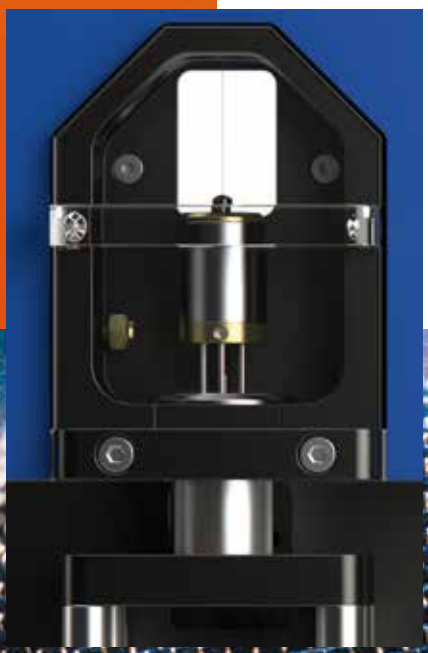
Textechno
textile testing technology



FIMATEST

Fibre-Matrix Adhesion Tester

Fibre-Matrix Adhesion Tester FIMATEST

The performance of composite materials strongly depends on the adhesion of the fibres to the matrix. On the microscopic level different test procedures have been established in various research institutes, however, most results are not comparable, since none of these tests are standardized or commercially available.

To make a versatile and reproducible single-fibre pull-out test available to institutes and industrial customers world-wide, Textechno, leading experts in the field of fibre testing, has developed a suitable system together with the Leibniz Institute of Polymer research Dresden (IPF) and the Faser-institut Bremen (FIBRE). While the IPF has long-standing competence and experience in the field of fibre-to-matrix adhesion, FIBRE has contributed by their experience in image analysis for automating the embedding process. The system consists of two devices: the partially automated embedding station **FIMABOND**, which is suited for all kind of reinforcement fibres as well as for thermoset, thermoplastic or mineral matrices, and a device that performs high precision pull-out tests as a new accessory to Textechno's single-fibre linear-density and tensile tester **FAVIMAT+**. In this way a "measurement of interfacial shear strength by means of a micromechanical single-fibre pull-out test" is implemented which has been standardized as ISO 19375.

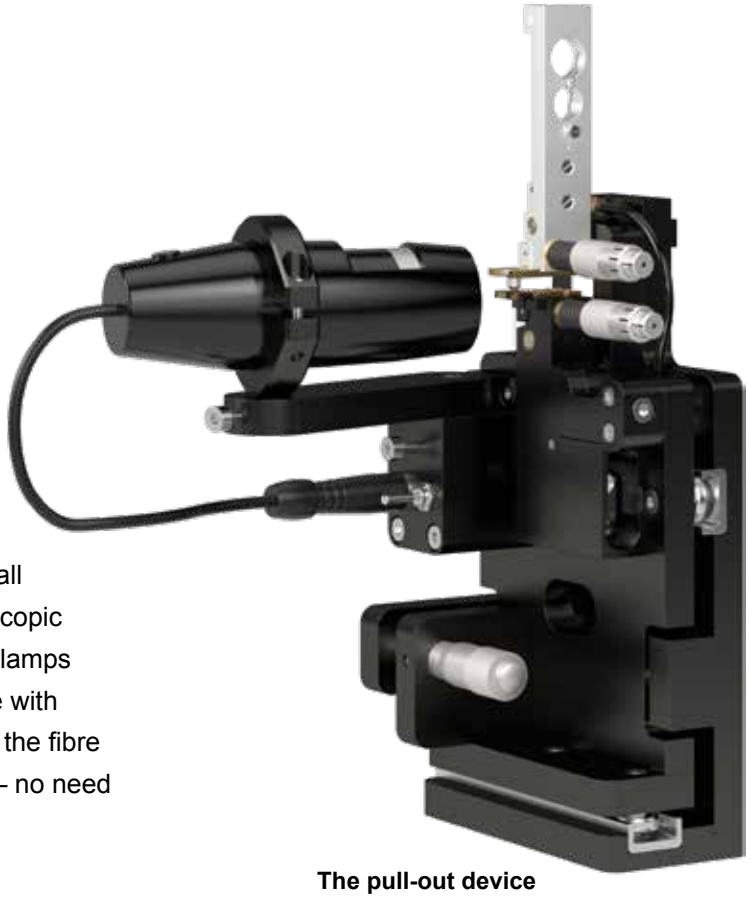
FIMABOND

One of the most critical points to assure reproducible results in a single-fibre pull-out test is the precise embedding of the fibre into the matrix which is required to avoid shear forces. For this purpose, the fibre must be embedded exactly in the centre of the matrix droplet. This critical adjustment is perfectly performed with the **FIMABOND** embedding station. **FIMABOND** features freely programmable temperature profiles up to 400 °C and embedding under inert gas. The device is well suited for thermoplastic and thermoset as well as mineral matrices. Also, an option to prepare UV-curing matrix systems is available.

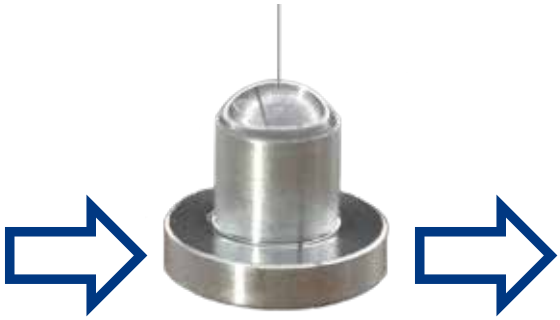
The FIMABOND embedding station

Pull-out Device

The pull-out testing device is easy to install and operate in the **FAVIMAT+**. A microscopic camera facilitates the adjustment of the clamps as close as possible to the matrix surface with perfect alignment. The direct clamping of the fibre makes the pull-out test fast and efficient – no need for glues and tedious handling.

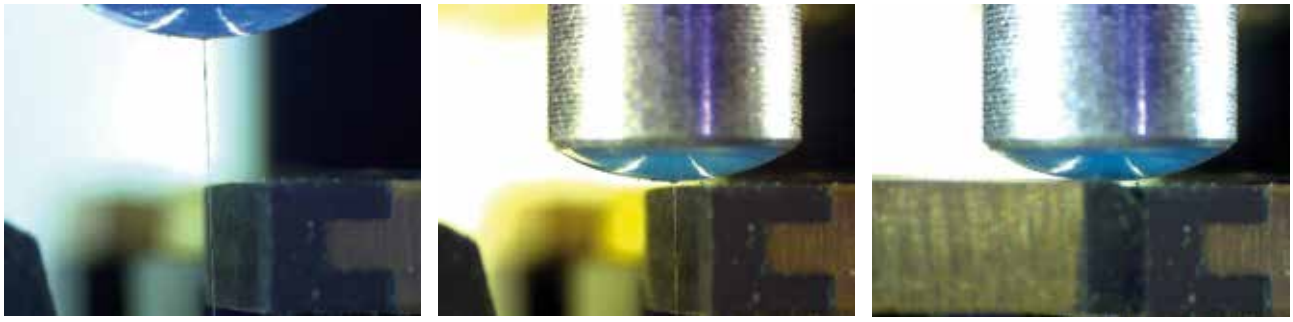


The pull-out device



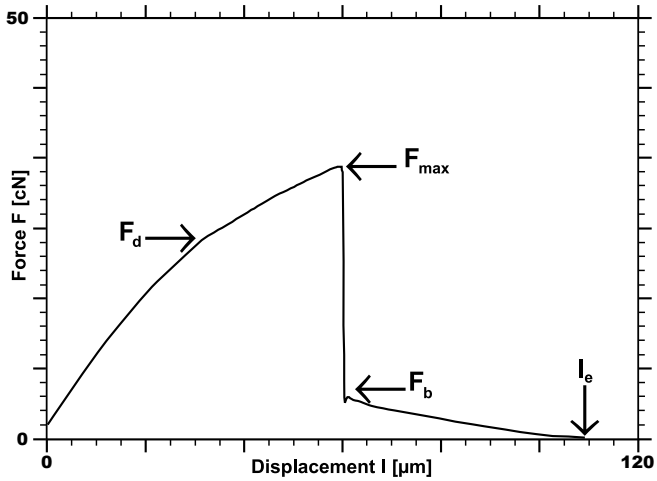
Prepared test specimen

The FAVIMAT+ single-fibre tester with installed pull-out device



Direct clamping process of the fibre as seen by the microscope camera of the pull-out device

When the fibre is clamped the **FAVIMAT+** automatically starts the pull-out test and records the force/displacement-curve.



From the force/displacement-curve the system determines all relevant parameters:

- maximum force (F_{max})
- frictional force (F_b)
- debonding force (F_d)
- actual embedding length (l_e)

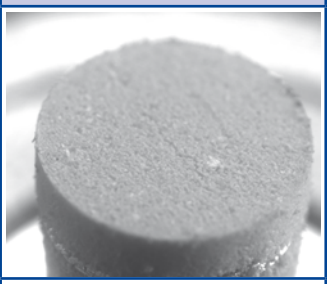
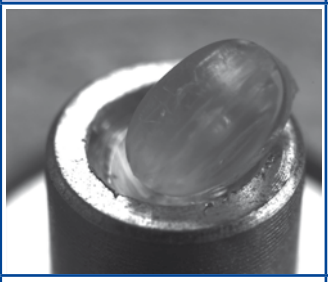
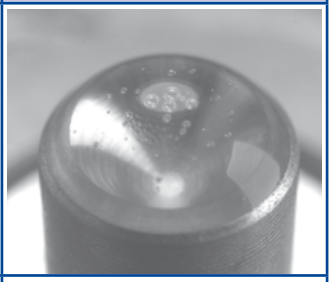
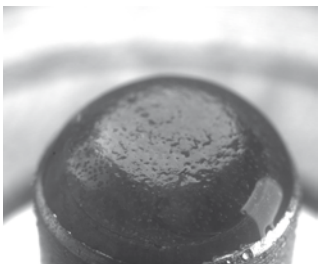
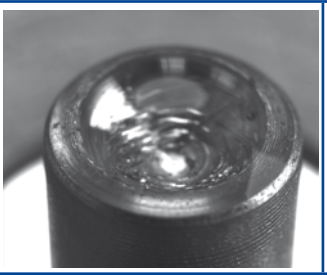
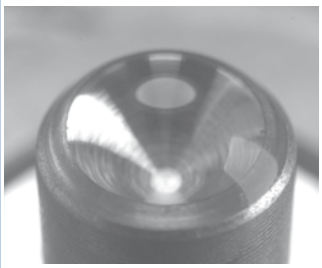
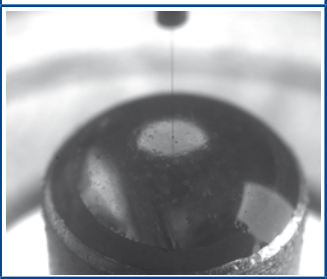
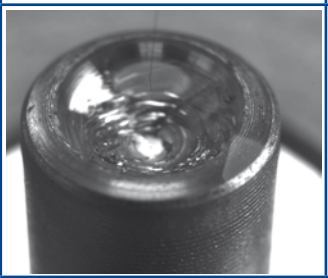
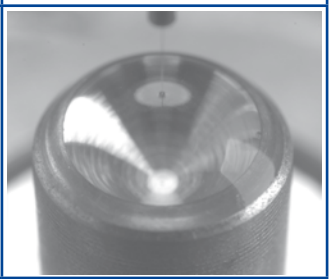
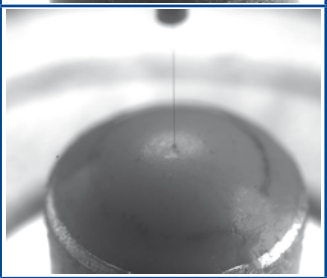
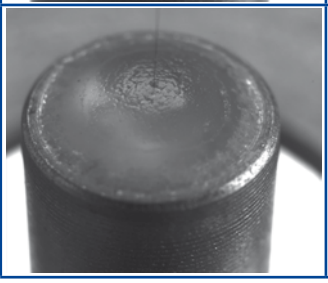
Based on the measured values the following quantities are calculated:

The **apparent interfacial shear strength** τ_{app} is based on the maximum force F_{max}. It is sufficient for a qualitative estimation and a simple distinction of different fiber-matrix-adhesion types. After the debonding of the fibre from the matrix, no bondings are left. The fiber will be completely pulled out and only friction, expressed by the **interfacial frictional stress** τ_f, will occur.

The **local interfacial shear strength** τ_d is based on the debonding force F_d. It describes the absolute measure of the fibre-to-matrix adhesion, independent from friction and corrected for deformation of fibre and matrix during the pull-out test.

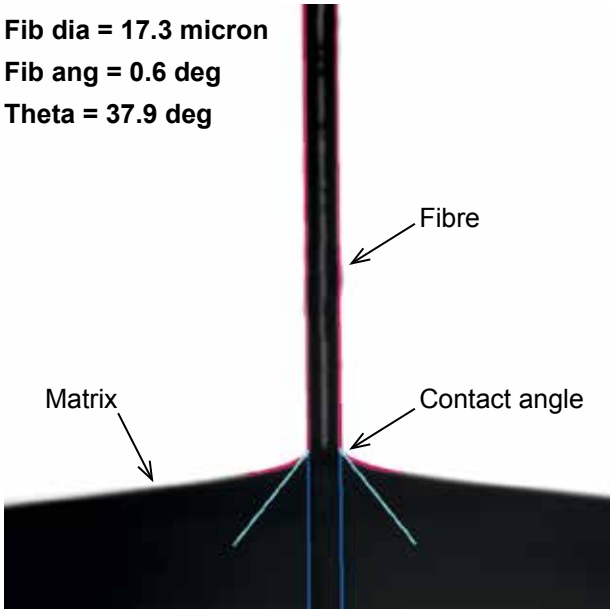
The **critical interfacial energy release rate** G_{ic} describes the energy required to debond the fibre per unit contact area. It is an alternative to the strain-based paramater τ_d.

With the integration of the pull-out device into Textechno's **FAVIMAT+**, the complete set-up allows for an easy and precise determination of linear density and cross section as well as modulus, breaking strength and elongation on top of the fibre-matrix-adhesion.

Process steps	PEEK	PP	Epoxy
Inserting Matrix is placed in an aluminum crucible under inert gas-atmosphere if desired			
Heating Freely-programmable heater up to 400°C			
Embedding Adjustable embedding speed and depth			
Cooling / Curing Active cooling available			

Sample generation as seen by FIMABOND

Contact Angle and Fibre Diameter Measurement with FIMABOND



Contact angle during embedding

As an option for **FIMABOND**, the contact angle between fibre and matrix is measured during sample preparation for the single-fibre pull-out test. A camera oriented at 90° to the fibre axis captures the wetting meniscus while the fibre is embedded into the matrix. **FIMABOND**'s image analysis continuously detects the three-phase line and evaluates the contact angle on both sides of the fibre (measurable angles up to about 90°).

Because the measurement is performed directly on the specific fibre/matrix system - at the relevant process temperature - it is suitable for thermoset and thermoplastic matrices (e.g., carbon fibre in molten PEEK) without preparing flat reference surfaces or using substitute probe liquids.

The same optical setup also determines the fibre diameter needed to normalize pull-out forces by the true fibre–matrix contact area. Direct optical diameter measurement is particularly useful for short fibres (≈ <12 mm) that cannot be tested vibroscopically on the **FAVIMAT+**. For longer fibres it reduces handling effort by avoiding clamp changes on the **FAVIMAT+** and eliminates separate microscopy/SEM steps.

Technical data FIMABOND

- Mains supply:	230 V, 50 (60) Hz
- Inert gas (optional):	depending on matrix
- Compressed air:	5 bar
- Lacquer finish:	RAL 9006/5002
- Dimensions:	height 670 mm
	width 480 mm
	depth 285 mm
- Weight:	approx. 35 kg

Supported by:

Federal Ministry of Economics and Technology

on the basis of a decision by the German Bundestag

FIMAMIX

The **FIMAMIX** Vacuum Mixer is an advanced laboratory mixing system designed for precise resin preparation in composite material research, micromechanical testing, and material science applications.

FIMAMIX

This high-performance vacuum laboratory mixer ensures homogeneous mixing, eliminates air bubbles, and optimizes resin consistency in laboratory environments when small sample quantities need to be mixed. An example is the sample preparation for micromechanical testing techniques like the single-fibre pullout test implemented in the **FIMATEST** system.

The main features of the **FIMAMIX** are:

- Vacuum: Evacuating the liquid resin before and while mixing to remove and avoid bubbles during curing,
- High speed: Rapidly and homogeneously mixed resin,
- Optimized for small quantities: Especially suited for lab scale – e.g. micromechanical testing,
- Mixing principle: Dual asymmetric centrifuge (DAC) also know as planetary centrifugal mixing or dual axis centrifugal mixing.

Technical data FIMAMIX

- Pressure:	approx. 30 mbar
- Speed:	up to 2500 rpm
- Mains supply:	230 V, 50 (60) Hz
- Dimensions:	310 x 410 x 270 mm
- Weight:	approx. 17 kg

The above technical contents can be subject to changes by Textechno.

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quality improvement

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