innovative experimental technique. In a typical step-displacement stress relaxation test, system compliance contributes to modest displacement as specimen force relaxes. The µTS improves results through *compliance compensation*, where the 25 nm closed loop control moves the cross-head to keep displacement constant as force relaxes.

3.5. Dual Independent Cross-Heads

Available dual independent cross heads ensure the specimen's area of interest remains within the microscope's field of view even under large deformation. By adjusting speeds of each cross-head, any area of the specimen can be kept in the field of view, even at large deformations.

The specimen centering algorithm can also leverage a new DIC strain measurement technique. Consider the schematic depicted in the image below. If the microscope objective is deliberately placed off center of a symmetric specimen, the gauge length could be defined as the distance between the specimen center and the field of view. Presuming the specimen center moves as the average of the cross heads, DIC could be used to monitor only the change in gauge length, rather than the entire gauge length itself.

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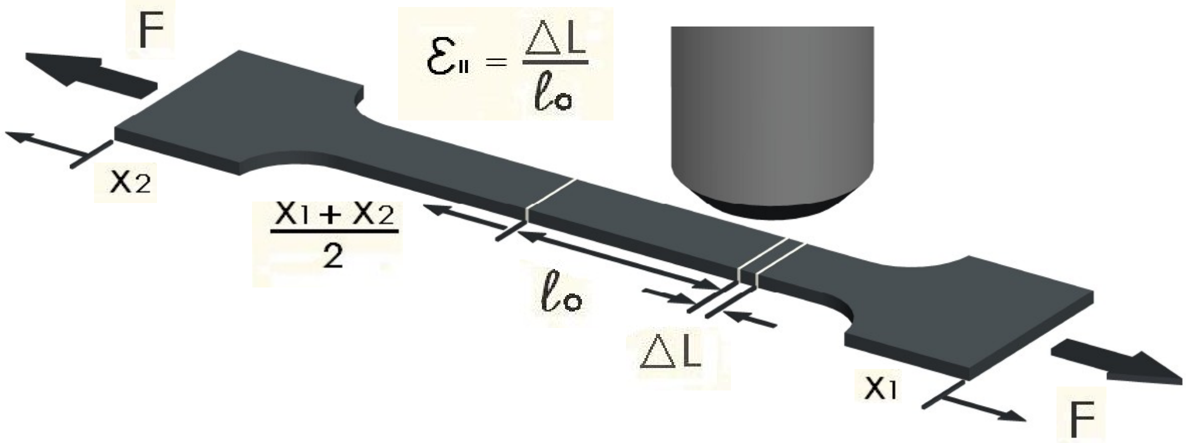

3.6. LabVIEW Control Software

Psylotech's μTS offers the user optional access to the LabVIEW source code. Such access facilitates development of new techniques. Advanced users can make adjustments to suit their specific needs or personal preference.

Accessing the control program enables novel experimental techniques. For example, a single cross head μTS can pull a specimen in displacement, while a user-installed rotational motor concurrently applies torsion to the specimen. Closed loop feedback on the applied torsion can be directly linked to measured axial force through the software.

4. Specifications

Force Capacity	2000 N
Load Resolution	1 mN
Stroke	140 mm
Displacement Resolution	25 nm
Rates	2 nm/sec to 200 mm/sec
Footprint	400mm x 200mm x 75mm
Weight	9 kg
Control Loop	5 kHz
Power Requirement	120/240V, 60/50Hz