

# FINAL REPORT

Faserinstitut Bremen e.V.



255670 MAPS

Bremen, 15.11.2012

Contact Person:

Prof. Dr.-Ing. Axel Herrmann



**Universität Bremen**

Bericht Nummer: **FWW-10-049-B1**  
 No. of report:

Faserinstitut Bremen e.V. - Am Biologischen Garten 2 - 28359 Bremen (Germany)

**Fraunhofer IFAM**  
**Herrn Thomas Kowalik**  
**Wiener Straße 12**  
  
**28359 Bremen**

**Kunden-Auftragsnummer** Clean Sky Maps  
 Client's order- No. JTI-CS-2009\_1\_GRA01\_015  
  
**FIBRE-Auftragsnr.** FWV-10-049-B1  
 FIBRE order-No.  
  
**Kundennummer** -  
 Client's No.

**Materialeingang**  
 Receipt of sample  
  
**Anlieferzustand**  
 Condition of receipt  
  
**Datum:**  
 Date: \_\_\_\_\_

OK

**Uhrzeit:**  
 Time: \_\_\_\_\_

**Materialidentifikation**  
 Definition of sample  
 CFRP

**Nummerierung Kunde**  
 Client-Sample No.  
 A409197-CS08R10 16.03.2010  
 A409197-CS09R10  
 A409197-CS37R10  
 A409197-CS45R10 30.06.2010  
 A409197-CS53R10 04.08.2010  
 A409197-CS55R10 01.07.2010  
 A409197-CS57R10 03.08.2010

**Nummerierung FIBRE**  
 FIBRE-Sample No.  
 M1  
 M2  
 M3  
 M4  
 M5  
 M6  
 M7

**Klimatisierung:** Die Vor- und Prüfklimatisierung entspricht den zugrundeliegenden Normen und Bestimmungen.

| Durchgeführte Prüfungen<br>Test procedures |     |                                                          | Material<br>Nr.<br>Material No. | Ergebnisse<br>Results       | Anlage<br>Nr.<br>Attachment<br>No. | Hinweise*<br>Comments* |
|--------------------------------------------|-----|----------------------------------------------------------|---------------------------------|-----------------------------|------------------------------------|------------------------|
| Typ                                        | Nr. | Verfahrensgrundlage, Stand, Name                         |                                 |                             |                                    |                        |
| C                                          | -1  | Compression after Impact (CAI)<br>according to ISO 18352 | see above                       | Siehe Anlage<br>See summary | 1                                  | ---                    |
| C                                          | -1  | Single fibre pull out test                               | see above                       | Siehe Anlage<br>See summary | 1                                  | ---                    |

**Ergebniszusammenfassung:**  
 Summary of results:

**1. Compression after Impact (CAI)**

**1.1 Preparation of Test Plates**

The customer provided the test plates (280mm x 210mm).

**1.2 Internal Error Detection (Ultrasound Examination using Phase Array)**

The test plates were examined using phased array ultrasonic testing (according to AITM 6-4010 04/2010) thus should be better incorporated impact damages assessed. These tests were carried out at the company GMA-Werkstofftechnik (Stade).

The plates CS09, CS45, CS57, CS55 and CS53 were not conform to 80T-31-2910(04/2008) due to the internal defects (> 2.5 % porosity).

Bericht Nummer: **FWW-10-049-B1**  
No. of report:

### 1.3 Cutting of Test Samples using abrasive Water Jet Cutting

Test samples (150 x 100 mm) were prepared by abrasive water jet cutting.

### 1.4 Cutting Line testing using Ultrasound (see Appendix 2)

The cutting lines of the test plates were checked to damage caused by the cutting process according to AITM 6-4005. Damages could not be found.

### 1.5 Incorporating the Impact Stress

The Incorporating of the impact stress was carried out by a modified impact tester from Zwick / Roell (FIBRE). The impact stress is included in the test protocols (see Appendix 4).

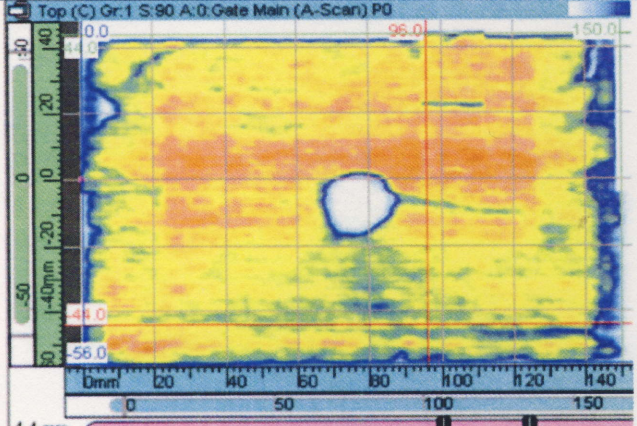
### 1.6 Assessment of the Impact Damage (Ultrasound Examination using Phase Array)

To assess the impact damage the test plates were examined by phased-array-ultrasound (according to AITM 6-4010 04/2010). These tests were carried out at the company GMA-Werkstofftechnik (Stade).

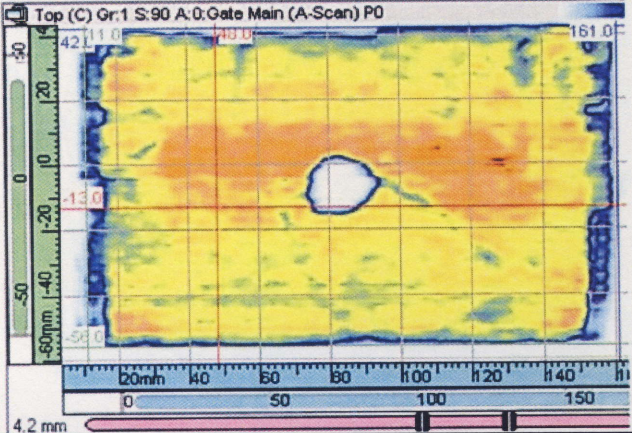
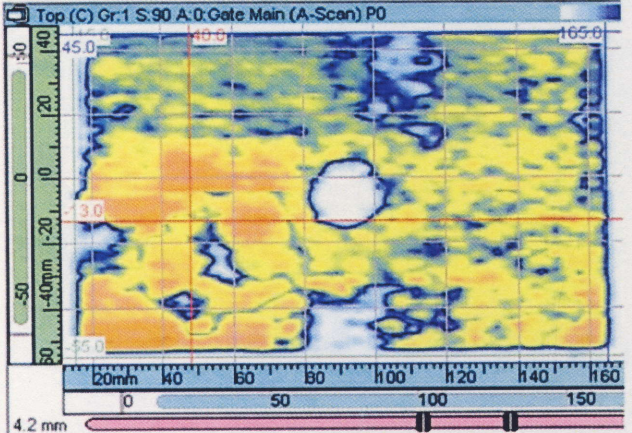
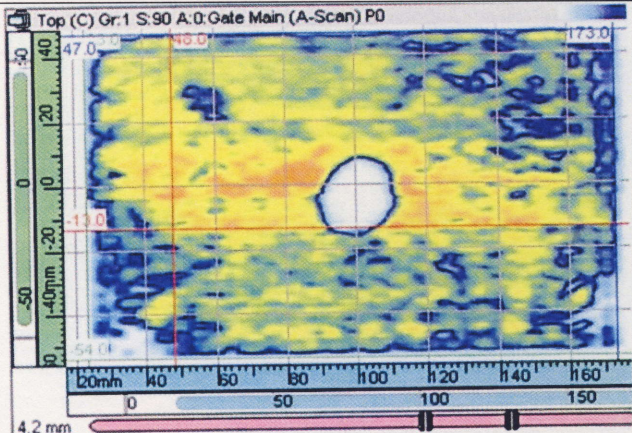
### 1.7 Pressure Test

Pressure test (according to ISO 18352, standard atmosphere were carried out at FIBRE. The overview the individual values are listed. A2. n static analysis of the measurements is not meaningful, because the values are due to the inhomogeneous distribution of the internal error differ greatly.

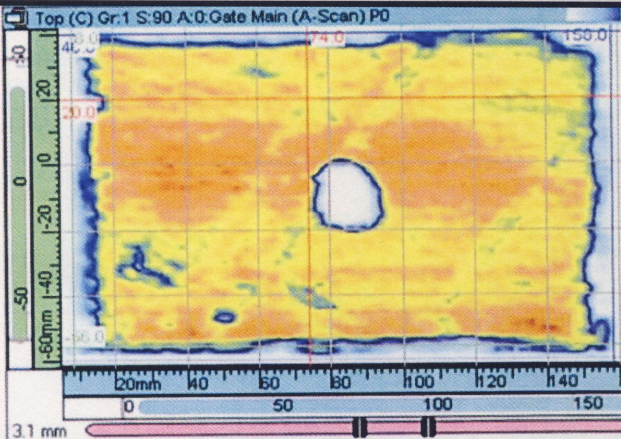
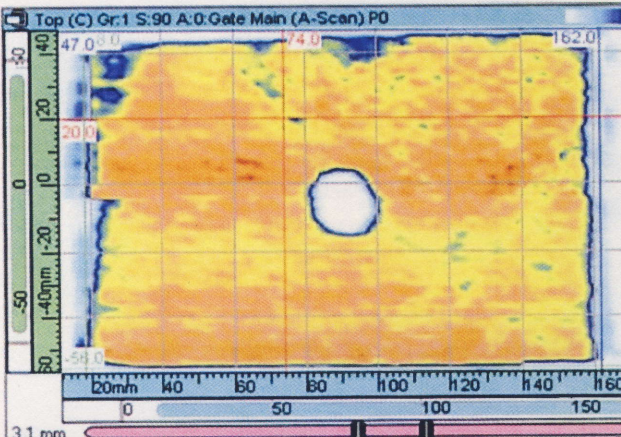
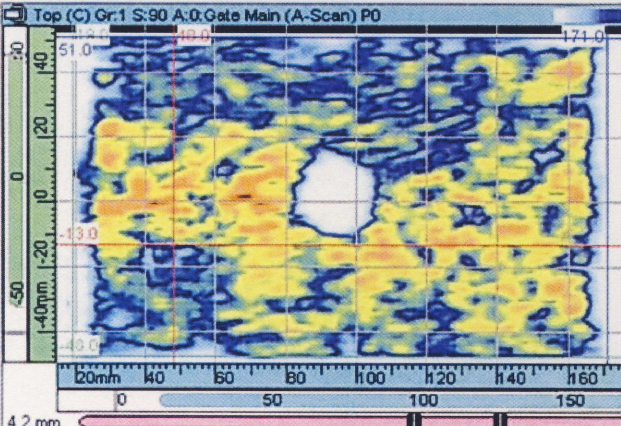
### Overview of the results

| Sample                       | Young modulus [GPa] | residual pressure strength [MPa] | C-Picture after impact                                                               |
|------------------------------|---------------------|----------------------------------|--------------------------------------------------------------------------------------|
| A409197 CS08 R10<br>Sample 1 | 37,6                | 198                              |  |

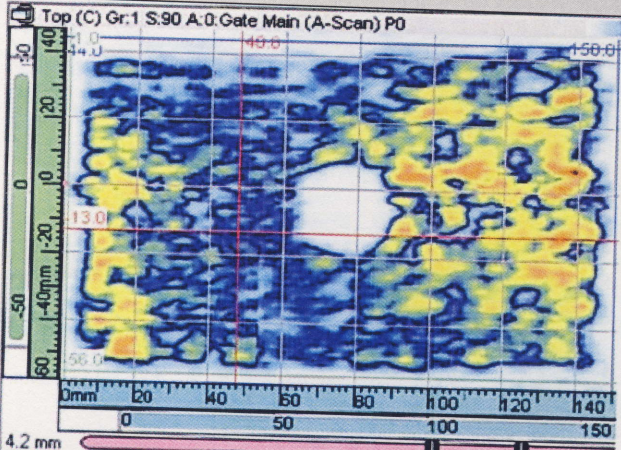
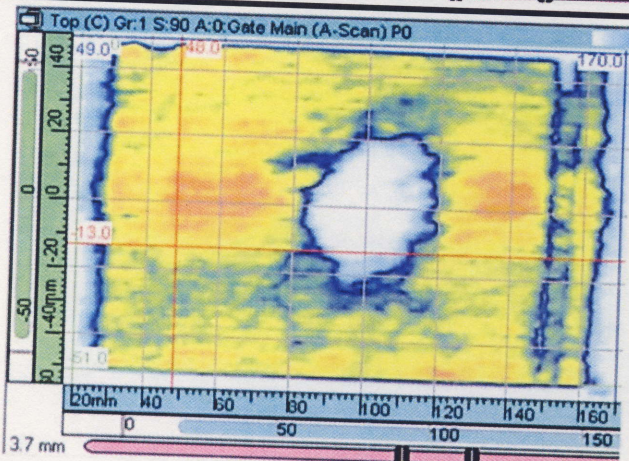
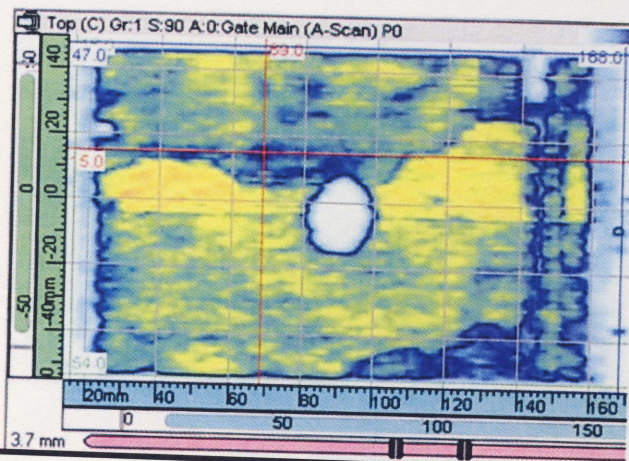
Bericht Nummer: **FWW-10-049-B1**  
No. of report:

| Sample                       | Young modulus [GPa] | residual pressure strength [MPa] | C-Picture after impact                                                               |
|------------------------------|---------------------|----------------------------------|--------------------------------------------------------------------------------------|
| A409197 CS08 R10<br>Sample 2 | 38,6                | 228                              |    |
| A409197 CS09 R10<br>Sample 1 | 38,8                | 228                              |   |
| A409197 CS09 R10<br>Sample 2 | 38,7                | 222                              |  |

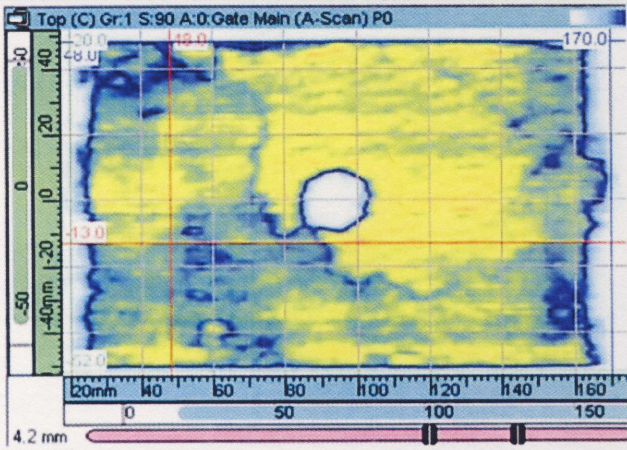
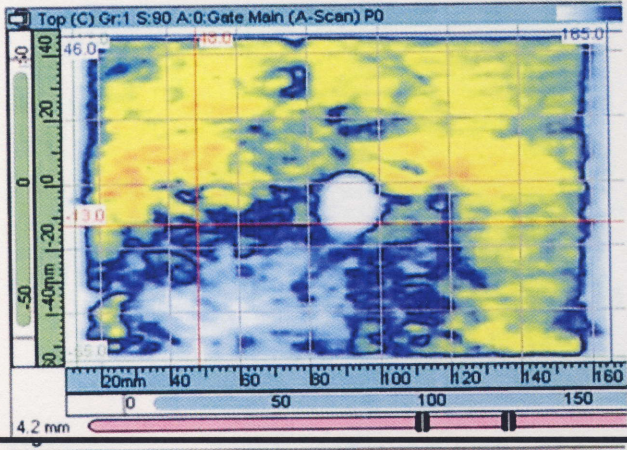
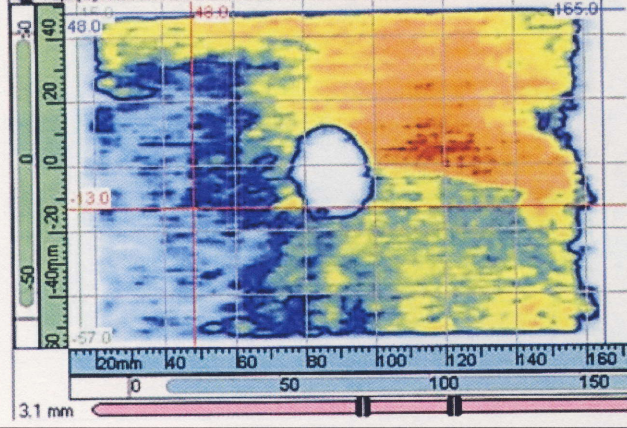
Bericht Nummer: FFW-10-049-B1  
No. of report:

| Sample                       | Young modulus [GPa] | residual pressure strength [MPa] | C-Picture after impact                                                               |
|------------------------------|---------------------|----------------------------------|--------------------------------------------------------------------------------------|
| A409197 CS37 R10<br>Sample 1 | 47,8                | 229                              |    |
| A409197 CS37 R10<br>Sample 2 | 45,1                | 204                              |   |
| A409197 CS45 R10<br>Sample 1 | 50,5                | 204                              |  |

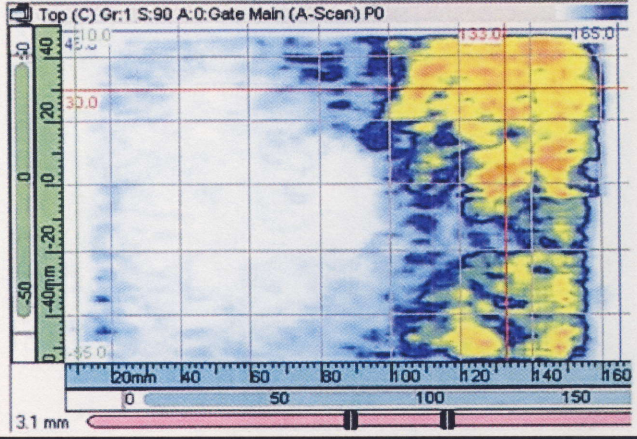
Bericht Nummer: **FVW-10-049-B1**  
No. of report:

| Sample                       | Young modulus [GPa] | residual pressure strength [MPa] | C-Picture after impact                                                               |
|------------------------------|---------------------|----------------------------------|--------------------------------------------------------------------------------------|
| A409197 CS45 R10<br>Sample 2 | 66,5                | 211                              |    |
| A409197 CS53 R10<br>Sample 1 | 46,5                | 208                              |   |
| A409197 CS53 R10<br>Sample 2 | 43,6                | 156                              |  |

Bericht Nummer: FWW-10-049-B1  
No. of report:

| Sample                       | Young modulus [GPa] | residual pressure strength [MPa] | C-Picture after impact                                                               |
|------------------------------|---------------------|----------------------------------|--------------------------------------------------------------------------------------|
| A409197 CS55 R10<br>Sample 1 | 40,2                | 225                              |    |
| A409197 CS55 R10<br>Sample 2 | 39,4                | 207                              |   |
| A409197 CS57 R10<br>Sample 1 | 44,3                | 196                              |  |

Bericht Nummer: **FWW-10-049-B1**  
No. of report:

| Sample                       | Young modulus [GPa] | residual pressure strength [MPa] | C-Picture after impact                                                             |
|------------------------------|---------------------|----------------------------------|------------------------------------------------------------------------------------|
| A409197 CS57 R10<br>Sample 2 | 42                  | 175                              |  |

## 2. Single Fibre Pull Out test

### 2.1 DiaStron-Measure with Uncross Linked Resin

The experiments are preparative feasible and practical. There are two problems. The applied forces are less than the accuracy of force sensor and adhesive surface varies with the strain, because the resin is adheres to the fibre and also pulled out.

### 2.2 DiaStron-Measure with Cross Linked Resin

The first step in this part was the production of new sample holders from aluminum, because the conventional plastic holder (PMMA) endures the curing temperature of the resin of 180 ° C.

The preparation of the samples is possible, but very extensive, because the resin muss processed at a temperature of 130 ° C according to customer requirement.

The fiber has been failing during the examination. A reduction of the adhesive surface is due to the handling of the resin (temperature / viscosity) not possible.

### 2.3 Roving Pull Out with Cross Linked Resin

In the next step the fiber cross-section has been increased, i.e. thin roving was used instead of a single fiber, because a weakening of the adhesion of the above-mentioned reasons was not possible. This experiment also leads to failure of the external filaments of the roving, therefore there is no inference is to the fiber-matrix adhesion, because the resin distributed over the free clamping length of the roving.

## Meinungen, Interpretationen und Kommentar

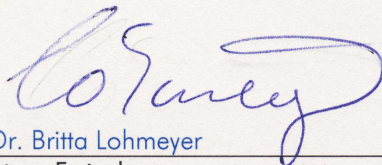
Interpretation and Comment:

A comparative statement about the influence of the resin system on the CAI values is due to the significant fault in the laminates not possible, because they are greatly influenced by the quality of the component.

Bericht Nummer: **FWW-10-049-B1**  
No. of report:

Single Fibre Pull Out test

Different variations of the experiment led to no usable result. The Diastron method is for the combination of carbon fiber and the here tested resin not suitable.



Bremen, 2012/11/15 Dr. Britta Lohmeyer

Ausstellungsort, Datum, Freigabe (Name und Unterschrift)  
Location, Date, Release (Name and sign)