



(51) International Patent Classification:
A61M 11/00 (2006.01)

(21) International Application Number:
PCT/US2013/039734

(22) International Filing Date:
6 May 2013 (06.05.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/642,284 4 May 2012 (04.05.2012) US

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU,
RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ,
TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA,
ZM, ZW.

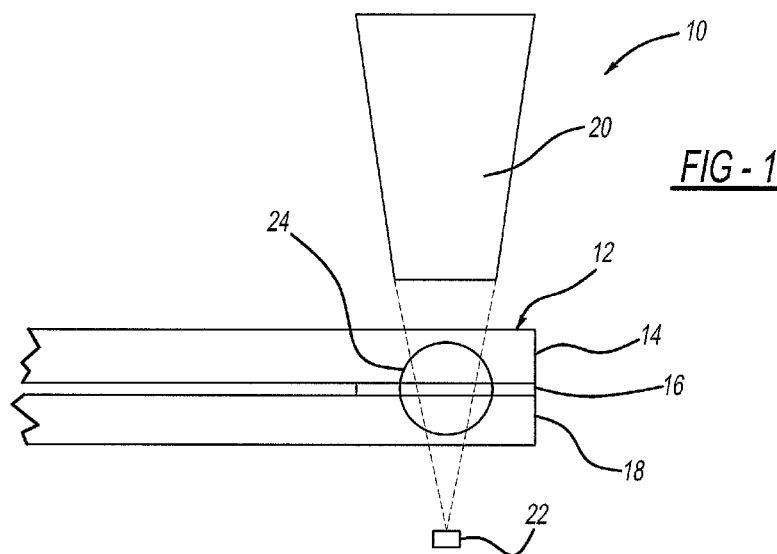
(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))

[Continued on next page]

(54) Title: METHOD OF CURING AND ADHESIVE BETWEEN TWO OR MORE PANELS



(57) Abstract: A process for curing of an adhesive using laser energy. A substrate sandwich assembly is provided with an adhesive interposed between the substrates. The adhesive used at least partially requires heat to assist in curing of the adhesive. The area where the adhesive is found in the sandwich is heated with a laser. The laser used is defocused for instance the laser is focused to a point behind the substrates to be bonded. Thereafter the defocused laser is used to contact the surface of the substrates to be bonded at the location of said adhesive with the out of focus laser energy beam for imparting heat on the bonding area with an effective amount of laser energy sufficient to assist in bond curing of the adhesive at that area.





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- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *of inventorship (Rule 4.17(iv))*
- Published:**
- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

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METHOD OF CURING AND ADHESIVE BETWEEN TWO OR MORE PANELS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a PCT International Application of United States Patent
5 Application No. 61/642,284 filed on 04 May 2012.

FIELD OF THE INVENTION

The present invention relates to a method for curing an adhesive bond using
laser energy.

10 BACKGROUND OF THE INVENTION

Adhesive bonding of materials has long been an important consideration in
design and manufacturing of products for sale in the market place.

In particular in automotive applications increasingly stringent bond strength
standards and increasing use of polymers, sheet molding compounds, composites
15 and the like have made adhesive bonding an increasingly important area to be
improved upon.

Picking adhesives having the proper curing system and providing fixtures and
equipment for curing is critical to proper bonding. Adhesives typically require curing
by a mechanism such as: heat curing; chemical; moisture and/or UV curing.

20 Heat curable adhesives require that external heat be applied through the
substrate by various methods of heat. Typically ovens, heating elements, flames or
heat lamps may be used. These methods require that external heat be applied
through the substrate by these various methods of heat. Because heating is not
instantaneous the parts to be adhered to one another must be held in the final
25 bonded position for long lengths of time. Thus, complex and expensive fixtures or
work piece holders are often required to maintain proper dimensions. Heated bonder
machines are often used but are expensive and often job specific. Some systems
use infrared lights to heat such bonds, while others use microwave curing to impart
heat but requires constant monitoring for leaks and has high energy costs. Induction
30 heat curing is also possible but metal particles in the bond may cause excessive
wear on the adhesive bonding equipment.

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Chemical curing mixes 2 or more components together so that the chemical curing reaction takes place. This method has a limited time from when the components are mixed in which to apply the adhesive to the parts and secure the parts together. If this is not done on a timely basis (referred to as "open time") the adhesive is rendered useless or the bonding properties can be compromised.

Moisture cure systems typically are cured by initiating a polymerization reaction with water. Humidity in the air or application of water to the adhesive directly can be used for reaction initiation. The reaction is very slow typically and therefore expensive fixtures are also needed with this method. At times parts to be cured can be held in position with mechanical fasteners. However, this is not desirable and may be impractical depending on the types of fasteners necessary. Fasteners disrupt the surfaces of the substrates to be bonded and also may compromise the strength of the materials due to the necessary holes through the materials and stresses placed on the materials at the fastening location.

Ultraviolet light curing of adhesives uses ultraviolet light of a particular frequency to initiate the polymerization reaction. This type of curing requires that the adhesive be exposed to light. Thus, either the adhesive must be exposed to the ambient environment or if hidden beneath a part or panel the part or panel must be UV transparent at least where the UV curable adhesive is applied.

All of these prior processes use fixtures and/or high amounts of energy to cure the adhesives. Therefore, the known processes are somewhat undesirable because they suffer from the disadvantages of one or more of: high energy costs; too slow; expensive fixtures; not enough time between dispensing and mating parts; and/or, require a level of transparency that is not possible.

Additionally, it is desirable to provide a substitute for mechanical fasteners for at least temporarily holding of parts together during adhesion without disrupting the surface such as with mechanical fasteners.

Therefore, there remains a need in the art to provide an improved fast, energy efficient curing method for adhesives.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a process for curing of an adhesive using laser energy. In a first step a substrate sandwich

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assembly comprising at least one substrate is provided. A second substrate is bonded to the first substrate with an adhesive interposed between the substrates. The adhesive used at least partially requires heat to assist in curing of the adhesive. The area where the adhesive is found in the sandwich is heated with a laser. The laser used is defocused, meaning the laser is focused to a point (e.g. focal point) behind the substrates to be bonded. Thereafter the surface of the substrates to be bonded is contacted with a laser at the location of the adhesive with the out of focus laser energy beam for imparting heat into the bonding area. The laser energy used is an effective amount of laser energy sufficient to assist in bond curing of the adhesive at that area.

Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic view showing the process in accordance with the present invention.

Figure 2 is a schematic view showing and alternate embodiment of the process of the present invention;

Figure 3A is a schematic view showing an alternate embodiment of the present invention having a pretreatment laser etching process;

Figure 3B is an alternate embodiment of the process of the present invention incorporating the pretreatment laser etching process of Fig. 3A; and

Figure 4 is a schematic view showing an alternate embodiment of the process of the present invention.

The present invention will become more fully understood from the detailed description and the accompanying drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the present invention there is provided a process for curing of an adhesive using laser energy generally indicated at 10. In a first step a

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substrate sandwich assembly generally indicated at 12 is provided. The assembly 12 includes at least one substrate 14 (also referred to as a first panel) such as a panel or part of the vehicle, an adhesive 16 and a second substrate 18 (also referred to as a second panel). In the present invention panel (14, 18) materials to be adhered are typically automotive parts and assemblies. Typically panels to be bonded are made out of polymer, sheet metal, aluminum, sheet molding compound, composites, thermoset polymers, thermoformable polymers and sometimes combinations of these materials. While the process is particularly useful in modern thermoplastic and composite vehicle parts it is to be readily appreciated that the process can be useful in any heat cured adhesive situation.

A Laser 20 is used for curing of the adhesive 14. Lasers 20 used in the present invention are typically in the 1KW to 100KW range. The process is used for treating the surface of the substrate to provide a surface energy of from about 40 to about 80 Dynes and preferably from about 60 to 80 Dynes. Depending on the application and the laser available a single laser may be used. If a higher energy laser is used the beam is split to apply laser energy to more than one bond area. The laser is focused at a point 22 beyond both of the substrates and then is passed over the substrate to create heat at the substrate. This creates an area of heat 24 at the adhesive area for curing of the adhesive.

The second substrate 18 is bonded to the first substrate 14 with an adhesive 16 interposed between the substrates (14, 18). The adhesive used at least partially requires heat to assist in curing of the adhesive. Heat cure adhesives are known to those skilled in the art. Heat curing may also be used in volatile organic compounds (VOC) containing adhesives to assist in drying of the adhesives. The area where the adhesive is found in the sandwich is heated with a laser. In order to create a wider area of energy input on the adhesive layer, the laser is focused to the point 22 beyond the sandwich 12 construction. This creates a defocused area 24 of the laser beam that inputs energy in the area of adhesive layer 16 in contact with substrate 14, 18. The energy in the defocused area 24 imports heat to create a bond area using an effective amount of laser energy sufficient to assist in bond curing of the adhesive with the substrates 14, 18.

Referring now to Figure 2, in a second embodiment of the present invention (wherein like numerals differing by 100 indicate like elements) a multiple layer

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sandwich is provided which includes a second adhesive 126 for connecting to a third substrate 128. Again the laser is defocused to a point 122 beyond either panel. The defocused area 124 concentrates heat in the points of both adhesive bonds.

As an alternative process of the present invention the laser is used in spot locations to keep the panels together by turning the defocused laser on along a bond line for providing predetermined points of bonding. This allows secure positioning of the substrates 14, 18, 114, 118, 128 to be held in position while the bond is further being cured.

Figures 3A and 3B show another alternate embodiment of the invention wherein like reference numerals differing by 200 indicate like elements. Referring now to Figure 3A, a pretreatment process 200 is shown wherein substrates 214, 218 are pretreated or etched with a laser 220. The laser 220 is focused to a point 222 in order to create an etching 223 on the surface of the substrates 214, 218. The etching 223 creates a rough surface on the substrates 214, 218 to allow an adhesive layer to more efficiently bond to the surface. The laser 220 is focused to a point 222 in order to provide enough energy to etch the surface of the substrates 214, 218. On a microscopic level, the surface of the substrates 214, 218 will be rough as opposed to smooth, thereby creating a larger surface area on the area of the etched surface 223. Once both substrates 214, 218 have been etched they are then bonded in a manner similar to Figure 1. Figure 3B shows the process where the laser 220 is focused to a point 225 beyond the substrates 214, 218 with an adhesive layer 216 placed between the substrates 214, 218. The adhesive layer extends over the etched surface 223 of the substrate 214, 218. As stated above, the laser beam is defocused to a point 225 beyond and thereby creates a defocused area 224 in order to input energy in the region between the substrates 214, 218, etched surface 223 and adhesive layer 216.

Referring now to Figure 4, an alternate embodiment of the present invention is shown wherein the single laser beam is split to create a bond at a different location using the same laser beam. In Figure 4, like reference numerals to Figure 1 are shown differing by 300. In Figure 4, a process for curing two bonds using laser energy is generally shown at 300. The process has a first substrate 314, second substrate 318 with two different adhesive layers 316, 316' positioned between the first substrate 314 and second substrate 318. The location of the adhesive layers

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316, 316' are locations where two different bonds between the substrates 314, 318 will be created. It is within the scope of this invention for the adhesive layers 316, 316' to be located or used in connecting multiple substrates, thus while Figure 4 shows two adhesive layers 316, 316' between a first substrate 314 and second substrate 318, it is within the scope of this invention for the adhesive layers to be located between any number of substrates and the present invention is not just limited to creating two separate bonds between the same two substrates.

The process 300 uses a laser 320 for creating a laser beam 317 focused to a point 322 located beyond the first substrate 314, adhesive later 316 second substrate 318. The beam 317 creates a first defocused area 324 where energy in the form of heat is applied between the adhesive layer 316 and the first substrate 314 and second substrate 318 in a manner similar to Figure 1.

A mirror 321 or other suitable light refractive object such as a light tunnel, prism or other suitable device or arrangement is positioned within a portion of the path of the first beam 317 at a location near the laser beam 320 in order to redirect a portion of the beam 317. The portion of the beam 317 that is refocused by the mirror 321 creates a second beam 319 that is focused to a point 322' beyond the first substrate 314, second adhesive layer 316' and second substrate 318. The second beam 319 being focused at a point 322' creates a second defocused area 324' for inputting energy in the form of heat at a second location in order to form a bond between the first substrate 314, adhesive layer 316' and second substrate 318. The process 300 shown in Figure 4 demonstrates how a single beam 317 can be split in order to create two different bonds using a single laser 320.

The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

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CLAIMS

What is claimed is:

1. A process for curing of an adhesive comprising the steps of:
 - 5 a. providing a substrate sandwich assembly comprising at least one substrate being bonded to a second substrate with an adhesive interposed between the substrates, said adhesive at least partially requiring heat to assist in curing;
 - b. contacting the surface of the substrates to be bonded at the location of
10 said adhesive with an out of focus laser energy beam for imparting heat on the bonding area with an effective amount of laser energy sufficient to assist in bond curing of the adhesive at that area.
2. The process in accordance with claim 1 wherein the laser is focused at a point behind the second substrate for imparting heat at the area of the adhesive.
3. The process in accordance with claim 2 wherein the substrate is
15 selected from the group of a polymeric substrate a metal substrate or combinations of same.
4. The process in accordance with claim 1 wherein a third substrate is bonded to the second substrate by a second adhesive adjacent to the first adhesive and the defocused laser heats both bonds for curing.
- 20 5. The process in accordance with claim 3 wherein said laser produces a laser beam using about 1 KW to about 100 KW.
6. The process in accordance with claim 4 wherein the laser is a high output laser which has a beam which is split into one or more discrete beams for curing more than one bond from a single laser.
- 25 7. The process in accordance with claim 1 wherein the laser is used to cure preselected locations along a bond line for providing temporary location during final curing of a part to be bonded.
8. A process for curing an adhesive comprising the steps of:
providing a first substrate and a second substrate;

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providing an adhesive layer positioned between said first substrate and said second substrate in a region where a bond is to be created;

providing a laser directed toward said first substrate, said adhesive layer and said second substrate;

5 focusing said laser to a point beyond said first substrate, said adhesive layer and said second substrate;

energizing said laser and creating a defocused area at a region where said first substrate and said second substrate contacts said adhesive layer, wherein said defocused area is created by focusing said laser to a point beyond said first
10 substrate, said adhesive layer and said second substrate, wherein the laser beam in the region of said defocused area in parts heat on said adhesive layer sufficient to assist in bond curing of said adhesive layer in the region between said first substrate and said second substrate.

9. The process in accordance with claim 8 wherein the first substrate and
15 the second substrate are one selected from the group comprising a polymeric substrate, a metal substrate or combinations of the same.

10. The process according to claim 8 wherein a third substrate is bonded to said second substrate by a second adhesive layer positioned between said second substrate and said third substrate.

20 11. The process according to claim 10 wherein said third substrate is bonded to said second substrate by said step of energizing said layer, wherein said defocused area encompasses an area where said adhesive layer and said second adhesive layer are positioned.

12. The process according to claim 8 wherein said laser produces a laser
25 beam using about 1 KW to about 100 KW.

13. The process according to claim 8 wherein said laser is a high output laser which has a beam which is split into one or more discrete beams for curing more than one bond from a single laser.

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14. The process according to claim 8 wherein the laser is used to cure preselected locations along a bond line for forming a temporary location during final curing of the part to be bonded.

15. A process for curing an adhesive comprising the steps of:

5 providing a first substrate and a second substrate;

providing a laser;

focusing said laser to a point on said first substrate or said second substrate where a bond is desired;

10 etching the surface of said first substrate and said second substrate by energizing said laser focused to a point on said first substrate or said second substrate;

providing an adhesive layer positioned between said first substrate and said second substrate at an area where said first substrate and said second substrate have been etched;

15 focusing said laser to a point beyond said first substrate, said adhesive layer and said second substrate; and

energizing said laser and creating a defocused area at a region where said first substrate and said second substrate contact said adhesive layer, wherein said defocused area is created by focusing said laser to a point beyond said first
20 substrate, said adhesive layer and said second substrate.

16. The process according to claim 15 wherein said first substrate and said second substrate are one selected from the group comprising a polymeric substrate, metal substrate or combinations thereof.

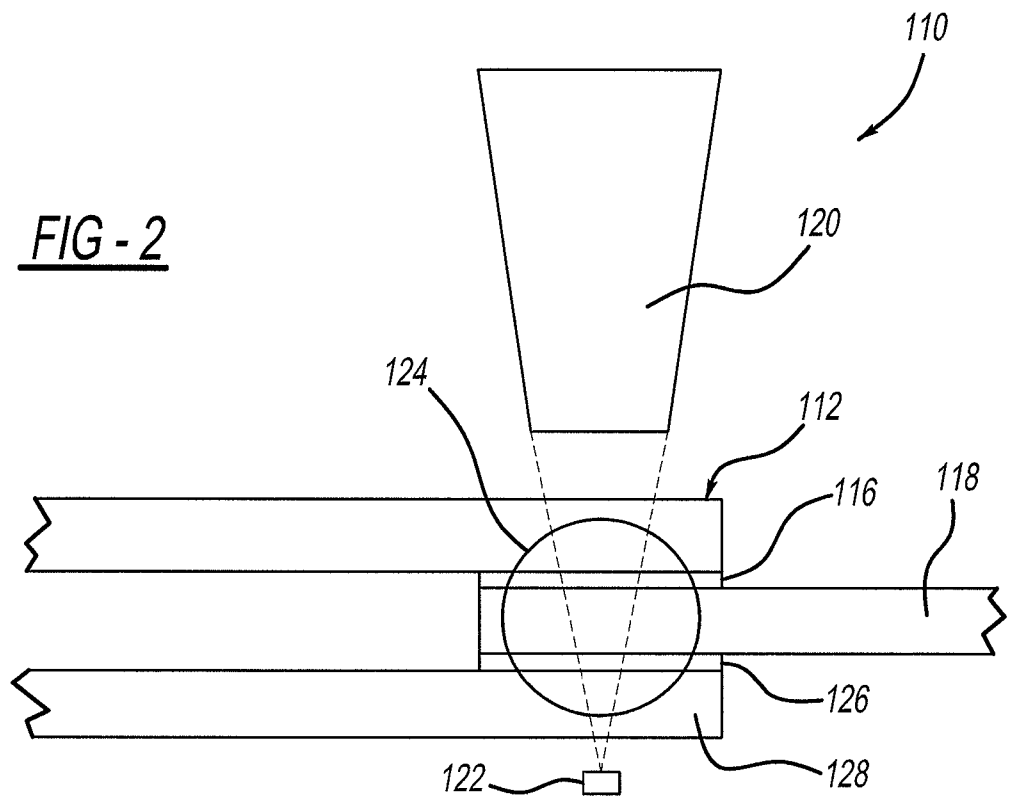
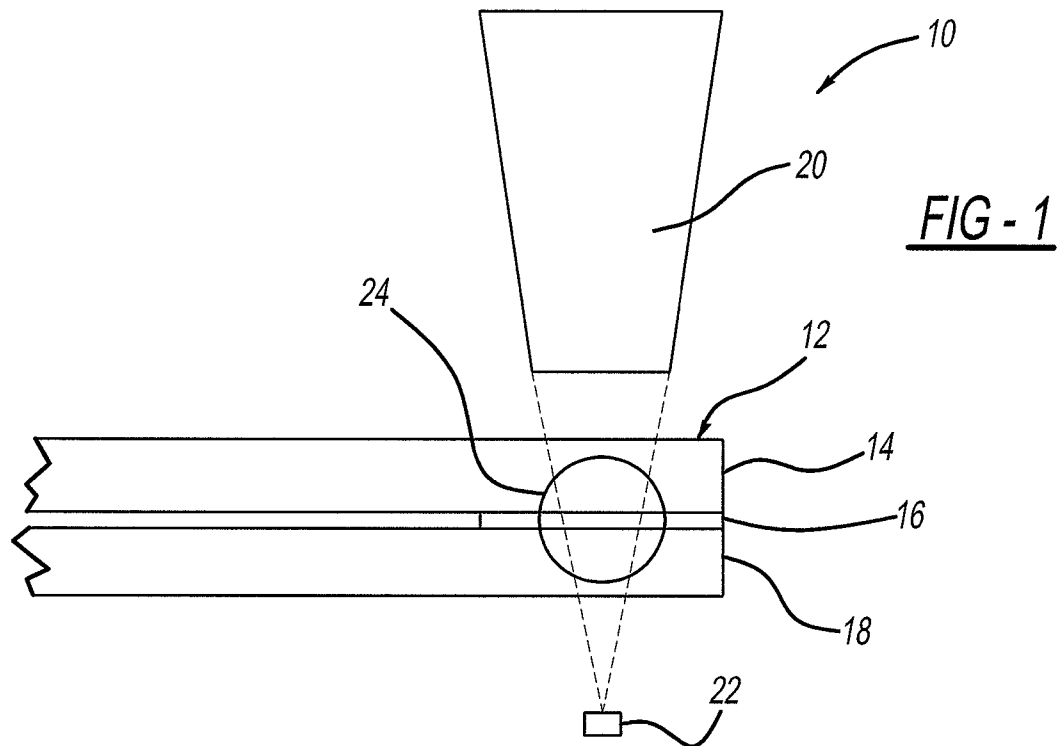
17. The process according to claim 15 wherein a third substrate is bonded
25 to said second substrate by a second adhesive layer positioned between said second substrate and said third substrate.

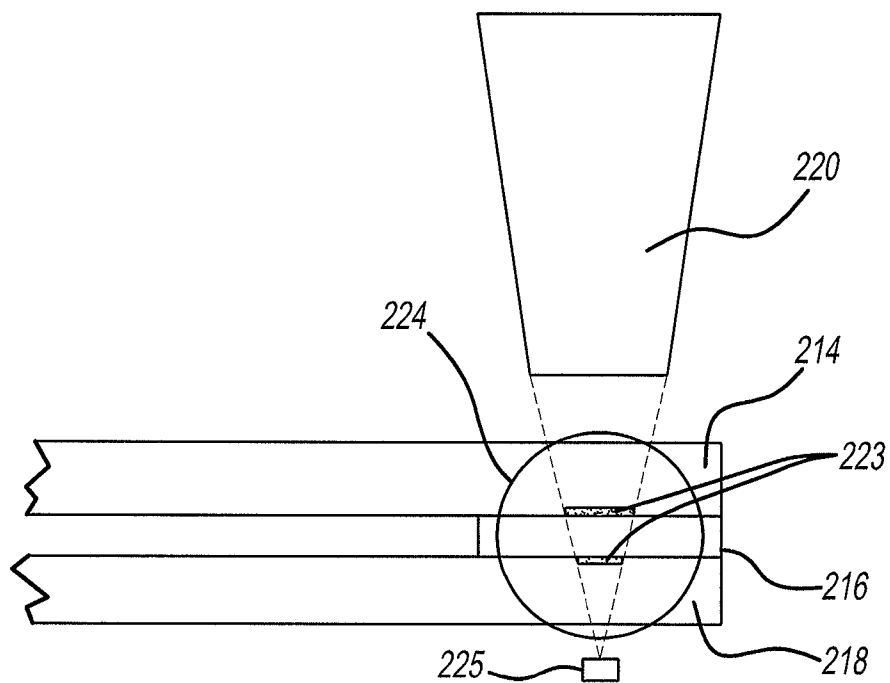
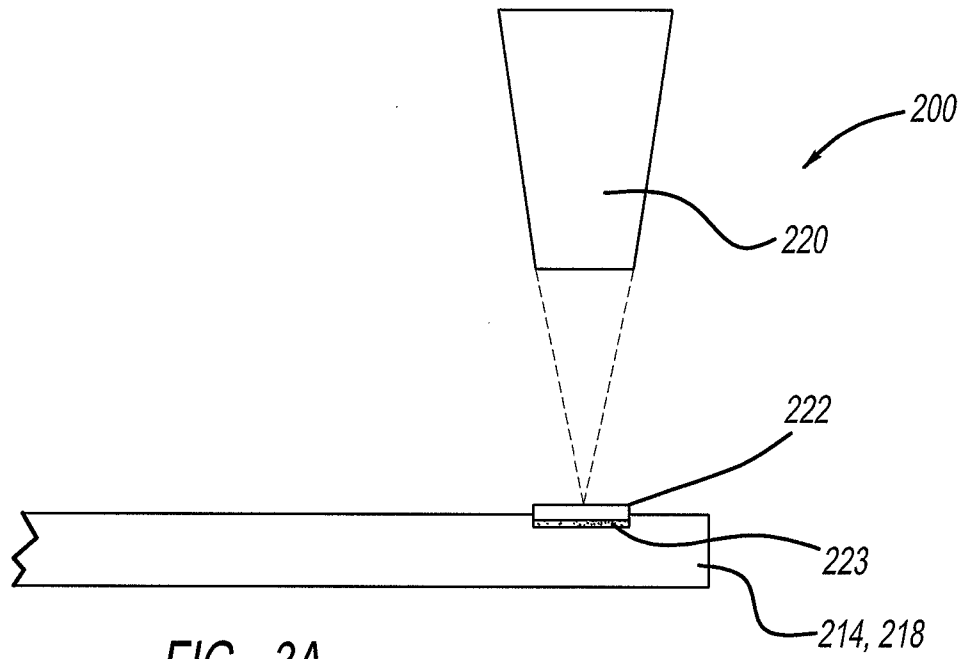
18. The process according to claim 15 wherein said laser produces a laser beam using about 1 KW to about 100 KW.

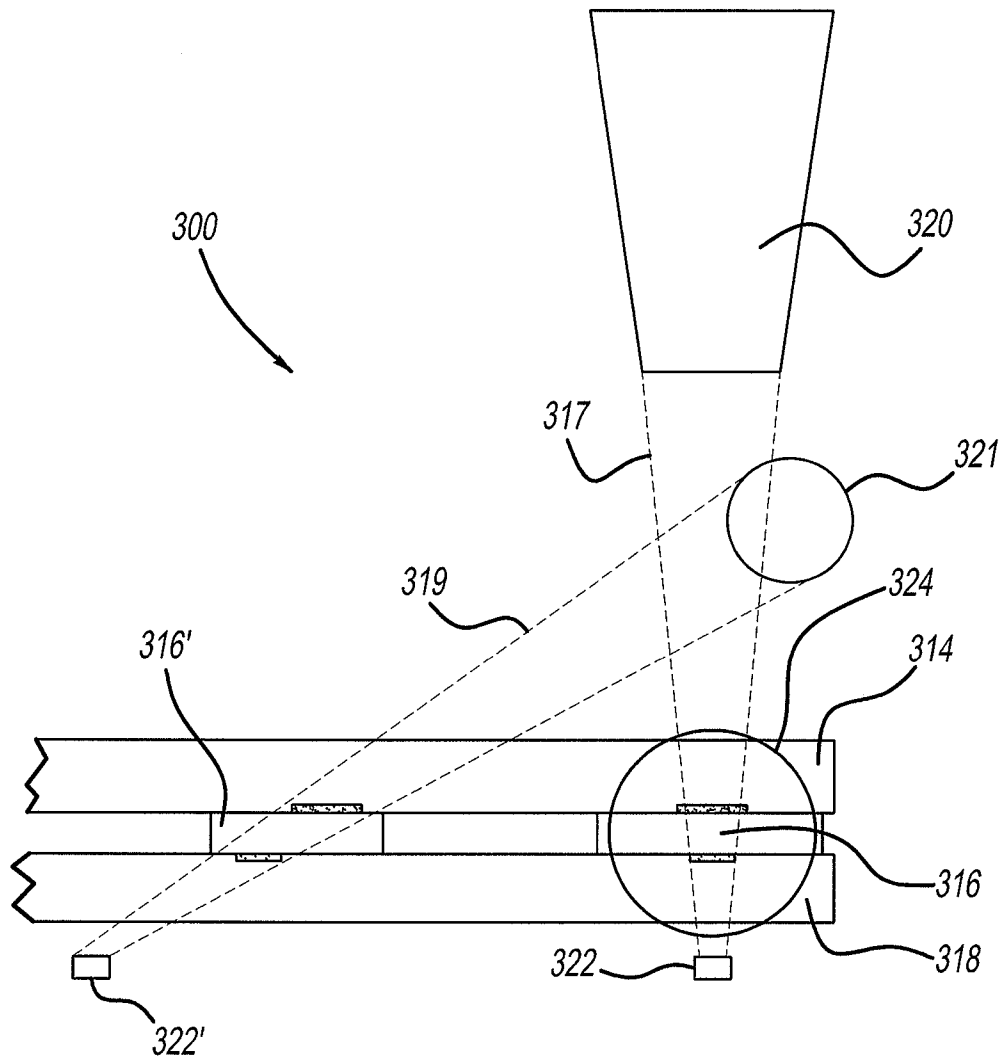
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19. The process according to claim 15 wherein said laser is a high output laser which has a beam which is split into one or more discreet beams for curing more than one bond from a single laser.

5 20. The process according to claim 15 wherein the laser is used to cure preselected locations along a bond line for forming a temporary location during final curing of the part to be bonded.





FIG - 4