



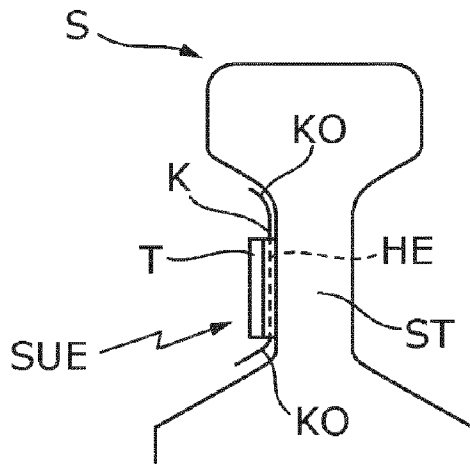
(12) **DEMANDE DE BREVET CANADIEN  
CANADIAN PATENT APPLICATION**

(13) **A1**

(86) Date de dépôt PCT/PCT Filing Date: 2020/04/28  
 (87) Date publication PCT/PCT Publication Date: 2020/12/17  
 (85) Entrée phase nationale/National Entry: 2021/11/23  
 (86) N° demande PCT/PCT Application No.: EP 2020/061776  
 (87) N° publication PCT/PCT Publication No.: 2020/249300  
 (30) Priorité/Priority: 2019/06/14 (EP19180254.5)

(51) Cl.Int./Int.Cl. *G01L 1/24* (2006.01),  
*B61L 1/02* (2006.01), *B61L 23/04* (2006.01),  
*G01K 5/48* (2006.01), *G01M 5/00* (2006.01)  
 (71) Demandeur/Applicant:  
 THALES MANAGEMENT & SERVICES  
 DEUTSCHLAND GMBH, DE  
 (72) Inventeurs/Inventors:  
 SCHICKER, KAI, DE;  
 SOLLEDER, STEFAN, DE  
 (74) Agent: CASSAN MACLEAN IP AGENCY INC.

(54) Titre : ELEMENT DE SURVEILLANCE DE RAIL, PROCEDE DE MONTAGE D'UN ELEMENT DE SURVEILLANCE DE RAIL ET PROCEDE DE FABRICATION D'UN ELEMENT DE SURVEILLANCE DE RAIL  
 (54) Title: RAIL-MONITORING ELEMENT, METHOD FOR MOUNTING A RAIL-MONITORING ELEMENT, AND METHOD FOR MANUFACTURING A RAIL-MONITORING ELEMENT



**Fig. 1**

(57) **Abrégé/Abstract:**

The invention relates to a rail monitoring element (SUE) comprising a carrier (T) on which a strain sensor, in particular comprising an optical fibre (F) having a fibre Bragg grating (FBG), is attached. According to the invention, the carrier (T) has an adhesive layer (K) for adhesive attachment to a rail (S) having a thermally activatable or thermally curable adhesive, the adhesive layer (K) comprising a heating element (HE) having contacts (KO) that can be supplied with electrical energy. The rail monitoring element according to the invention can be installed more easily and in a manner which saves more energy.

### **Abstract**

The invention relates to a rail-monitoring element (SUE) comprising a carrier (T) on which a strain sensor, in particular comprising an optical fiber (F) having a fiber Bragg grating (FBG), is attached. According to the invention, the carrier (T) has an adhesive layer (K) for adhesive attachment to a rail (S) having a thermally activatable or thermally curable adhesive, the adhesive layer (K) comprising a heating element (HE) having contacts (KO) for receiving electrical energy. The rail-monitoring element according to the invention can be installed more easily and in a manner which saves more energy.

**(Fig. 1)**

**Rail-monitoring element, method for mounting a rail-monitoring element, and  
method for manufacturing a rail-monitoring element**

**Background of the invention**

5 The invention relates to a rail-monitoring element comprising a carrier on which a strain sensor, in particular comprising an optical fiber having a fiber Bragg grating (FBG), is attached, the carrier having an adhesive layer for adhesive attachment to a rail having a thermally activatable or thermally curable adhesive. The invention further relates to a method for mounting a rail-monitoring element and to a method for manufacturing a rail-monitoring element.

10

A rail-monitoring element with FBG sensors is known from DE 10 2017 216 811 A1, for example.

15

To make rail traffic safer, rail-monitoring elements, for example sensor elements for axle counters, are used. Axle counters can be used in particular to check whether the location of the axle counter has been completely passed by a train, for example to determine whether the associated track sections are free or occupied. Such rail-monitoring elements comprise sensor elements that usually have to be attached to the rail.

20

Fiber optic sensors are becoming increasingly important in measurement systems. One or more sensors embedded in optical waveguides, such as fiber Bragg gratings, are used to detect an expansion or a compression of the optical fiber caused by a mechanical variable, and thus to be able to detect forces, torques, accelerations, loads, pressure states, etc.

25

EP 3 069 952 A1 and WO 2016/150670 A1 describe the use of fiber optic sensors with fiber Bragg gratings (FBG) as strain sensor elements on railroad tracks, for example as the rail contact of an axle counter.

30

DE 10 2017 216 811 A1 describes a method in which a rail-monitoring element is adhesively attached to a rail. Attachment by means of a heat activated adhesive is proposed. Activation is achieved by heating the rail using an inductive heating

element. However, a great deal of energy is required for this, since a large volume (rail) has to be heated in order to ensure sufficient heat input into the adhesive layer of the rail-monitoring element.

- 5 A method for connecting two joining elements is described in WO 2017/162829 A1. The joining elements are connected by means of a thermally activatable adhesive and a flat heating element arranged therein. The adhesive is heated by the heating element by supplying electrical energy to the heating element.

10

It is the object of the invention to propose a rail-monitoring element and a method for manufacturing a rail-monitoring element in which mounting can be carried out more easily and in a energy saving manner. It is a further object of the invention to propose a simplified method for mounting a rail-monitoring element.

15

This object is achieved by a rail-monitoring element according to claim 1, a method for mounting a rail-monitoring element according to claim 11, and a method for manufacturing a rail-monitoring element according to claim 14. The dependent claims  
20 specify advantageous embodiments of the invention.

The rail-monitoring element according to the invention comprises a carrier on which a strain sensor, in particular comprising an optical fiber having a fiber Bragg grating, is attached. The carrier is a flat element that has the purpose of receiving and stabilizing  
25 the strain sensor. The carrier also has an adhesive layer for adhesive attachment to a rail. The adhesive can be activated or cured thermally. According to the invention, the adhesive layer comprises a heating element having contacts for receiving electrical energy.

- 30 A thermally activatable adhesive is, for example, a heat activated film (HAF). A thermally activatable adhesive is a finished adhesive whose curing is blocked or extremely slowed down. The blockage is released when exposed to heat and the adhesive begins to cure quickly or at an accelerated rate.

A thermally curable adhesive is an adhesive whose curing process is accelerated with heat. A thermally curable adhesive is therefore also called, for example, a heat-curing adhesive. This means that a thermally curable adhesive cures much faster when exposed to heat than at lower temperatures. Curing refers to the crosslinking of the adhesive; the crosslinking process being accelerated under heat.

The adhesive layer is preferably located on the side of the carrier opposite the strain sensor. This allows the carrier to be attached to the rail, for example to the rail web of the rail, and allows the desired sensor data to be supplied to the strain sensor unaffected by the adhesive layer.

The invention thus provides an energy-efficient method of heating the adhesive. The heat source is placed exactly where it is needed, i.e. in the adhesive layer. This reduces the energy required to heat the adhesive. For example, the entire rail or the entire rail web does not have to be heated.

In preferred embodiments of the invention, the heating element is designed in the form of a wire, a grid or, for example, is flat. A flat design can be, for example, a film, a mesh or a fabric. Corresponding wire meshes can be lasered, for example. The advantage of these embodiments is that the heating element has a large surface contact with the adhesive of the adhesive layer and thus the heat can be transferred effectively into the adhesive surface of the adhesive layer. This allows for further energy savings.

In a preferred embodiment of the invention, the heating element is embedded in the adhesive layer. Such an embedding can be manufactured, for example, in a sandwich process, in which an adhesive layer is applied to the carrier, the heating element is applied to said layer and a second adhesive layer is then applied to the heating element. This adhesive-heating-element-adhesive sandwich layer can be applied, for example, during manufacture of the rail-monitoring element, as described above. Alternatively, it is also possible to apply this adhesive-heating-element-adhesive sandwich layer to the carrier during mounting, i.e. shortly prior to application to the rail, as described above. This allows great flexibility in the manufacturing and mounting processes of the rail-monitoring element.

In one embodiment of the invention, it is also possible for the heating element to be applied to the adhesive layer. One possibility here is that the heating element is arranged between the adhesive layer and the carrier. Alternatively, the adhesive layer is applied between the heating element and the carrier. Both embodiments are possible.

In a preferred embodiment of the invention, the heating element comprises a thermally conductive, electrically insulating sheath. This sheath allows, on the one hand, good heat transfer between the heating element and adhesive layer and, on the other hand, good electrical insulation. For example, an enameled wire can be used as a heating element for this purpose. The electrical insulation here provides that the electrical current applied to the heating element does not come into electrical contact with other parts of the rail-monitoring element. The insulating sheath prevents, for example, an electrical contact from being established between the heating element and, for example, the rail and/or, for example, the carrier of the rail-monitoring element. The insulating sheath further simplifies the manufacturing and mounting of the rail-monitoring element. Since the heating element is electrically insulated, it is not a problem if the insulating sheath contacts the rail, for example. The insulating sheath protects against electrical contact. In the same way, it is possible for the heating element with its insulating sheath to be in contact with the carrier. The electrically insulating sheath prevents electrical current from being transferred to the carrier and, for example, the sensor element. Such simple assembly and robustness are particularly advantageous for use in the railway sector and on the rail. Compared to uninsulated heating elements, this embodiment also has the advantage that no spacer elements have to be provided in the adhesive layer in order to prevent the heating element from coming into contact with the rail. These spacer elements can therefore be dispensed with, which leads to a further simplification of the mounting or manufacturing of the rail-monitoring element. The insulating sheath around the heating element is also advantageous because the heating element can be designed in such a way that portions of the heating element can cross or be arranged very close to one another without causing a short circuit as a result. This further facilitates the mounting. This also allows a closer arrangement of the heating element, e.g. the heating wires, in the adhesive layer.

In a preferred embodiment of the invention, the adhesive layer is a heat activated film (HAF). A heat activated film is a film made of adhesive that is activated by heat; i.e. the linkage in the adhesive and thus the adhesive effect begins as a result of heat. For  
5 example, two heat activated films can surround a heating wire in a sandwich-like manner. These heat activated films can be activated by supplying electrical energy to the heating wire.

By embedding a temperature sensor in the adhesive layer, the process of heating the  
10 adhesive layer can be controlled even more precisely by reading the sensor data and observing a certain temperature range. If a fiber Bragg grating is used as the strain sensor, the temperature monitoring can already be carried out precisely by bonding the fiber Bragg grating, so that an additional temperature sensor can be dispensed with in such an embodiment.

15 The adhesive layer preferably has a thickness of between 0.5 and 1.5 mm, for example 0.8 mm. This thickness is advantageous in order to be able to compensate for any curvature or unevenness of the rail and still achieve a sufficient adhesive effect. The viscosity of the adhesive should be pasty or "stable" (20,000 to 100,000 mPas). This  
20 ensures that, despite the relatively large thickness of the adhesive layer selected, said adhesive layer does not emerge from the space between the carrier and the rail during mounting.

Particularly when using heat activated adhesives, to activate said heat activated  
25 adhesives, in addition to heating the adhesive layer, a contact pressure is preferably exerted on the adhesive layer, for example between 0.3 bar and 0.7 bar, preferably approx. 0.5 bar. The heating element is therefore preferably designed in such a way that it is not pressure-sensitive to such pressures. When applied to the rail web, the adhesive surface is vertical with regard to gravity. This means that a contact pressure  
30 on the adhesive surface is required, since the rail-monitoring element to be bonded could otherwise slip. This results in a double benefit from the contact pressure: It prevents slipping during vertical bonding and at the same time allows the heat activated adhesive to be activated.

The invention also relates to a mounting arrangement for mounting the rail-monitoring element. The mounting arrangement comprises a rail-monitoring element, as described above, and a mobile energy supply. The heating element of the adhesive layer is electrically connected to the mobile energy supply via the contacts. The mobile  
5 energy supply supplies the adhesive layer with electrical energy and thus heats it.

A particularly preferred embodiment comprises a switch for the electrical connection of the energy supply to the contacts of the heating element and a control unit that controls the switching state of the switch. This control takes place as a function of a  
10 temperature detected by a temperature sensor, the temperature sensor preferably being arranged in the adhesive layer, as described above. In this way, the temperature of the adhesive layer can be set particularly precisely and reliably.

When mounting the rail-monitoring element according to the invention at a mounting  
15 point on a rail, the following steps should be carried out: The rail-monitoring element is positioned at the mounting point with the adhesive layer of the carrier coming into contact with the rail. The adhesive layer is then heated by supplying electrical energy to the heating element. A battery is preferably used to supply electrical energy to the heating element. The battery can be a conventional 12-V battery, for example. A  
20 mobile and/or portable voltage supply can also be used to supply electrical energy to the heating element, in particular in the region of protective extra-low voltage.

In a preferred embodiment of the invention, the electrical energy is controlled as a function of the temperature of the adhesive. The temperature of the adhesive is  
25 preferably determined by a temperature sensor embedded in the adhesive layer. In this way, the curing of the adhesive can be further favorably influenced, since the optimum temperature can be maintained as well as possible.

In one embodiment of the invention, prior to arranging the adhesive layer at the rail,  
30 heat is applied to the rail in the area of the mounting point. This heating of the rail was in addition to the heating element heating the adhesive layer. By heating the rail, the mounting point can be prepared for bonding, for example in very cold weather. This is particularly advantageous if the heat generated by the heating element would not be sufficient to cure the adhesive because the weather is too cold.

In a method for mounting a rail-monitoring element, in a first step a strain sensor, in particular comprising an optical fiber having a fiber Bragg grating, is attached to a first side of a flat carrier. An adhesive layer is then applied to the side of the carrier opposite  
5 the strain sensor. A heating element having contacts that can be supplied with electrical energy is arranged in the adhesive layer or on the adhesive layer. The arrangement of the heating element on the adhesive layer has the advantage that this arrangement can be easily manufactured. In this arrangement, the heating element is preferably provided with an insulating sheath in order to avoid direct contact between  
10 the heating element and the rail. If the heating element is arranged in a sandwich construction between two layers of the adhesive layer, an insulating sheath of the heating element can be dispensed with if the adhesive layer is chosen to be thick enough. The provision of an insulating sheath for the heating element is, however, also advantageous here, since this allows greater flexibility in the application of  
15 pressure during mounting. The heating element can be arranged and fixed in sandwich fashion, in particular between two heat activated adhesive films. The fixation is possible, for example, using static friction or pre-lamination of the heat activated films.

Further advantages of the invention can be found in the descriptions and the drawings.  
20 Likewise, according to invention, the aforementioned features and those which are to be explained below can each be used individually for themselves or for a plurality of combinations of any kind. The embodiments shown and described are not to be understood as an exhaustive enumeration but rather have exemplary character for the description of the invention.

25

#### Detailed description of the invention and drawings

In the drawings:

30

**Fig. 1** shows a cross-section through a rail comprising an applied rail-monitoring element having a carrier, an adhesive layer and contacts;

- Fig. 2** shows a cross-section through a rail-monitoring element comprising a carrier with an adhesive layer, consisting of two layers and a heating element arranged between them;
- 5 **Fig. 3** shows a cross-section through a rail-monitoring element comprising a carrier having an adhesive layer and a heating element arranged thereon having an insulating sheath;
- Fig. 4** is a schematic illustration of an adhesive layer comprising a heating element  
10 in the form of a grid and a voltage supply;
- Fig. 5** is a schematic illustration of an adhesive layer comprising a heating element and a control unit;
- 15 **Fig. 6** is a perspective view of a rail having a rail-monitoring element attached thereto.

**Fig. 1** shows a section through a rail **S** having a rail web **ST**. A rail-monitoring element **SUE**, comprising a carrier **T** and an adhesive layer **K**, is mounted to the rail web.  
20 According to the invention, a heating element **HE** is arranged in the adhesive layer **K**. Contacts **KO** are connected to the heating element **HE**. The contacts **KO** are electrical contacts and serve to supply electrical energy to the heating element **HE**.

**Fig. 2** shows an embodiment of the rail-monitoring element according to the invention,  
25 in which the adhesive layer **K** applied to the carrier **T** consists of two layers. The heating element **HE** is arranged between the two layers of the adhesive layer **K**. **Fig. 2** shows a cross-section through this arrangement. In the present example, the heating element **HE** consists of wires that run between the two layers of the adhesive layer **K**. When electrical energy is supplied to the heating element **HE**, the two layers of the  
30 adhesive layer **K** connect and enclose the heating element **HE**.

**Fig. 3** shows a further embodiment of the rail-monitoring element according to the invention, in which the adhesive layer **K** applied to the carrier **T** is a single layer. The heating element **HE** is arranged between the adhesive layer **K** and the carrier **T**. In the

present example, the heating element HE consists of wires that are surrounded by an insulating sheath I. Fig. 3 shows a cross-section through this arrangement. In the embodiment shown in Fig. 3, it is possible to arrange the heating element HE between the adhesive layer K and the carrier T, in contrast to the embodiment shown in Fig. 2, in which the heating element HE is completely embedded in the adhesive layer K. Here, electrical insulation from the carrier T is ensured by an insulating sheath I. By supplying electrical energy to the heating element HE, the adhesive layer K connects to the carrier T and encloses the heating element HE.

10 **Fig. 4** is a schematic view of an adhesive layer K comprising a heating element HE. This can be a plan view (when the heating element is arranged on the adhesive layer) or a sectional view (when the heating element is arranged in the adhesive layer or between two layers of the adhesive layer) parallel to the surface area of the adhesive layer. In the example shown in Fig. 4, the heating element forms a type of grid, formed by a wire running zigzag and meandering over a surface. The heating element HE can run between two layers of the adhesive layer K. The heating element HE has contacts KO via which, for example, a direct voltage source **V**, for example in the form of a battery, is connected. The heating element HE can be supplied with electrical energy via the voltage source, for example the direct voltage source V. Instead of the direct voltage source V, it is also possible to use an alternating voltage source.

25 **Fig. 5** shows an arrangement **A** for mounting the rail-monitoring element. A temperature sensor **TS** is also arranged in the adhesive layer K with the heating element HE. As in Fig. 4, here too the heating element HE is connected to the direct voltage source V via the contact elements KO. The connection of the direct voltage source V to the contact elements KO is controlled in a control unit **CU**. This control takes place via a switch **SW**, which can be opened and closed by the control unit **CU**. The temperature sensor TS detects the temperature of the adhesive layer K. The collected data are recorded by the control unit CU. The supply of electrical energy via the contact elements KO is controlled via the switch SW as a function of the detected temperature of the adhesive layer K. A user can control the control unit CU via a user interface **UI**.

**Fig. 6** is a perspective view of the rail S comprising a neutral axis NF. A rail-monitoring element SUE in the form of a fiber optic sensor element is mounted to the rail S. The rail-monitoring element SUE comprises a carrier T on which two fiber Bragg gratings FBG are pre-mounted. An optical fiber F connects the two fiber Bragg gratings FBG on the rail-monitoring element SUE. The rail-monitoring element SUE is preferably mounted in the region of the neutral axis NF, in particular such that each fiber Bragg grating FBG is arranged with one end below the neutral axis NF and with the other end above the neutral axis NF. The carrier T of the rail-monitoring element SUE is preferably mounted to the rail web ST of the rail S. After mounting, the direct voltage source is removed and can be used to mount additional rail-monitoring elements.

With the method according to the invention, a simple and secure planar bonding between the carrier T of the rail-monitoring element SUE and the rail S is made possible. In particular, mounting is made cheaper and simplified, which in particular improves use in the field. The rail-monitoring element SUE can be mounted faster and more safely.

List of reference signs

	A	Mounting arrangement
5	CU	Control unit
	F	Optical fiber
	FBG	Fiber Bragg grating
	HE	Heating element
	I	Electrically insulating sheath
10	K	Adhesive layer
	KO	Electrical contacts
	NF	Neutral axis
	S	Rail
	ST	Rail web
15	SUE	Rail-monitoring element
	SW	Switch
	T	Carrier
	TS	Temperature sensor
	UI	User interface
20	V	Direct voltage source

Reference list

	DE 10 2017 216 811 A1
25	EP 3 069 952 A1
	WO 2016/150670 A1
	WO 2017/162829 A1

## Claims

1. Rail-monitoring element (SUE) comprising a carrier (T) on which a strain sensor, in particular comprising an optical fiber (F) having a fiber Bragg grating (FBG), is attached, the carrier (T) having an adhesive layer (K) for adhesive attachment to a rail (S) having a thermally activatable or thermally curable adhesive,  
5  
**characterized in that**  
the adhesive layer (K) comprises a heating element (HE) having contacts (KO)  
10 that can be supplied with electrical energy.
2. Rail-monitoring element according to claim 1, characterized in that the heating element (HE) is in the form of a wire.
- 15 3. Rail-monitoring element according to claim 2, characterized in that the heating element (HE) is arranged in the form of a grid in the adhesive layer.
4. Rail-monitoring element according to claim 1, characterized in that the heating element (HE) is flat, in particular a film, a mesh or a fabric.  
20
5. Rail-monitoring element according to any of claims 1 to 4, characterized in that the heating element (HE) is embedded in the adhesive layer (K).
6. Rail-monitoring element according to any of claims 1 to 4, characterized in that  
25 the heating element (HE) is applied to the adhesive layer.
7. Rail-monitoring element according to any of the preceding claims, characterized in that the heating element (HE) has a thermally conductive, electrically insulating sheath (I).  
30
8. Rail-monitoring element according to any of the preceding claims, characterized in that the adhesive layer (K) is a heat activated film.

9. Rail-monitoring element according to any of the preceding claims, characterized in that a temperature sensor (TS) is embedded in the adhesive layer.
- 5 10. Rail-monitoring element according to any of the preceding claims, characterized in that the adhesive layer (K) has a thickness of at least 0.5 mm, preferably of at least 0.8 mm.
- 10 11. Mounting arrangement (A) comprising a rail-monitoring element according to any of the preceding claims and a mobile energy supply (V), the heating element (HE) comprising contacts (KO) that are electrically connected to the mobile energy supply (V).
- 15 12. Mounting arrangement according to claim 11, characterized by a control unit (CU) that controls the switching state of a switch (SW) for the electrical connection of the energy supply (V) to the contacts (KO) of the heating element as a function of a temperature detected by a temperature sensor (TS).
- 20 13. Method for mounting a rail-monitoring element (SUE) according to any of the preceding claims at a mounting point of a rail (S), comprising the following steps:
- Positioning the rail-monitoring element (SUE) at the mounting point, the adhesive layer (K) of the carrier (T) coming into contact with the rail (S),
  - Heating the adhesive layer (K) by supplying electrical energy to the heating
- 25 element (HE).
14. Method according to claim 13, characterized in that the electrical energy is controlled as a function of the temperature of the adhesive.
- 30 15. Method according to either claim 13 or claim 14, characterized in that before the adhesive layer (K) is arranged on the rail (S), heat is applied to the rail (S) in the area of the mounting point.

16. Method for manufacturing a rail-monitoring element (SUE) comprising the following steps:
- Attaching a strain sensor, in particular comprising an optical fiber (F) having a fiber Bragg grating (FBG), on a first side of a flat carrier (T),
  - Applying an adhesive layer (K) on the side of the carrier opposite the strain sensor,
- characterized in that**  
a heating element (HE) having contacts (KO) for receiving electrical energy is arranged in or on the adhesive layer.
17. Method according to claim 16, characterized in that the heating element is arranged and fixed between two heat activated films.
18. Rail-monitoring element manufactured by a method according to either claim 16 or claim 17.

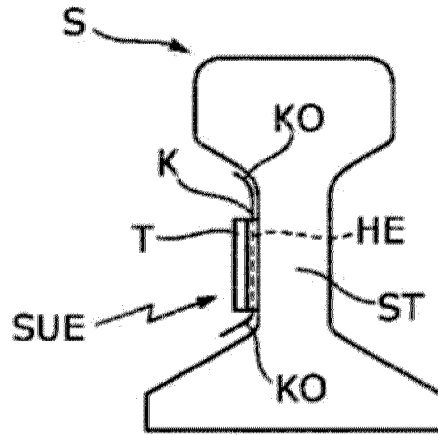


Fig. 1

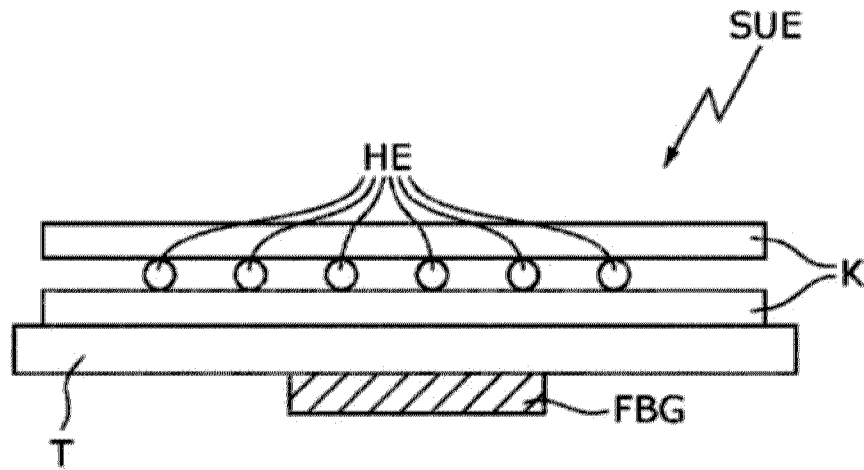


Fig. 2

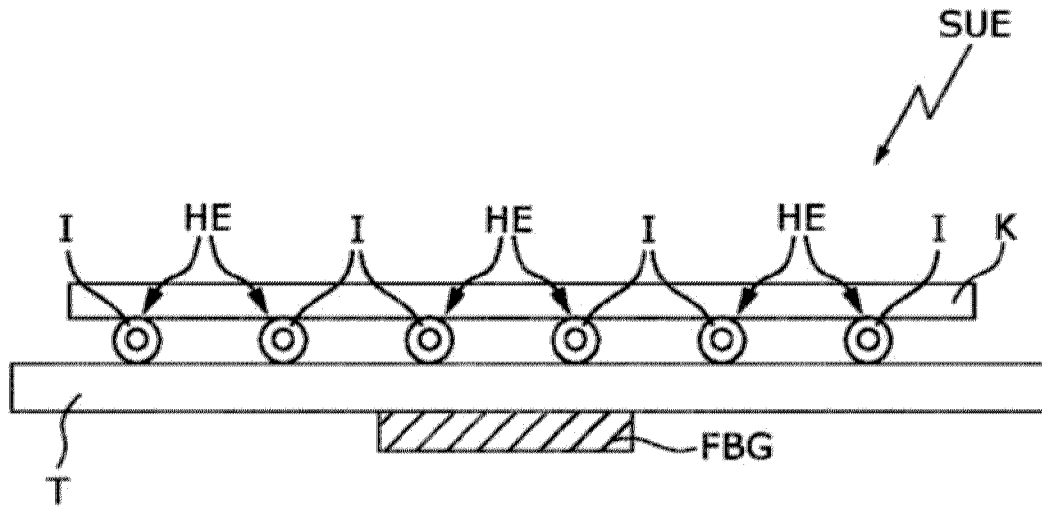


Fig. 3

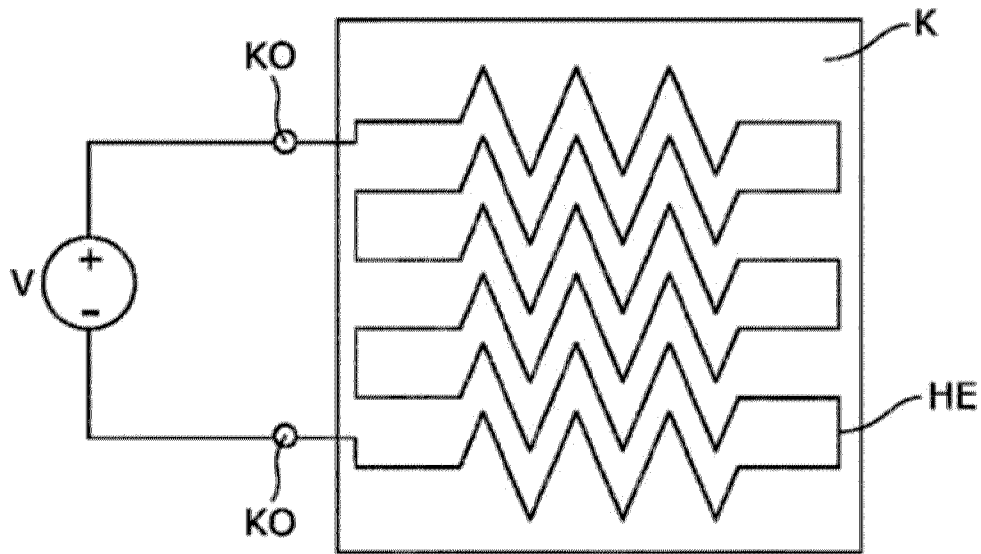


Fig. 4

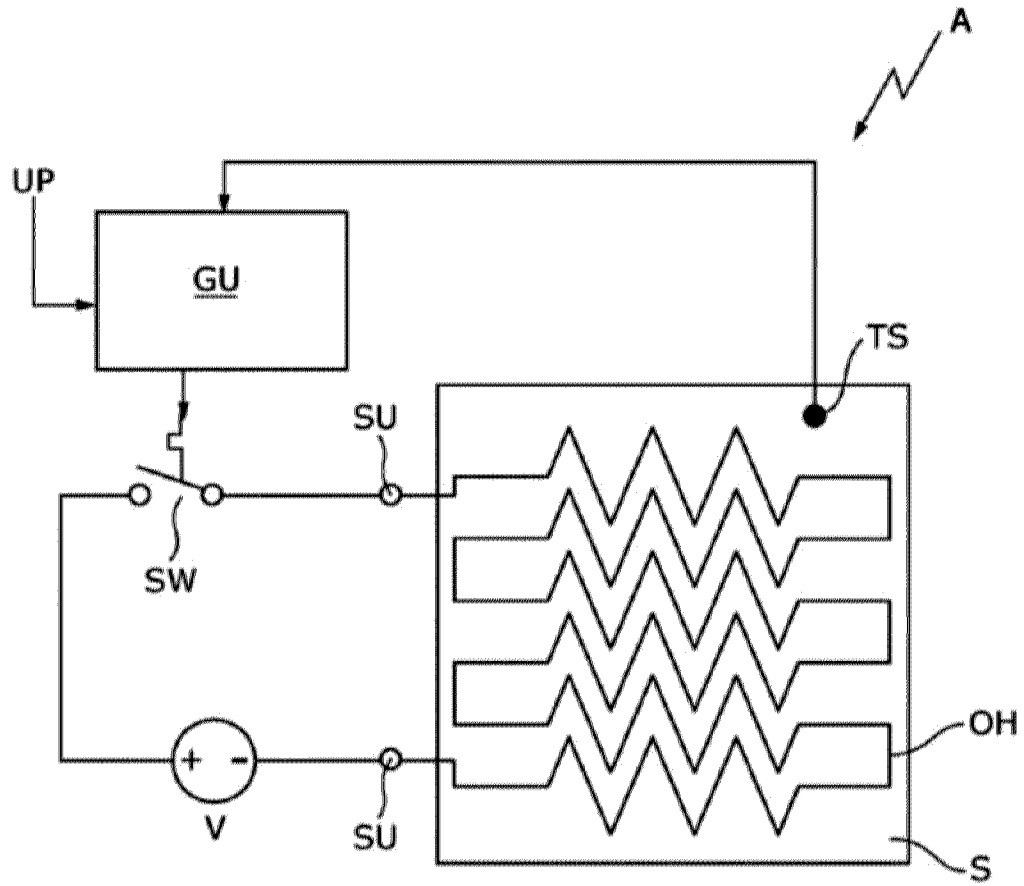


Fig. 5

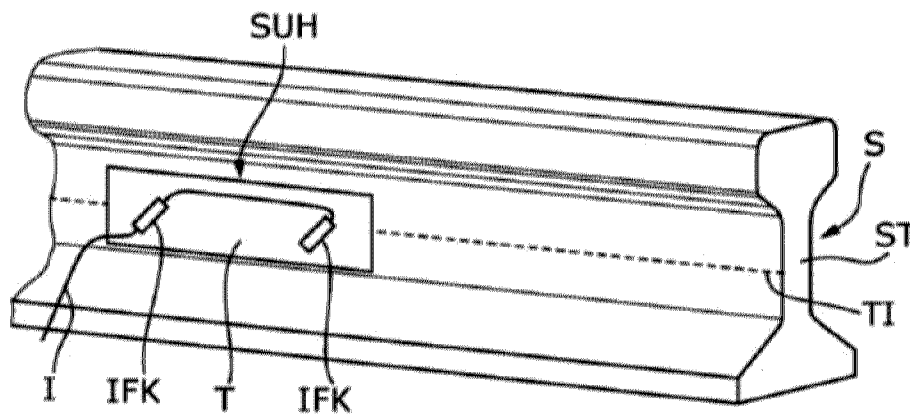
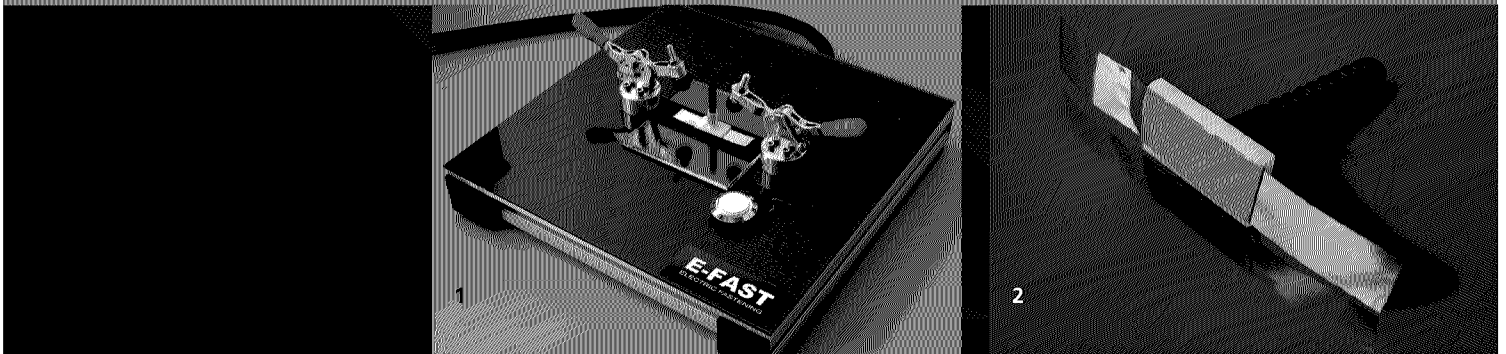


Fig. 6



- 1 Prototyp der E-FAST Anlage.
- 2 Bolzen mit vorappliziertem Klebstoff und Heizelement.

## E-FAST-VERFAHREN ZUR SCHNELLHÄRTUNG VON KLEBSTOFFEN

Fraunhofer-Institut für  
Fertigungstechnik und  
Angewandte Materialforschung IFAM  
– Klebtechnik und Oberflächen –

Wiener Straße 12  
28359 Bremen

Institutsleiter  
Prof. Dr. Bernd Mayer

Kontakt

Klebstoffe und Polymerchemie

Dipl.-Ing. (FH) Andreas Lühring  
Telefon +49 421 2246-494  
andreas.luehring@ifam.fraunhofer.de

Dr. Malte Kleemeier  
Telefon +49 421 2246-483  
malte.kleemeier@ifam.fraunhofer.de

www.ifam.fraunhofer.de

© Fraunhofer IFAM

CA 03141665 2021-11-23

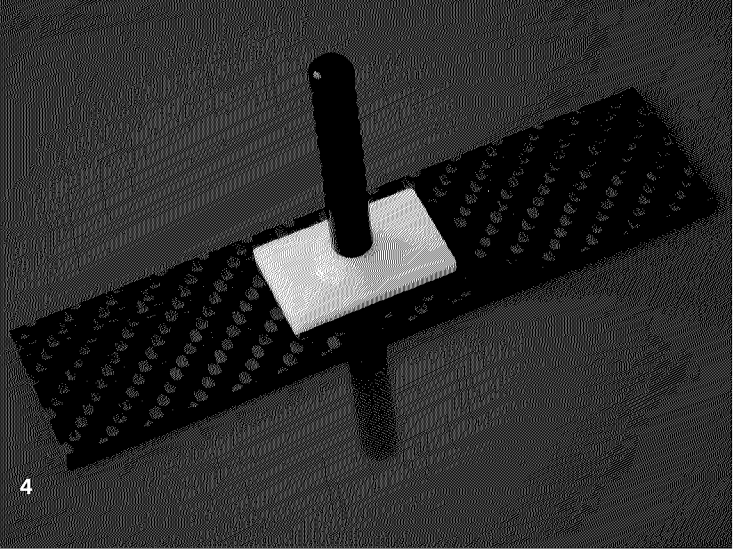
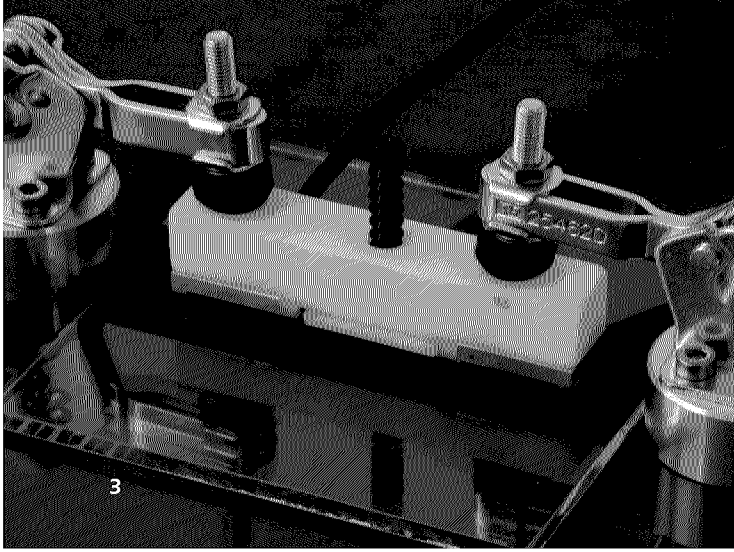
### Motivation

In der industriellen klebtechnischen Fertigung gewinnen Methoden zum schnellen Aushärten von Klebstoffen zunehmend an Bedeutung. Insbesondere sind Schnellhärtungsprozesse, bei denen die Wärme nur lokal im Bereich der zu fügenden Bauteile eingebracht wird, von großem Interesse. Damit lassen sich kurze Aushärtungszeiten im Bereich von einigen Minuten bis zu Sekunden erreichen und umliegende, möglicherweise temperaturempfindliche Strukturen werden nicht beeinflusst. Als Möglichkeiten stehen nach dem gegenwärtigen Stand der Technik die induktive Erwärmung sowie die Erwärmung durch Mikrowellen, Infrarotstrahlung oder Heißluft zur Verfügung. Diese Techniken ermöglichen gegenüber einer konventionellen Ofenhärtung schon eine erhebliche Energieeinsparung, dennoch liegt die elektrische Anschlussleistung gängiger Mikrowellenanlagen, Infrarotstrahler und

Heißluftgebläse immer noch im Bereich einiger Kilowatt. Durch den relativ hohen Energiebedarf und die damit unter Umständen verbundene Notwendigkeit zur aktiven Gerätekühlung, ergibt sich oft ein hoher Platzbedarf bzw. ein hohes Gewicht für das System, sodass die Konstruktion von kompakten manuell oder Roboter-geführten Systemen zur lokalen Erwärmung aufwendig ist.

### E-FAST-Verfahren

Das E-FAST-Verfahren ermöglicht es, Klebstoffe in wenigen Sekunden mit geringem Energieaufwand prozesssicher auszuhärten. In den Klebstoff wird dafür ein kombiniertes Heiz-/Sensorelement integriert (Abb. 5). Das Heiz-/Sensorelement dient dabei einerseits dazu, die Klebschicht auf die notwendige Härtungstemperatur zu erwärmen, andererseits ermöglicht es die direkte Messung der Temperatur innerhalb der Klebschicht, sodass der Härtungsprozess sehr präzise geregelt werden kann.



### Temperaturführung

Für eine zuverlässige Schnellhärtung von Klebstoffen ist eine präzise Temperaturkontrolle während des Prozesses erforderlich. Eine Unterschreitung der optimalen Härtungstemperatur führt zu einer reduzierten Festigkeit und Beständigkeit der Klebverbindung, während der Klebstoff bei einer Überhitzung der Klebschicht direkt thermisch geschädigt wird. Da bei einer Schnellhärtung mit hohen Aufheiz- und Abkühlgeschwindigkeiten gearbeitet wird, treten starke Temperaturgradienten zwischen Klebstoff und den zu fügenden Bauteilen auf, sodass die Temperatur im Klebstoff nicht mit der von außen messbaren Bauteiltemperatur gleichgesetzt werden darf.

Das E-FAST-Verfahren bietet aufgrund der integrierten Temperaturmessungen innerhalb der Klebschicht einen entscheidenden Vorteil gegenüber herkömmlichen Verfahren, bei denen die Temperatur von außen gemessen wird.

### Verfahrensbeschreibung

Als Heiz-/Sensorelement dient eine dünne Metallfolie, die in der Mitte der Klebschicht platziert wird und sich beim Anlegen einer elektrischen Spannung erwärmt. Da die Wärme über das Heizelement direkt in den Klebstoff eingebracht wird, erfolgt die Erwärmung mit maximaler Effizienz. Nach der Härtung verbleibt das Heizelement prinzipbedingt in der Klebfuge. Versuche zeigen aber, dass dadurch die Verbundfestigkeit der Klebung nicht wesentlich herabgesetzt wird.

### Vorteile des Verfahrens

Dadurch dass Klebstoff und Heiz/Sensorelement eine Einheit bilden, ermöglicht das E-FAST-Verfahren ein sehr schnelles Fügen von Bauteilen bei gleichzeitig hoher Zuverlässigkeit. Die durch das zusätzliche Heiz/Sensorelement geringfügig steigenden Bauteilkosten werden durch einen geringeren Investitionsbedarf für die Anlage, reduzierte Energiekosten und schnellere Taktzeiten deutlich kompensiert.

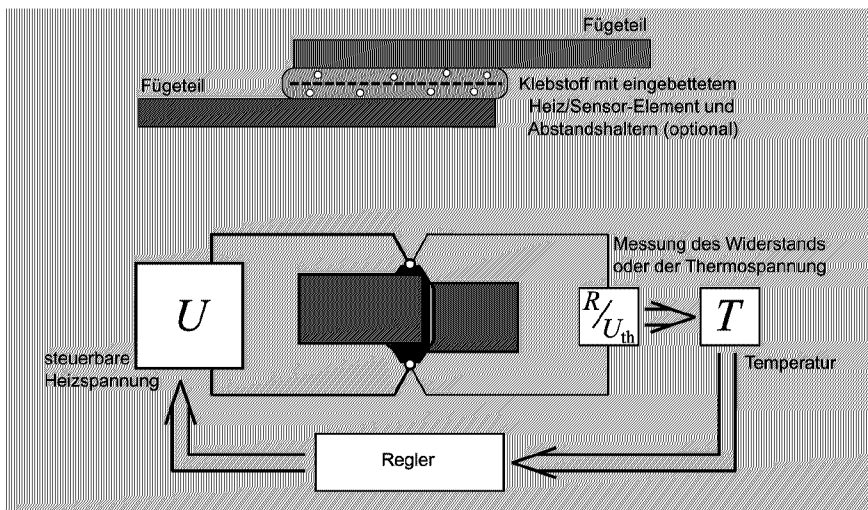
- Erwärmung mit hoher Leistungsdichte bei niedrigem Energieverbrauch
- Integrierte Temperaturmessung für eine reproduzierbare Prozessführung
- Zuverlässige Klebstoffhärtung im Sekundenbereich

### Industrielle Umsetzung

Das am Fraunhofer IFAM entwickelte und zum Patent angemeldet E-FAST-Verfahren kann flexibel an verschiedenste Applikationen angepasst werden. Das Fraunhofer IFAM kann dabei sowohl das notwendige Know-how zur Verfahrenstechnik als auch maßgeschneiderte Klebstoffe für den Prozess bereitstellen.

3 Prototyp der E-FAST-Anlage (Detailaufnahme).

4 Aufgeklebter Bolzen.



5 Integriertes Heiz-/Sensorelement zur temperaturgeregelten schnellen Aushärtung von Klebstoff.

CA 03141665 2021-11-23

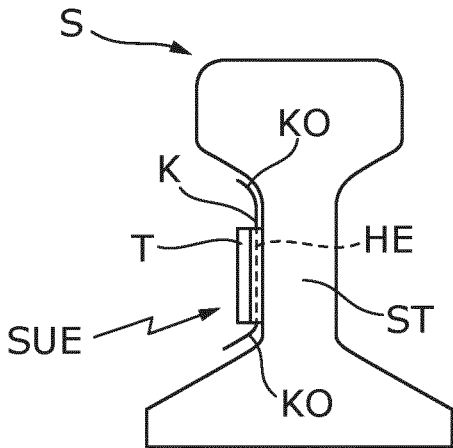


Fig. 1