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(57) **ABSTRACT**

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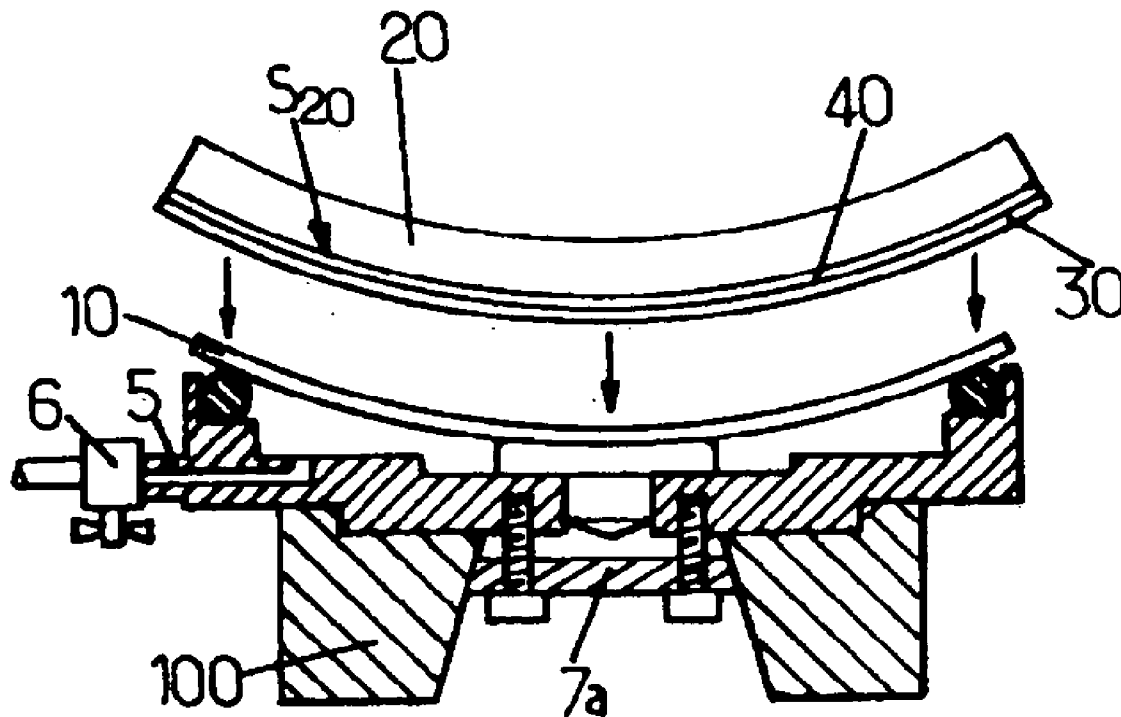
A process is provided for rapidly holding an optical article having a convex surface on a holder of a lens machining equipment, the holder being equipped with a suction chuck comprising a cavity with a side wall and sealing means on a front end of the side wall, comprising the following steps:

/a/ providing a flexible curved wafer with a concave surface arranged to close the cavity at the front end of the side wall;

/b/ a fixing step in which the wafer is fixed onto the holder by providing vacuum between the concave surface of the wafer and the suction chuck; and

/c/ a pressing step in which the concave surface of the optical article is pressed onto the concave surface of the wafer, an adhesive material being arranged between the wafer and the optical article

The assembly is tight enough for sustaining machining forces, and the lens can be released rapidly.



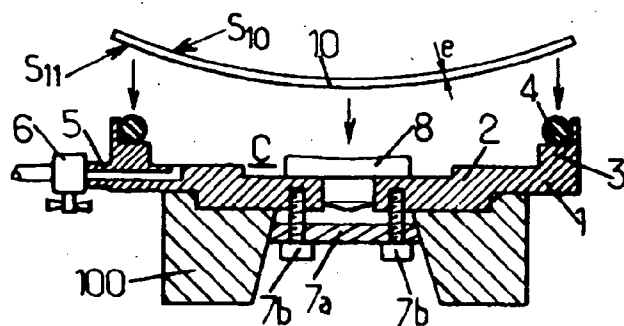


FIG. 1.

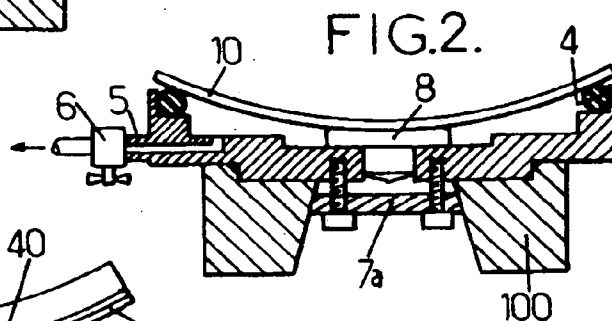


FIG. 2.

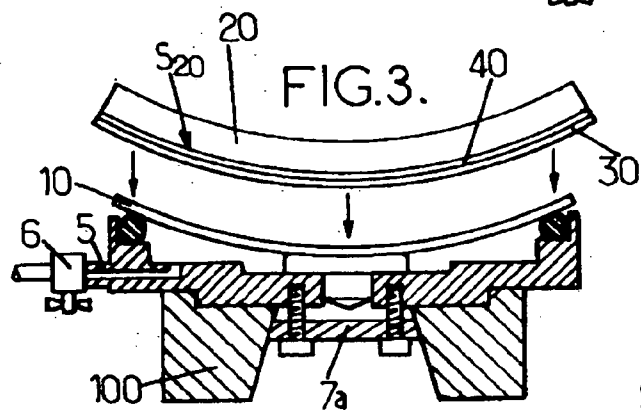


FIG. 3.

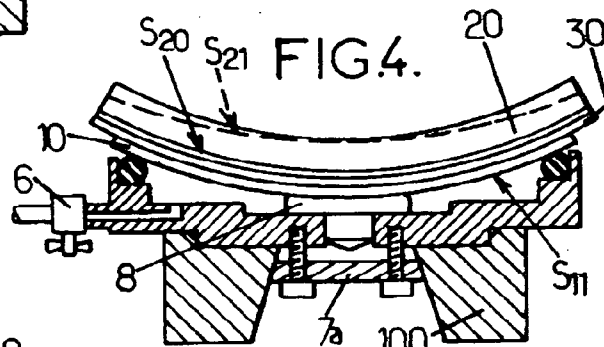


FIG. 4.

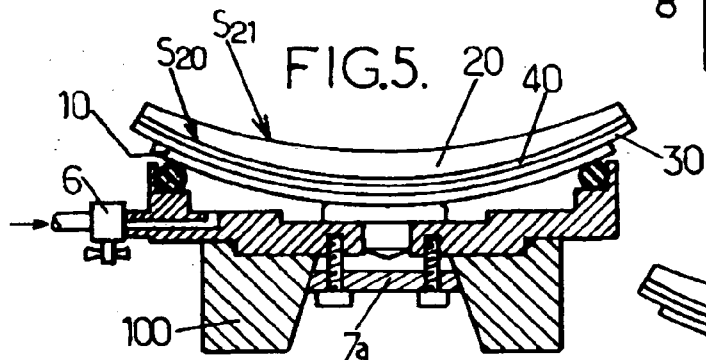


FIG. 5.

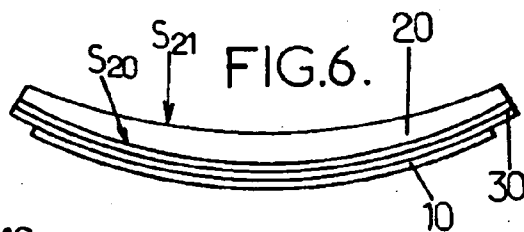


FIG. 6.

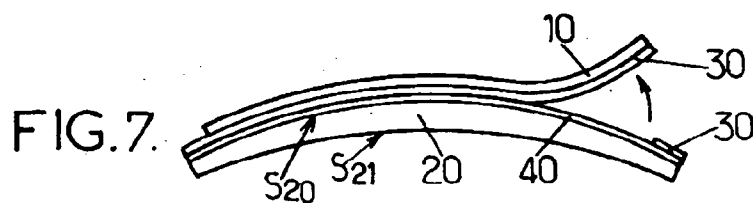


FIG. 7.

PROCESS FOR HOLDING AN OPTICAL LENS ON A HOLDER OF A LENS MACHINING EQUIPMENT

FIELD OF THE INVENTION

[0001] The invention relates to a process for holding an optical article, for example a lens, on a holder of a lens machining equipment. In particular, it is useful when manufacturing an ophthalmic lens.

BACKGROUND OF THE INVENTION

[0002] When producing an optical lens, and especially an ophthalmic lens, it is necessary to fix the lens on the holder of a machining equipment for machining the lens. For example, the machining corresponds to the lens surface generating step, the fining step, the polishing step or the edging step in the lens production process. For an ophthalmic lens, such production steps are carried out in a prescription lab where a semi-finished lens is machined so as to obtain a spectacle lens which corresponds to the ametropia of a lens carrier.

[0003] Usually, a wax or an alloy is used for fixing firmly the semi-finished optical lens on the equipment holder. The wax or alloy connects the convex surface of the semi-finished lens to an end part of the holder. But such method requires heating the wax or alloy for making it adhering to the lens and to the holder and, after machining has been performed, heating again for removing the lens from the holder. During each heating step, the lens shape may be modified due to thermal stresses created in the lens material. Then, such lens deformation prevents from achieving accurate machining, and may also alter the lens material. Furthermore, such method with heating steps is time-consuming and costly. Such method involves in general toxic alloys, generates waste, in particular contaminated wax and alloys.

[0004] For avoiding these drawbacks of wax- or alloy-based holding methods, other methods have been developed which are based on vacuum use. For example, U.S. Pat. No. 3,994,101 discloses using a suction chuck, but this method may create lens deformation, especially when the lens is rather thin. Furthermore, the vacuum sealing produces scratches on the convex lens surface.

[0005] U.S. Pat. No. 5,567,198 describes a compression sleeve chuck suitable for holding a lens, but such holding system is rather complex for easy fitting to conventional machining equipment. It also discloses using an intermediate wafer arranged between the convex lens surface and the chuck, which is connected on one side to the chuck and on the other side to the lens by means of instant adhesive films.

[0006] U.S. Pat. No. 6,863,602 corresponding to WO 2004/050303 discloses using a holder provided with a flexible surface which is supported by a low-melting point material. The flexible surface can conform permanently to the surface of a lens to be machined, but heating steps are still required for holding the lens on such holder.

[0007] Finally, the Applicant has also developed a tool device whose shape adapts automatically to the surface of an ophthalmic lens. This tool device is described in U.S. Pat. No. 4,831,789. It comprises a deformable buffer which encloses small-sized grains. When the lens is pressed against a resilient membrane of the buffer, this buffer membrane conforms to the lens surface. Then, air is pumped from the inner of the buffer, while retaining the grains. The grains are

thus closely packed together, so that they cannot move any longer and the shape of the membrane is fixed. Such device is also rather complex and requires a back-supporting system for supporting the buffer on a side opposite to the resilient membrane.

[0008] An object of the present invention is to propose a method for holding a semi-finished lens on a machining equipment holder, which is simple and easy to implement, does not implement any wax or alloy and is thus environment friendly.

SUMMARY OF THE INVENTION

[0009] To this end, the present invention provides a process for holding an optical article having a convex surface on a holder of a lens machining equipment, the holder being equipped with a suction chuck, the chuck comprising a cavity with a side wall and sealing means on a front end of the side wall, comprising the following steps:

[0010] /a/ providing a flexible curved wafer with a concave surface arranged to close the cavity at the front end of the side wall;

[0011] /b/ a fixing step in which the wafer is fixed onto the holder by providing vacuum between the concave surface of the wafer and the suction chuck; and

[0012] /c/ a pressing step in which the concave surface of the optical article is pressed onto the concave surface of the wafer, an adhesive material being arranged between the wafer and the optical article

[0013] In a process according to the invention, the optical element is connected to the holder of the machining equipment via a three-level connecting system. First, a vacuum chuck is fixed to the holder. Second, a wafer is vacuum-maintained on the chuck and the optical element is finally stuck to the wafer with an adhesive material used as bonding medium.

[0014] Using a flexible wafer between the optical element and the suction chuck ensures that all stresses produced by the vacuum implementation are accommodated by the wafer. This also results from the chronological order between steps /b/ and /c/. The stress level produced in the lens is then significantly reduced, so that no change occurs in the lens shape. Therefore, an accurate lens machining can be achieved, because the positioning of the optical element with respect to the holder is accurately defined, and because the optical element shape is not altered after machining for recovering the optical element.

[0015] Using a flexible wafer also ensures that the wafer is blocked firmly to the vacuum chuck. An important optical element holding strength can be obtained, because the flexible wafer together with the sealing means provides a tight vacuum sealing. Then lens machining can be performed, even if it involves important forces transmitted from the optical element to the holder.

[0016] The process of the invention may be used for a wide range of optical articles such as optical lenses, semi-finished optical lenses, screens for portable devices such as PDA or mobile phone. Optical lenses may be single vision lenses or any other ophthalmic lenses with numerous design such as for example spherical, toric or progressive design. They can also be lenses of other types, such as microscope, photographic, telescope lenses.

[0017] According to an embodiment of the invention, the adhesive material is selected in the list consisting of: a pressure sensitive adhesive, a hot melt adhesive, an instant curable adhesive, a UV curable adhesive, a thermal curable adhesive.

[0018] Using a pressure sensitive adhesive for sticking the optical element to the wafer enables easy removal of the optical element from the holder of the machining equipment. This can be achieved in a two-step process. First, the vacuum in the cavity of the suction chuck is suppressed, so that the optical element together with the wafer is removed from the suction chuck. Then, the wafer is removed from the convex surface of the optical element.

[0019] An advantage of a process according to the invention results from the fact that no toxic material is used. Furthermore, materials that are used are very cheap, such as a pressure sensitive adhesive, or can be used again, such as the flexible curved wafer.

[0020] Another advantage results from the fact that neither heating step nor cooling step is involved. Then, the optical element is free of thermal stresses. In addition, all steps can be implemented rapidly, so that a process according to the invention allows high production rate in a prescription lab for manufacturing ophthalmic lenses.

[0021] Every suitable sealing means known by the men skill in the art may be used in the frame of the present invention. According to an embodiment of the invention, the sealing means is selected in the list consisting of: a O-ring seal, a V-ring seal, a silicone ring.

[0022] According to an improvement of the invention, the suction chuck may further comprise a rigid support arranged within the cavity. It is arranged so that a rear surface of the flexible curved wafer is in contact with the rigid support on a side opposite to the wafer concave surface, once said wafer has been fixed to the holder in step /b/. Such support helps to further avoid deformation of a lens being machined, by providing a back contact to the wafer for supporting the machining forces. This may be useful when the lens thickness is small, especially for negative lenses.

[0023] The invention also provides a process for machining a optical element having a convex surface, which process comprises the following steps:

[0024] /1/ holding the optical element on a holder of a lens machining equipment, using a holding process as described above;

[0025] /2/ machining the optical element;

[0026] /3/ removing the optical element together with the flexible curved wafer from the holder by removing the vacuum in the cavity of the suction chuck; and

[0027] /4/ removing the flexible curved wafer from the optical element.

[0028] The invention also relates to a lens machining equipment comprising a holder being equipped with a suction chuck, the chuck comprising a cavity with a side wall and sealing means on a front end of the side wall. According to an embodiment, the suction chuck further comprises a rigid support arranged within the cavity, so that a rear surface of a flexible curved wafer with a concave

surface is in contact with the rigid support on a side opposite to concave surface of the wafer, once the wafer has been fixed to the holder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] These and other aspects of the invention will become apparent from the non-limiting implementations described hereafter in reference to the following drawings:

[0030] FIGS. 1-4 illustrate steps for holding a lens onto a machining equipment holder according to the present invention; and

[0031] FIGS. 5-7 illustrate steps for removing the lens from the holder.

[0032] In these figures, identical reference numbers refer to identical elements. Furthermore, for clarity reason, the sizes of the elements represented do not correspond to sizes of actual elements.

DETAILED DESCRIPTION OF THE INVENTION

[0033] On FIG. 1, reference 1 refers to a suction chuck according to the invention. It comprises a bottom part 2 and a side wall 3 of generally cylindrical shape, so as to form an inner cavity C. The side wall 3 has a limited height, so that the suction chuck 1 can be easily fitted on a holder 100 of a lens machining equipment. Such lens machining equipment may be a lens surface generating machine, a lens polishing or fining machine, an edging machine, etc. In particular, it can be fitted on machines such as LOH's V95 or Toro-X-S/SL. Chuck 1 can be, for example, made of aluminum for light-weight purpose, or any other rigid material. Self-centering part 7a and screws 7b allow tight fixing of the suction chuck 1 onto the holder 100, but other equivalent systems may be used, depending on the actual holder 100.

[0034] The side wall 3 is provided with an O-ring seal 4 at its end opposite the bottom part 2. It is also provided on a side with an air conduct 5 which connects the cavity C to a pumping system (not represented) outside the suction chuck 1. A valve 6 is arranged on the conduct 5.

[0035] The suction chuck 1 may also comprise a rigid support 8 which is arranged within the cavity C. Support 8 may be of variable shape, such as a rigid 1.5 mm thick curved wafer of polycarbonate. It may also be comprised of a pad adjustable in height in a middle part of cavity C.

[0036] A flexible curved wafer 10 has a concave surface S_{10} . Surface S_{10} may be spherical, corresponding to base values ranging from 2.0 to 8.0, for example. The base value for the curvature of the wafer surface S_{10} is selected depending on the curvature of the front surface of the lens to be machined. It is selected so as to match approximately the front convex surface of the lens. The other surface of the wafer 10 is referenced S_{11} and is designed so that it can fit to the O-ring seal 4. The wafer 10 is preferably made of a thermoplastic material, such as polycarbonate (PC), polymethylmetacrylate (PMMA), polyester, or nature absorbing material like, for example, nature absorbing plastics, etc., so that it is cheap. The wafer 10 can be either disposable or adapted for multiple uses for holding several lenses that are to be machined successively. It has a thickness e suitable for

the wafer **10** being flexible. Advantageously, the thickness e is comprised between 0.3 and 3 mm (millimeter). For example, e is equal to about 0.5 mm. The diameter of wafer **10** is selected depending on the diameter of the lens to be machined. It must be greater than the diameter of the O-ring seal **4**. For example, the diameter of the wafer **10** is within 40-80 mm.

[0037] The wafer **10** is placed on the O-ring seal **4**, with surface S_{11} facing the cavity C . Air is then pumped out from cavity C through conduct **5** and valve **6** is turned off. Vacuum is thus created in cavity C and ambient pressure outside chuck **1** maintains the wafer **10** firmly held on the chuck (FIG. 2). A pressure difference of 80 kPa (kilopascal) between outside and inside of the chuck **1** appears to provide strong enough holding.

[0038] A semifinished lens **20** has a front convex surface S_{20} . Lens **20** may be an ophthalmic lens, in a preferred implementation of the invention. It may be 71 mm in diameter, for example.

[0039] Lens surface S_{20} may be initially covered with a surface protective tape **40**. Such protective tape is well known in the art and protects the lens surface from being scratched or stained during lens handling and machining. It makes it possible holding the lens via adhesion to the tape itself, and it can be easily removed from the lens after the lens machining has been completed. Tape **40** is applied on lens surface S_{20} in a usual manner, for example by implementing a vacuum-based application process.

[0040] The lens **20** is then provided on surface S_{20} with a film **30** comprising a layer of pressure sensitive adhesive, or PSA. Any known pressure sensitive adhesive can be used, which provides an adhesion force which is strong enough. Film **30** can be a single PSA layer, for example 0.025 mm thick, or a laminate which is PSA-double sided. Film **30** is applied on the lens surface S_{20} using any known process which provides uniform coverage without film tearing or wrinkle. For example, processes that combine film preforming, film transfer from a carrier onto the lens, and suitable heating may be used. When a surface protective tape **40** is used, PSA film **30** adheres to that tape. Same application process as used for tape **40** may be used again for applying the PSA film **30** onto the lens surface S_{20} .

[0041] According to an advantageous implementation of the invention, a laminate may be supplied which incorporates the surface protective tape **40** and the film **30** of pressure sensitive adhesive. Then, a single application step provides the lens **20** with both the tape **40** and the PSA film **30**.

[0042] Then the lens surface S_{20} is pressed against the surface S_{11} of the wafer **10**, this latter being vacuum-fixed on the chuck **1** (FIG. 3). It is pressed with a force of about 50 N (Newton) for example, so that the PSA film **30** sticks to the wafer surface S_{10} . Waiting time of about 1 mn (minute) may be implemented so as to ensure a tight bonding of lens **20** to wafer **10**. The lens **20** is now firmly held onto the holder **100** (FIG. 4).

[0043] Lens **20** can now be machined accurately, because it does not move relative to holder **100**. For illustrative purpose, the rear surface S_{21} of the lens **20** is generated,

thereby providing a vergence to the lens which may correspond to the ametropia of a spectacle carrier. For example, the rear surface S_{21} of lens **20** is machined corresponding to a final base value of 6.0 and a toric curve of 7.0.

[0044] When a rigid support **8** is used in cavity C , the rear surface S_{11} of the flexible curved wafer **10** is in contact with the support **8**. Then support **8** can sustain at least part of the forces which are produced on lens **20** during machining. Therefore, any deformation of the lens is avoided, even when the lens thickness is small in the middle part of the lens. Therefore, the invention can be implemented for negative lenses as well, although negative lenses are thinner in their middle part compared to their peripheral part.

[0045] Recovering of the lens is now described.

[0046] In a first step, vacuum is suppressed in cavity C , by operating valve **6** so that air enters into the cavity (FIG. 5). Lens **20** is released from the chuck **1**, with wafer **10** stuck on the lens surface S_{20} (FIG. 6).

[0047] In a second step, the wafer **10** is removed from the lens surface S_{20} . Due to flexibility of wafer **10**, it can be peeled easily, even by hands (FIG. 7). Depending on the pressure sensitive adhesive used for the film **30**, wafer **10** can be alternatively removed by irradiating or heating so that adhesion to the lens **20** or to the tape **40** is suppressed.

[0048] The inventors point out that the process just described has numerous advantages. Among these advantages, they cite the following ones:

[0049] the process is time saving: lens holding and lens recovering steps each correspond to duration of few minutes. This is much shorter than implementing wax- or alloy-based holding, which requires more than 20 minutes either for lens holding and for lens releasing;

[0050] thanks to the use of the resilient wafer **10** and the pressure sensitive adhesive film **30**, the holding process of the invention can be implemented with a lens **20** having a progressive front surface S_{20} ;

[0051] the lens **20** with the wafer **10** stuck thereon can pass several machining steps on various machining equipments with one and same wafer, without removal of this latter from the lens. This further contributes in time-saving in the whole lens manufacturing process; and

[0052] because the material of the wafer **10** can be the same as that of the lens **20**, it can be edged together with the lens in the holding assembly, so that lens diameter crib is no longer an issue.

[0053] Table 1 hereafter gathers process parameters for four lenses machined by holding these lenses on machining equipment holders according to the present invention. The optical qualities of the final lenses are observed using Humphery and B&L lensometer according to US Z80.1 standard. All lenses that are referred to in the table have a front surface curvature corresponding to base value of 3.25 and have been machined for generating lens back surfaces corresponding to target base value of 5.00. The target optical power and cylinder values were -2.00 and 0.00 respectively. The lenses are 76 mm in diameter and the rear surface machining diameter is 71 mm. The fining and polishing times were respectively 2 and 6 mn. The comparative example (noted comp.) corresponds to lens holding onto the holders using vacuum without wafer and using alloy.

TABLE 1

Example	Wafer with a rigid support curve	Lens back surface actual curve	Actual optical power	Actual optical cylinder	Lensometer inspection	Lens center thickness	Lens deformation
1	Base 3.0	4.96	-1.93	0.02	good	1.86 mm	no
2	Base 3.0	4.93	-1.89	0.10	good	1.51 mm	no
Comparative Example 1	No wafer used	4.30	-0.55	0.03	not good	1.3 mm	yes
Comparative Example 2	Alloy Blocking-	4.90	-1.90	0.01	good	1.1 mm	no

[0054] Table 1 shows that for minus lens, the lens thickness appears as a predominant parameter for assessing whether using a rigid support within the cavity of the vacuum chuck is necessary or not.

[0055] In the frame of the present invention, a “minus” lens is a lens which is thinner at the center and thicker at the edges, where a “plus” lens is a lens which is thicker in the center and thinner at the edges.

[0056] Table 2 shows another example of using wafer with vacuum chuck for plus lens compared to the example without wafer. All lenses that are referred to in the table have a front surface curvature corresponding to base value of 5.50 and have been machined for generating lens back surfaces corresponding to target base value of 3.60. The target optical power and cylinder values were +2.00 and 0.00 respectively. The lenses are 76 mm in diameter and the rear surface machining diameter is 71 mm.

TABLE 2

Example	Wafer with vacuum chuck	Lens back surface target curve	Lens back surface actual curve	Target optical power	Actual optical power	Actual optical cylinder
3	Base 4.5	3.60	3.63	+2.00	+2.03	0.03
Comp. 3	No wafer	3.60	3.35	+2.00	+2.37	0.01

[0057] In example 3 of table 2, there is no rigid support used in wafer with vacuum chuck for plus lens, since the lens is usually quite thick (e.g. >2.5 mm). However, without using wafer for the same vacuum and lens, the obtained lens will be out of the target optical power and the target curve.

[0058] It is obvious that variations may be introduced in the implementations of the invention that have been described in detail above, while retaining at least some of the advantages of the invention. In particular, shape and size of the vacuum chuck may be varied, as well as some of the materials used and the system for fixing the vacuum chuck to the holder of the machining equipment.

1. A process for holding an optical article having a convex surface on a holder of a lens machining equipment, the holder being equipped with a suction chuck, the chuck comprising a cavity with a side wall and sealing means on a front end of the side wall, comprising the following steps:

/a/ providing a flexible curved wafer with a concave surface arranged to close the cavity at the front end of the side wall;

/b/ a fixing step in which the wafer is fixed onto the holder by providing vacuum between the concave surface of the wafer and the suction chuck; and

/c/ a pressing step in which the concave surface of the optical article is pressed onto the concave surface of the wafer, an adhesive material being arranged between the wafer and the optical article.

2. The process according to claim 1, wherein the flexible curved wafer is made of a thermoplastic material.

3. The process according to claim 1, wherein the flexible curved wafer has a thickness comprised between 0.3 and 3 mm.

4. The process according to claim 1, wherein the concave surface of the flexible curved wafer is spherical.

5. The process according to claim 1, wherein the sealing means is selected in the list consisting of: a O-ring seal, a V-ring seal, a silicone ring.

6. The process according to claim 1, wherein the adhesive material is selected in the list consisting of: a pressure sensitive adhesive, a hot melt adhesive, an instant curable adhesive, a UV curable adhesive, a thermal curable adhesive.

7. The process according to claim 1, wherein the lens machining equipment is selected from a list comprising a lens surface generating machine, a lens polishing or fining machine, and an edging machine.

8. The process according to claim 1, wherein the optical article is a semi-finished optical lens.

9. The process according to claim 1, wherein the convex surface of the optical article is initially covered with a surface protective tape, and wherein the adhesive means adhere to the surface protective tape in step /c/.

10. The process according to claim 1, wherein the suction chuck further comprises a rigid support arranged within the cavity, so that a rear surface of the flexible curved wafer is in contact with said rigid support on a side opposite to the wafer concave surface, once the wafer has been fixed to the holder in step /b/.

11. A process for machining an optical article having a convex surface, comprising the following steps:

- /1/ holding the optical article on a holder of a lens machining equipment, using a holding process according to claim 1;
- /2/ machining the optical article;
- /3/ removing the optical article together with the flexible curved wafer from the holder by removing the vacuum in the cavity of the suction chuck; and
- /4/ removing the flexible curved wafer from the optical article.

12. The process according to claim 11, wherein the flexible curved wafer is removed from the optical article in step /4/ by peeling said wafer off.

13. The process according to claim 11, wherein the flexible curved wafer is removed from the optical article in

step /4/ by irradiating or heating the film of pressure sensitive adhesive so that adhesion to the optical article is suppressed.

14. A lens machining equipment comprising a holder being equipped with a suction chuck, the chuck comprising a cavity with a side wall and sealing means on a front end of the side wall.

15. The lens machining equipment according to claim 14, wherein the suction chuck further comprises a rigid support arranged within the cavity, so that a rear surface of a flexible curved wafer with a concave surface is in contact with the rigid support on a side opposite to concave surface of the wafer, once the wafer has been fixed to the holder.

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