

MC050: ULTRA MINIATURE MECHANICAL STRESS CELL

The MC050 sample straining flag is a mechanical strain device compatible with a range of instruments and techniques using a 20 mm “flag” type sample carrier. Sample strain is adjusted by a differential screw, and the force on the sample is indicated by a moving needle.

The MC050 is usually sold as a kit of 3 devices along with a screwdriver adapter for the standard manipulator.

SPECIFICATIONS

Physical Specifications			
Height	Excluding sample	4	mm
Width		20	mm
Length		21	mm
Performance			
Max Force	Stiff sample	± 120	N
Max Travel	Soft sample	60	µm
Device stiffness		2	N/µm
Environment			
Max temperature	e.g. bakeout	100	°C
Min temperature		< 1	°K
Atmosphere	Designed for UHV. Also suitable for ambient air or gas phase cryogenics		

OPTIONS AT POINT OF PURCHASE

The free length of the sample is set when the sample carrier stubs are inserted at the factory. The possible nominal lengths are 0.6, 0.75, and 0.9 mm.

There are also two variations in shape for the backplane, which should be selected according to the design of the receiver, as indicated in Figure 1. The optional spurs limit the insertion depth for receivers where this is the intended means of repeatably locating the flag. If you are unsure what type of receiver your system uses, inspect your existing stock of sample carrier flags.

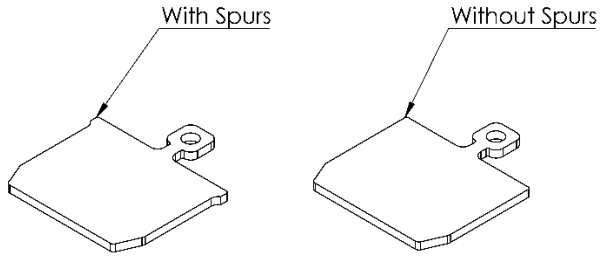


Figure 1 - Device backplane is available with or without spurs

SAMPLE SIZE AND SHAPE

The sample shape should be chosen to allow the desired strain within the displacement, force, and stiffness constraints of the device.

If the sample cross section is designed too large, high forces are generated, but the large cross section prevents the desired stress (and therefore strain) being reached.

If the sample cross section is too small, large displacements and strains are easily reached, so the experiment can succeed, but the forces are too small to move the indicator needle.

For example, let us consider a sample of free length 0.75 mm, width 0.4 mm, and height 0.2 mm. If the material has a stiffness of 100 GPa, the sample has a stiffness of 10 N/ μ m, which is somewhat stiffer than the device. If we combine the stiffness of the device (2 N/ μ m) with that of the sample, we get 1.6 N/ μ m. The 60 μ m travel therefore generates a maximum force of 100 N. This corresponds to a stress of 1250 MPa and strain of 1.25 %, which would cause failure in most materials. Actual performance is likely to be reduced slightly by the strength and stiffness of the glue.

The actual length of the sample should be greater than the free length, up to a maximum of 4 mm. This extra length is required for a strong glue join at both ends.

SAMPLE MOUNTING AND REMOVAL

Before mounting a sample, move the drive screw to the desired position. If you wish to explore tension and compression on the same sample, it makes sense to begin with the screw near the centre.

You should also consider differential expansion between the sample and device when setting up your experiment. The device is manufactured from Grade 5 titanium (Ti-6Al-4V) which has thermal expansion properties as shown in the table below.

Temperature (K)	Thermal Contraction (%) ¹ $\frac{L_{293K} - L_T}{L_{293K}} \times 100$
293	0
250	0.036
200	0.078
150	0.118
100	0.154
77	0.163
40	0.171
4	0.173

The sample should be glued to the sample mounting stubs as shown in Figure 2. It is important that no glue enters the slots in the device. If this happens accidentally, it should be removed before it can cure. The device can be immersed in Isopropanol for this purpose. If glue does become cured in the slots, contact Razorbill Instruments for advice on removing it.

¹ Values from *Experimental Techniques for Low Temperature Measurements*, Jack W. Ekin, Oxford Univ. Press, 2011

The following tips might help you get a good glue joint:

- Available vacuum epoxies are likely to be softer and weaker than the sample, so it is important to build up sufficient glue all round both ends of the sample.
- Some epoxies can be built up in several layers, with curing in between. A very small amount of glue can be used to immobilise the sample, with strength added later. This prevents the sample being pulled around by the surface tension or viscosity of the larger glue droplet.
- You can keep the top of the sample clean with a small piece of Kapton tape or similar, to be removed once the glue is cured or semi-cured.
- Don't hesitate to remove glue that's got out of control and start again – the whole device can be washed in Isopropanol.
- The sharp edges of the sample stubs can help limit the spreading of low viscosity glues.

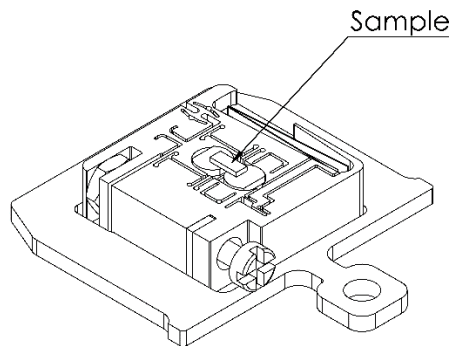


Figure 2 - Sample mounting location

The device may be heated to the maximum temperature indicated in the specification if this is required to cure the glue. In testing Razorbill Instruments used Stycast 2850FT with catalyst 23LV as the preferred glue, which requires curing at 65 °C for four hours. When the experiment is complete, the sample should be removed by scraping away the glue with a scalpel or similar instrument. It may be helpful to heat the device

to soften the glue, this is effective with the above mentioned Stycast product. The maximum temperature in the specification table should not be exceeded.

ADJUSTING THE STRAIN

The strain in the sample is adjusted by rotating the screw. The clockwise direction will compress the sample, anticlockwise will tension it. The full travel is approximately 6 turns of the screw.

READING THE INDICATOR

The indicator needle will move to the left for compression of the sample, and to the right for tension. If the needle does not move as expected, this may be evidence that the sample is slipping in the glue or has fractured.

If you intend to take force measurements from the indicator, rather than just using to detect fracture, we recommend cooling and photographing the device with no sample mounted. This should be done in the final location in your experimental apparatus, with a realistic temperature and radiation environment. Some drift of the indicator is expected with temperature and differing radiation environments. Our testing shows a typical change of 10 % Full Scale Range between room temperature and 4 K, but this is expected to be system dependent. Reference images may also assist in reading the indicator movement in systems where the indicator cannot be presented perpendicular to the observer or camera.

The sensitivity of the indicator is individually measured at time of manufacture, and is noted on a card in the packing case. If you have lost this card, contact razorbill instruments with the serial numbers of your devices.

The sensitivity of the indicator is expected to reduce slightly with reducing temperature. This is due to the changing stiffness of the

titanium the indicator mechanism is manufactured from. The reduction in movement of the indicator will be c. 3.7 % at 77 K and 11 % at 4 K².

SCREWDRIVER ADAPTER AND MAGNETIC HOLDER

For users who do not have a suitable screwdriver-tipped wobble stick, Razorbill Instruments provides a screwdriver adapter with the same interface as the sample flag. This allows the manipulator that was used to transfer the device into the receiver to be used to adjust the strain.

When the adapter is not in use, it can be stored on the included magnetic sample flag in any standard-width sample storage slot. The adapter can be freely positioned on the magnetic holder, allowing for differing system geometries.

FURTHER INFORMATION

To check for updates to this document visit the Razorbill Instruments website at www.razorbillinstruments.com. Our website also has detailed guides for some common techniques involving our products and we expect to add more information about the MC050 as the field develops.

² Values adapted from *Material Selection for Cryogenic Structures*, Kramer et al, J Low Temp Phys, 2014