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(54) **SYSTEMS AND DEVICES FOR ACHEIVING HIGH THROUGHPUT ATTACHMENT AND SUB-MICRON ALIGNMENT OF COMPONENTS**

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B23K 37/04	(2006.01)
G11B 5/105	(2006.01)

(52) **U.S. Cl.**

CPC ***G11B 5/105*** (2013.01)

(58) **Field of Classification Search**

CPC H01L 21/6838; H01L 21/6831; B25B 11/005; B23K 2201/40

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,324,053	A	6/1994	Kubota et al.
5,413,360	A	5/1995	Atari et al.
6,016,949	A	1/2000	Slesinger
6,032,997	A	5/2000	Elliott et al.
6,335,863	B1	1/2002	Yamamoto et al.
6,886,997	B2	5/2005	Cheung et al.
6,895,027	B2	5/2005	Treusch et al.
7,172,676	B2	2/2007	DeMeter
7,196,356	B2	3/2007	Ishii
7,223,617	B2	5/2007	Mochida et al.
7,337,939	B2	3/2008	Terada et al.
7,449,905	B2	11/2008	Shi et al.
7,502,397	B2	3/2009	Naganuma

(Continued)

OTHER PUBLICATIONS

Lei Wang et al., U.S. Appl. No. 13/664,271, filed Oct. 30, 2012, 28 pages.

(Continued)

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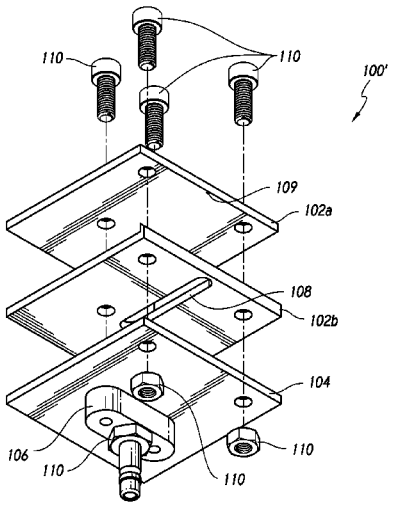
(57) **ABSTRACT**

Systems and devices for achieving high throughput attachment of sub-micron alignment of components are provided. One such device can include a fixture for holding a chuck, the fixture including a plurality of alignment features for adjusting a position of the chuck, the chuck includes a top layer including a vacuum aperture for holding a first component and a bottom layer made from a translucent material, wherein the bottom layer is directly attached to the top layer.

9 Claims, 4 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,522,649	B2	4/2009	Ha et al.	
7,524,390	B2	4/2009	DeMeter et al.	
7,548,673	B2	6/2009	Azimi et al.	
7,642,121	B2	1/2010	Slater, Jr. et al.	
7,921,436	B2	4/2011	Shimizu et al.	
8,193,634	B2	6/2012	Wong et al.	
8,456,961	B1	6/2013	Wang et al.	
8,593,914	B2	11/2013	Wang et al.	
2002/0089913	A1	7/2002	Moriyama et al.	
2006/0022019	A1*	2/2006	Terada	B23K 31/12 228/105
2007/0015313	A1	1/2007	Kwak et al.	
2007/0063453	A1*	3/2007	Ishikawa	B24B 37/30 279/3
2009/0045507	A1*	2/2009	Pendse	H01L 21/563 257/734
2011/0083786	A1	4/2011	Guo et al.	
2014/0159325	A1	6/2014	Parkhe et al.	

OTHER PUBLICATIONS

Chee Kheng Lim, U.S. Appl. No. 14/216,458, filed Mar. 17, 2014, 26 pages.
U.S. Pat. No. 8,593,914, Nov. 26, 2013, Lei Wang et al.

* cited by examiner

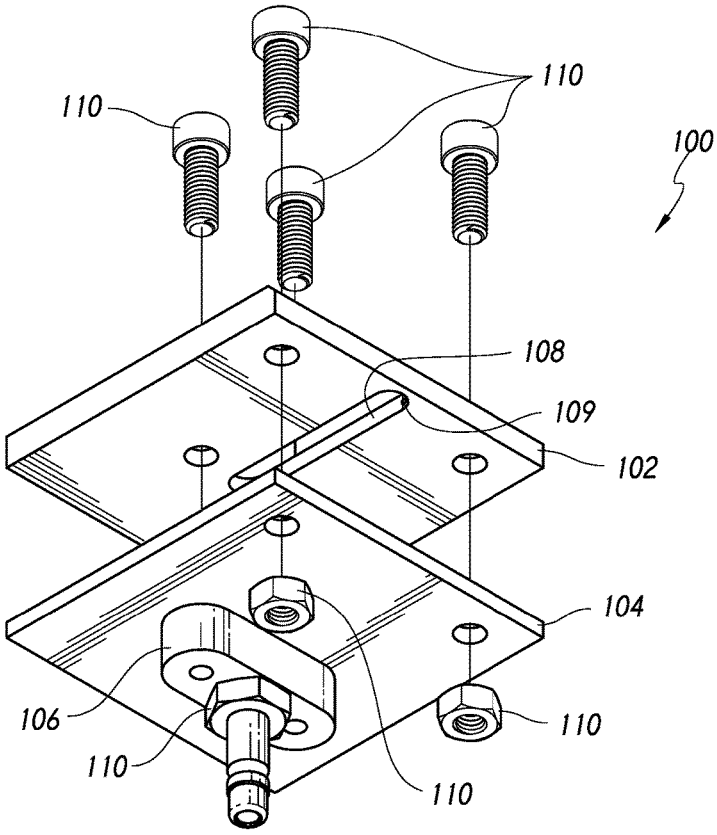

110
110
100
108
109
102
104
106
110
110
110

FIG. 1

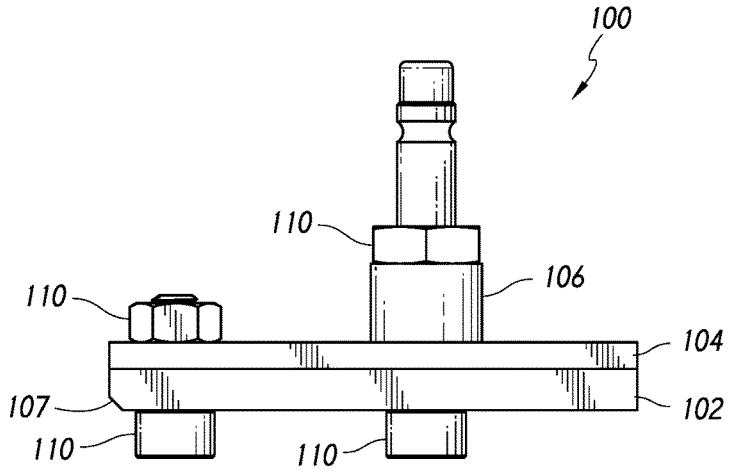

100
110
106
110
104
107
102
110
110

FIG. 2

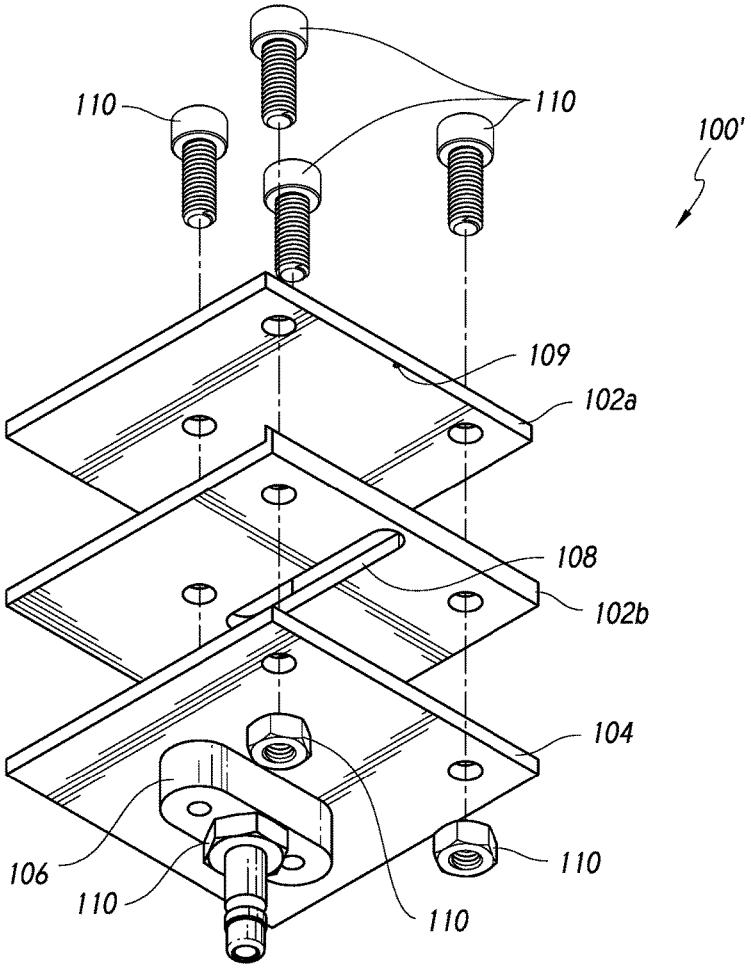

110
110
100'
109
102a
108
102b
104
106
110
110
110

FIG. 3

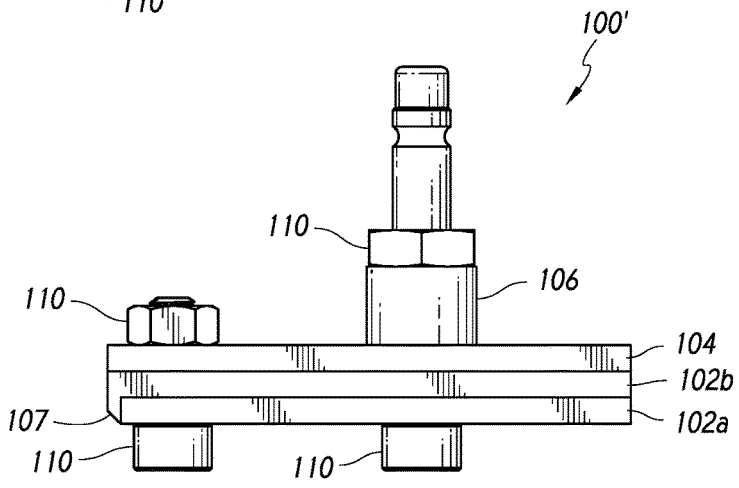

100'
110
106
110
104
102b
107
102a
110
110

FIG. 4

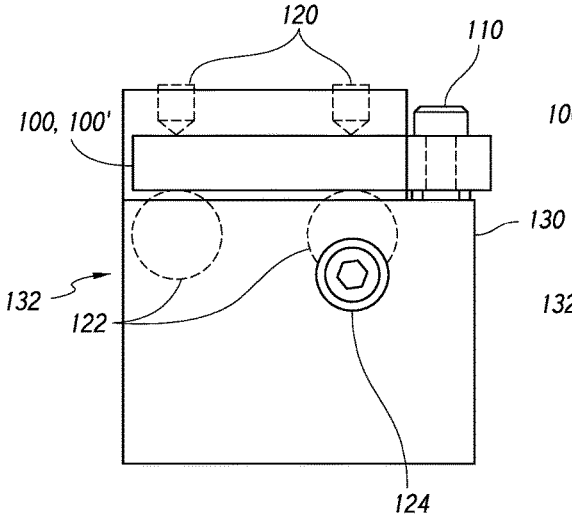


FIG. 5A

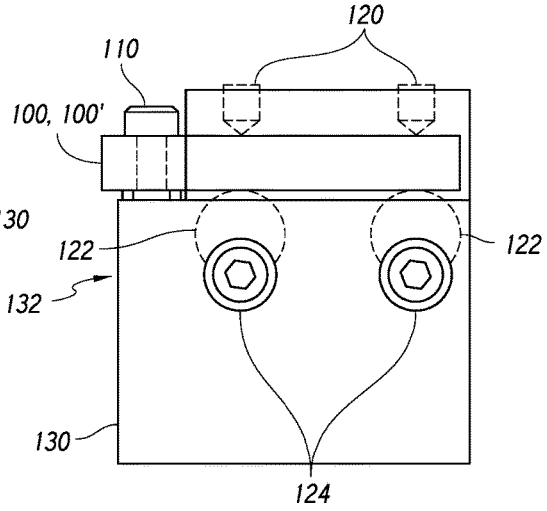


FIG. 5B

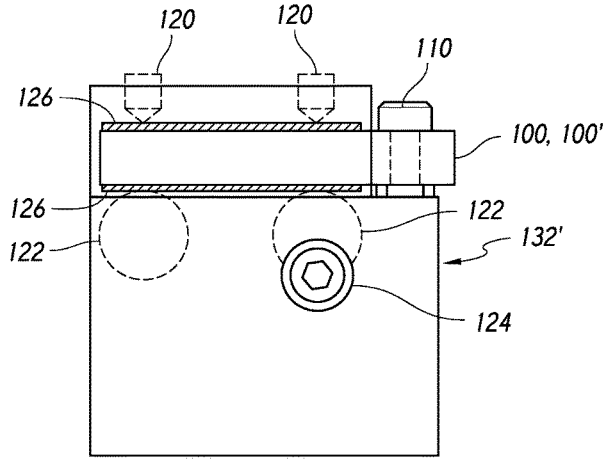


FIG. 6

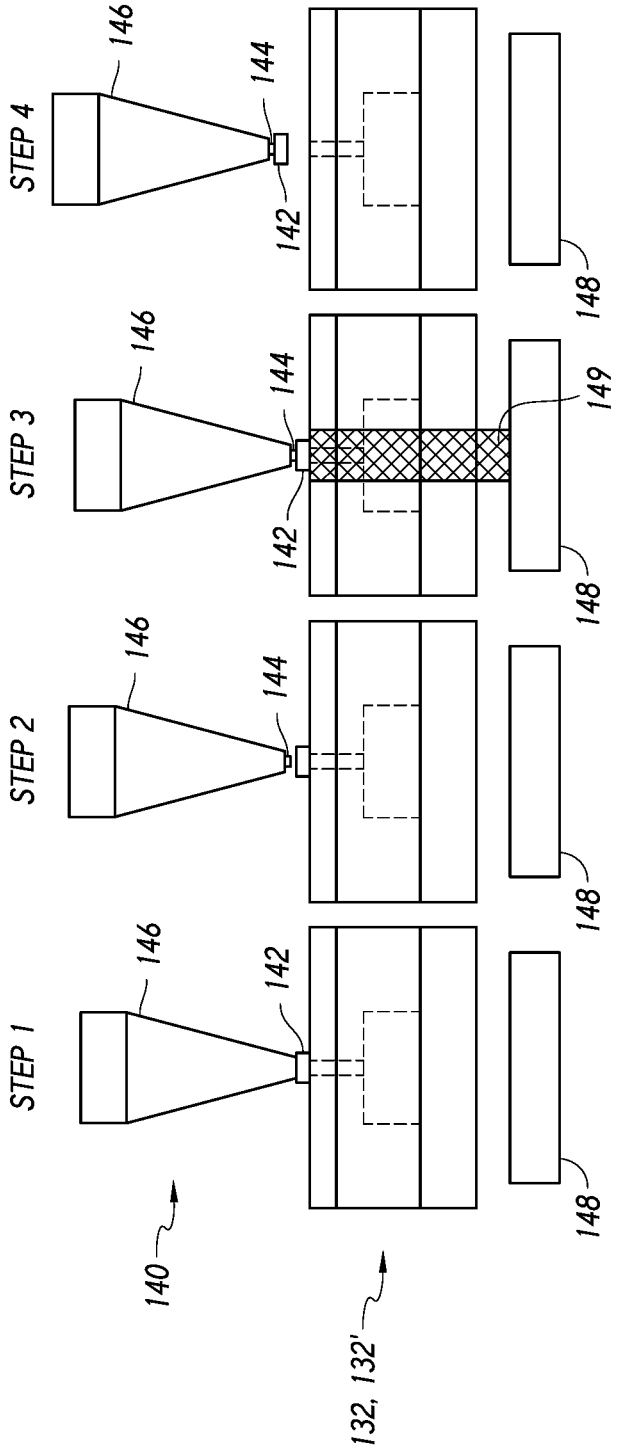


FIG. 7

SYSTEMS AND DEVICES FOR ACHEIVING HIGH THROUGHPUT ATTACHMENT AND SUB-MICRON ALIGNMENT OF COMPONENTS

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a continuation of U.S. patent application Ser. No. 14/748,607, filed on Jun. 24, 2015, and entitled, "SYSTEMS AND DEVICES FOR ACHIEVING HIGH THROUGHPUT ATTACHMENT AND SUB-MICRON ALIGNMENT OF COMPONENTS", which claims priority to and the benefit of U.S. Provisional Application No. 62/069,635 filed on Oct. 28, 2014, entitled, "LASER DIODE AND SUBMOUNT ASSEMBLY CHUCK WITH SILICON CARBIDE, SAPPHIRE, AND PLASTIC SHIM", the entire content of each application is incorporated herein by reference.

BACKGROUND

Heat assisted magnetic recording (HAMR) technology for use in a data storage device involves use of a laser heating source to provide additional energy during the data writing process (e.g., as data is written to a magnetic media disk). The energy/heat source is typically implemented using a semiconductor laser diode chip bonded on a sub-mount chip which, when the laser diode and sub-mount are considered together after bonding, is referred to as a Chip-On-Sub-mount-Assembly or COSA. The COSA is then attached to a magnetic head slider and the light energy from the laser diode chip is guided to the air bearing surface of the slider through a waveguide disposed in the slider to heat up the magnetic media for writing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** illustrate a perspective and expanded views of a chuck used for component bonding according to one embodiment.

FIGS. **3** and **4** illustrate a perspective and expanded views of another chuck used for component bonding according to one embodiment.

FIGS. **5***a* and **5***b* illustrate a side view of a component bonding fixture according to one embodiment.

FIG. **6** illustrates a side view of another component bonding fixture including an absorption layer according to one embodiment.

FIG. **7** illustrates a sequence of front views of a system and process for bonding components according to one embodiment.

DETAILED DESCRIPTION

Some embodiments include systems and devices for achieving high throughput attachment and sub-micron alignment of components. One example of a system and device to achieve this is in regard the assembly of components for COSA and COSA to slider bonding process. The COSA and COSA to slider bonding process both involve a high accuracy type alignment and bonding, which is preferably accurate to submicron levels or better. The bonding process itself can involve a eutectic or epoxy type attachment. The high accuracy bonding is needed to ensure that the output of a semiconductor laser diode chip (e.g. production laser, laser diode, HAMR laser, second component) is aligned to the entry point of the waveguide in the slider, and to thereby ensure that maximum light energy is transferred from the laser to the waveguide in the slider. The alignment accuracy determines the amount of energy channeled into the waveguide and therefore an efficiency of the assembly as a whole. When the alignment is poor, more energy is needed from the laser diode to ensure sufficient energy is channeled through the waveguide to heat the media. Thus, poor alignment leads to low energy efficiency and higher than needed light energy. Accordingly, systems and methods for achieving high throughput attachment and accurate alignment of components for HAMR are needed.

COSA production of HAMR requires a COSA bonding process which applies the laser energy through a chuck to heat up a submount (e.g. second component) to melt a bonding material (e.g. solder) positioned between a laser diode and a submount to bond the laser diode and submount. This system and process will be further described below in relation to FIG. **7**.

FIGS. **1** and **2** illustrate a perspective and expanded views of a chuck used for component bonding according to one embodiment. The chuck **100** can include a top layer **102**, where the top layer **102** can be made of a material having one or more of the following characteristics: sufficient thermal conductivity, high temperature strength, and low displacement material. High thermal conductivity, for example, can be between 50 to 200 W/(m·K). High temperature strength, for example, can have a specific heat between 600 to 800 J/(kg·K). Low displacement material, for example, can have a coefficient of linear thermal expansion between 40-800° C. less than 5×10^{-6}/° C. One example of material used for the top layer **102** is silicon carbide. The top layer **102** can have a thickness between 0.8-1.2 mm.

The chuck can include a bottom layer **104** connected to the first layer **102**. The bottom layer **104** can be made of material having one or more of the following characteristics: transparent, high temperature strength, low thermal expansion, and high compressive strength. Transparent material, for example, can be a material that has a percent transmittance more than 95% for 500 nm to 1500 nm wavelength laser. High temperature strength, for example, can have a specific heat between 600 to 800 J/(kg·K). Low thermal expansion, for example, can have a coefficient of linear thermal expansion between 40-800° C. less than 6×10^{-6}/° C. And, high compressive strength material, for example, can be a material having a compressive strength between 2,000 to 3,000 MPa. One example of material that can be used for bottom layer **104** is glass sapphire. The bottom layer **104** can have a thickness between 0.3-1.0 mm.

Chuck **100** can also include vacuum nozzle **106**, vacuum cavity **108**, and vacuum hole **109** to retain a first component (reference numeral **142** in FIG. **7**) on the chuck top layer **102** during component attachment. Vacuum nozzle **106** can be attached to bottom layer **104** and in fluid communication with vacuum cavity **108** formed in top layer **102**. Top layer **102** can also include vacuum hole **109** in fluid communication with vacuum cavity **108**. The vacuum hole **109** can be configured to facilitate a vacuum pressure on the first component.

Chuck **100** can also include fastener assembly **110**. Fastener assembly **110** can include a plurality of fasteners meant for attaching the top layer **102** and bottom layer **104**, and further for securing the vacuum nozzle **106** to the chuck **100**. A fastener (as used in this detailed description) can include, but is not limited to, any combination of nut, bolt, stud, weldment, washer, rivet, nail, screw, or the like. One skilled in the art can appreciate that vacuum nozzle **106**, vacuum

cavity **108** and vacuum hole **109** can be modified in structure and location in chuck **100** to achieve the goal of securing a component to chuck **100**.

FIGS. **3** and **4** illustrate a perspective and expanded views of another chuck **100'** used for component bonding according to one embodiment. Chuck **100'** is similar to chuck **100**, and therefore common features that have the same reference numeral will not be described. Chuck **100'** can include a top layer **102** that has a first layer **102***a* and second layer **102***b*. Second layer **102***b* can be positioned between first layer **102***a* and bottom layer **104**. First layer **102***a* can be made of material having one or more of the following characteristics: low thermal conductivity, low temperature strength, and has a high thermal expansion. Low thermal conductivity, for example, can be between 2 to 5 W/(m·K). Low temperature strength material, for example, can have a specific heat between 460 to 480 J/(kg·K). A low coefficient of thermal expansion, for example, can be between 40-800° C. less than 12×10^{-6}/° C. One example of material that can be used for first layer **102***a* is zirconia. First layer **102***a* can have a thickness between 0.3-0.7 mm.

Second layer **102***b* can be made of material having one or more of the following characteristics: low thermal conductivity, high temperature strength, and low displacement material. Low thermal conductivity material, for example, can be between 1.3-1.5 W/(m·° C.). High temperature strength material, for example, can be a specific heat between 0.6-0.85 J/(kg·° C.). Low displacement material, for example, can have a coefficient of linear thermal expansion between 25-800° C. less than 123×10^{-7}/° C. The thickness of second layer **102***b* can be between 0.3-0.7 mm One example of material that can be used for first layer **102***b* is machinable ceramic glass. Further, the vacuum hole **109** can extend through second layer **102***b*.

FIGS. **5***a* and **5***b* illustrate a side view of component bonding fixture **132** according to one embodiment. Component bonding fixture **132** can include a chuck housing **130**, chuck **100/100'**, and alignment features **120**, **122**, and **124**. The chuck housing **130** can be made of aluminum or stainless steel, and can be structured to substantially contain chuck **100/100'** except for portions of chuck **100** that are proximate to an assembly heating element (e.g., an assembly laser, a conductive heating device, a microwave heating device, an ultraviolet light heating device) **148** (see FIG. **7**) and areas where the first and second component are placed on the chuck **100/100'** (see FIG. **7**). The component bonding fixture **132** can also include alignment features **120**, **122**, and **124**, which function to finely position chuck **100/100'**. Alignment feature **120** (e.g. or top level fastener), can contact one or more locations of the chuck top layer **102**. By adjusting the alignment feature **120**, the alignment feature **120** can contact and alter the position of the chuck **100/100'**. Alignment features **122** (e.g. leveling ball) and **124** (e.g. side leveling fastener), can contact various locations of the chuck bottom layer **104**. By adjusting the alignment feature **124**, the alignment feature **124** will contact the alignment feature **122**, which will contact and alter the position of chuck **100/100'**.

FIG. **6** illustrates a side view of component bonding fixture **132'**, which includes a stress absorption layer **126** according to one embodiment. Component bonding fixture **132'** is similar to component bonding fixture **132**, and therefore common features that have the same reference numeral will not be described. The stress absorption layer **126** can be made of a high quality plastic material that can reduce compression (less than 0.15% displacement at 500 psi compressions) from alignment features **120** and **122**. The thickness of the stress absorption layer can be approximately between 0.010-0.012 inches. The stress absorption layer **126** can be positioned between the alignment feature **120** and the chuck top layer **102**. Further, the stress absorption layer **126** can be positioned between the alignment feature **122** and the chuck bottom layer **104**. Stress absorption layer **126** can be structured to have a length long enough to extend to a position between the alignment feature **120**, alignment feature **122**, and chuck **100/100'** in order to reduce stress imposed by those components on chuck **100/100'**. Component bonding fixture **132'** can include one or more stress absorption layers **126** without departing from the scope of the disclosure.

FIG. **7** illustrates one example of a sequence of front views of a system **140** and process for bonding components, using component bonding fixture **132/132'** and chuck **100/100'** according to one embodiment. This system **140** has been simplified for the purposes of illustrating one use of component bonding fixture **132/132'** and chuck **100/100'**. The system for bonding components **140** can include a pick up tool **146**, component bonding fixture **132/132'** and assembly heating element **148** (for bonding a first component **142** to a second component **144**). First, in Step **1**, the pick up tool **146** picks up the first component and places it on bonding fixture **132/132**, preferably on the vacuum hole **109** (not shown). Prior to the pick up tool releasing the first component **142**, the vacuum nozzle **106** is turned on creating a suction force at vacuum hole **109** in order to secure the first component **142** to chuck **100/100'**. Next, in Step **2**, the pick up tool **146** picks up the second component **144** and places it on the first component **142**. The pick up tool **146** pushes the second component **144** down onto the first component **142** with a sufficient amount of force to ensure proper bonding in the Step **3**. In Step **3**, the assembly heating element **148** is turned on to deliver heat energy **149** through chuck **100/100'** to the first component **142**. The heat energy **149** is transferred through the first component **142** to activate a bonding material between the first component **142** and second component **144**. In Step **4**, after the bonding of first component **142** and second component **144** is finished, the pick up tool **146** moves the finished assembly to another staging area.

As mentioned above, system **140** has been simplified for illustration purposes. Those skilled in the art will appreciate that system **140** can include various sensors and processors to enable the system to properly work to ensure high throughput and sub-micron alignment. For example, in Step **2**, in order to properly align the first component **142** and second component **144**, the system can include a vision or sensor system to enable sub-micron alignment of the components in relation to each other. For example, components can be brought close together using a distance sensor. The distance sensor can scan across the bottom surface of the first component **142** and the bottom surface of the second component **144** to determine a relative distance or offset between them. The relative offset between the components can be measured by the distance sensor and corrected by one or both the pick up tool **146** and chuck **100/100'** until a desired alignment is achieved. After a sufficient alignment is achieved, the second component **144** can be brought toward the first component **142**. Further, in Step **3**, the system **140** can include a force control sensor which is configured to sense a contact force between the first component **142** and second component **144**.

In one embodiment, the alignment process of Step **2** can be thought of as a passive alignment stage. In other embodiments, the process can use active alignment to align the

components prior to bonding. In one example, a waveguide configured to receive light and a sensor coupled to the waveguide can be used for alignment. More specifically, the sensor can provide information indicative of an amount of light received by the waveguide of the slider.

In one embodiment, the process can perform the sequence of actions in a different order. In another embodiment, the process can skip one or more of the actions. In other embodiments, one or more of the actions are performed simultaneously. In some embodiments, additional actions can be performed.

A processor can be coupled electrically to the first component **142**, the second component **144**, the assembly heat element **148**, the pick up tool **146**, a force control sensor, a distance sensor, and a high resolution camera. The processor can be coupled to other components as well. The processor can be coupled to the vacuum nozzle **106** and configured to continuously apply a vacuum pressure to the chuck **100/100'** to hold the first component **142**, during such vacuum pressure application, to aid in alignment of the first component **142** and second component **144**. A processor can also be coupled to the pick up tool **146** to bring the first component **142** and second component **144** into contact. Further, a processor can be coupled to assembly heat element **148**, to control laser power during the bonding process. In several embodiments, such a processor can effectively execute some or all of the aforementioned operational steps of the system **140** of FIG. **7**.

In this context, the processor refers to any machine or selection of logic that is capable of executing a sequence of instructions and should be taken to include, but not limited to, general purpose microprocessors, special purpose microprocessors, central processing units (CPUs), digital signal processors (DSPs), application specific integrated circuits (ASICs), signal processors, microcontrollers, and other suitable circuitry. Further, it should be appreciated that the term processor, microprocessor, circuitry, controller, and other such terms, refer to any type of logic or circuitry capable of executing logic, commands, instructions, software, firmware, functionality, or other such information. In some embodiments, a processor may be a computer.

The aforementioned description can be used in the bonding of components of a HAMR slider. For example, a sub-mount (first component **142**) can be bonded to a HAMR laser (second component **144**), to form a COSA. Further, the aforementioned description can be used in bonding a COSA (first component **142**) to slider (second component **144**) to form a HAMR slider. This can significantly reduce the machine cost by performing two bonding processes with one equipment set.

In several embodiments, the HAMR slider is can be useful for use within a hard disk drive to effect heat assisted magnetic recording. In other embodiments, the bonding of components can be suited for other applications (e.g., other micro-scale semiconductor chip applications involving use of a laser).

Both chuck **100** and **100'** were tested and found to have performed superior in specific metrics related to the system bonding process. For example, the use of a bottom layer **104** having translucent properties enabled the chuck **100/100'** to perform bonding process with lower laser power for longer time without significant degradation of the chuck **100/100'**. Further, use of top layer **102** material as described above resulted in a more robust chuck **100/100'**. For example, there was less damage to the vacuum hole **109**, thus increasing the alignment accuracy (e.g., maintaining position of first component or centering sigma).

While the above description contains many specific embodiments of the invention, these should not be construed as limitations on the scope of the invention, but rather as examples of specific embodiments thereof. Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their equivalents.

The various features and processes described above may be used independently of one another, or may be combined in various ways. All possible combinations and sub-combinations are intended to fall within the scope of this disclosure. In addition, certain method, event, state or process blocks may be omitted in some implementations. The methods and processes described herein are also not limited to any particular sequence, and the blocks or states relating thereto can be performed in other sequences that are appropriate. For example, described tasks or events may be performed in an order other than that specifically disclosed, or multiple may be combined in a single block or state. The example tasks or events may be performed in serial, in parallel, or in some other suitable manner Tasks or events may be added to or removed from the disclosed example embodiments. The example systems and components described herein may be configured differently than described. For example, elements may be added to, removed from, or rearranged compared to the disclosed example embodiments.

What is claimed is:

1. A system for bonding components, the system comprising:
- a first component;
- a second component;
- a device comprising:
  - a chuck including:
    - a top layer comprising a first material;
    - a bottom layer comprising a second material different from the first material wherein the bottom layer comprises a translucent material;
    - a vacuum hole; and
  - a fixture for holding the chuck;
  - a first stress absorption layer positioned between the fixture and an external surface of the chuck;
- a pick up tool; and
- an assembly heating element,
- wherein the pick up tool is configured to:
  - pick up the first component and place it on the vacuum hole of the chuck,
  - pick up and bring the second component into contact with the first component,
- wherein the assembly heating element is configured to heat the first component to thereby bond the first and second component.

2. The system of claim **1**, wherein the top layer comprises silicon carbide.

3. A system for bonding components, the system comprising:
- a first component;
- a second component;
- a device comprising:
  - a chuck including:
    - a top layer comprising a first material;
    - a bottom layer comprising a second material different from the first material wherein the bottom layer comprises glass sapphire;
    - a vacuum hole; and
  - a fixture for holding the chuck;

a first stress absorption layer positioned between the fixture and an external surface of the chuck;

a pick up tool; and

an assembly heating element,

wherein the pick up tool is configured to:

pick up the first component and place it on the vacuum hole of the chuck,

pick up and bring the second component into contact with the first component,

wherein the assembly heating element is configured to heat the first component to thereby bond the first and second component.

4. The system of claim **1**, wherein the first stress absorption layer is positioned between the top layer and the fixture, and wherein the system further comprises a second stress absorption layer that is positioned between the bottom layer and the fixture.

5. A system for bonding components, the system comprising:

a first component;

a second component;

a device comprising:

a chuck including:

a top layer comprising a first material, wherein the top layer includes a first layer and second layer, the first layer of the top layer comprises zirconia, and the second layer of the top layer comprises machinable glass ceramic:

a bottom layer comprising a second material different from the first material wherein the bottom layer comprises a translucent material;

a vacuum hole; and

a fixture for holding the chuck;

a first stress absorption layer positioned between the fixture and an external surface of the chuck;

a pick up tool; and

an assembly heating element,

wherein the pick up tool is configured to:

pick up the first component and place it on the vacuum hole of the chuck,

pick up and bring the second component into contact with the first component,

wherein the assembly heating element is configured to heat the first component to thereby bond the first and second component.

6. The system of claim **1**, wherein the fixture for holding the chuck further comprises at least one alignment feature for adjusting a position of the chuck.

7. The system of claim **1**, wherein the top layer is substantially parallel to the bottom layer.

8. The system of claim **1**, wherein the top layer and bottom layer are each substantially flat.

9. The system of claim **1** further comprising a fastener assembly, the fastener assembly connecting the top layer and the bottom layer.

* * * * *