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(54) **METHOD FOR MAKING A FINALLY SHAPED FORMING TOOL AND FORMING TOOL MADE BY SAME**

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(57) **ABSTRACT**

The forming tool has a structured forming surface having a high surface quality and uniform structure so that it accurately produces a predetermined structure in substrate. To avoid the great expense and effort associated with final shaping of the forming tools from blocks or rounded bodies made by forging or by a HIP method with subsequent machining, first a glass or plastic mold (1) is made with a molding surface for forming the structured forming surface of the forming tool, which is the negative of the structured forming surface for the forming tool with predetermined dimensions and surface quality in accordance with specifications of the structured forming surface of the forming tool; then the molding surface is coated with at least one coating material selected specifically according to the specifications to form a cladding body (2) in the glass or plastic mold, next the cladding body (2) with the structured forming surface is released from the glass or plastic mold (1) and bonded to a base body with a non-structured surface of the cladding body (2) in contact with the base body to form the forming tool with the structured forming surface.

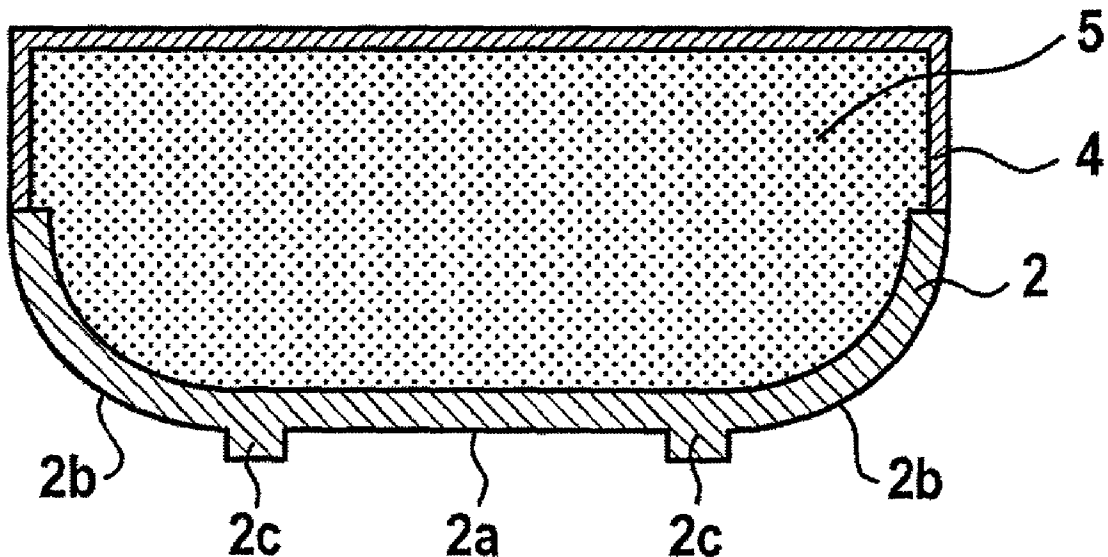


Fig. 1

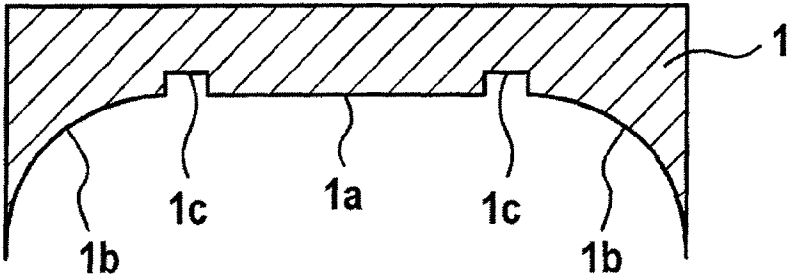


Fig. 2

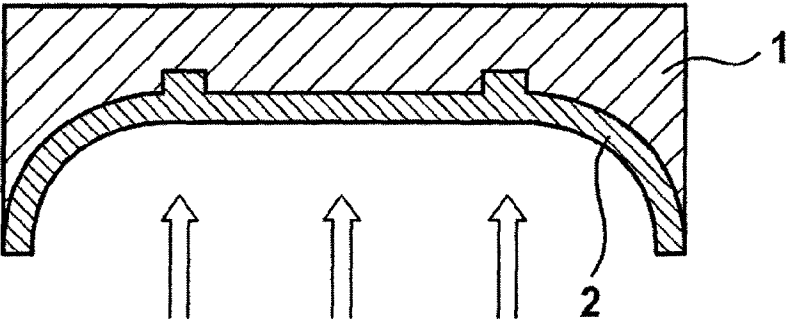


Fig. 3

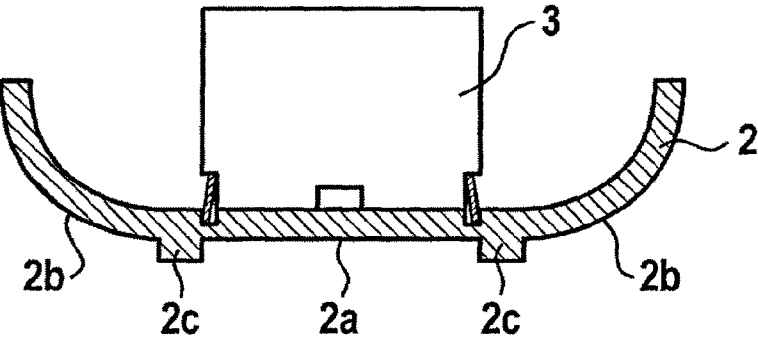
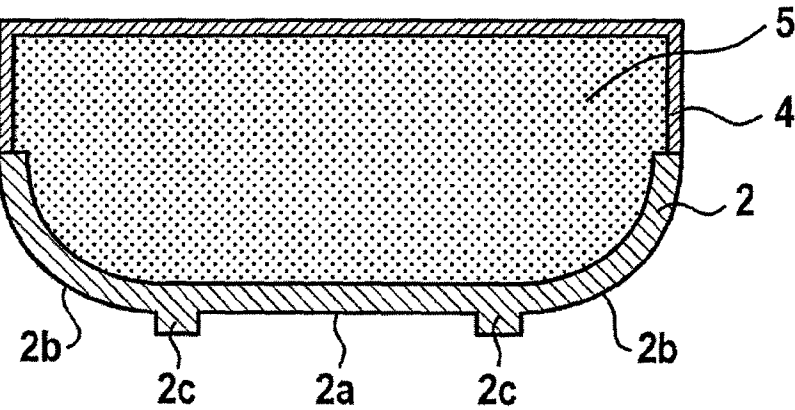


Fig. 4



METHOD FOR MAKING A FINALLY SHAPED FORMING TOOL AND FORMING TOOL MADE BY SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method of making a finally shaped forming tool with a forming surface, which is preferably structured and has a highly uniform structure. The invention also relates to a finally shaped forming tool with a forming surface that is preferably structured and that has a highly uniform structure.

[0003] 2. Related Art

[0004] Forming tools, typically with predetermined structures on their surfaces, are required to form or shape glass or plastic in a plasticized state. The predetermined structures in the surfaces of these forming tools are the negative of the structures produced in the glass or plastic. These forming tools are typically dies or roller shaped tools. The structures to be produced can be in the μm range, e.g. as in the hot forming of so-called channel plates for flat screen displays of modern TV sets.

[0005] Currently casting methods are used to obtain the finally shaped forming tool. The structural uniformity obtained with these casting methods is limited by technical considerations. There are strict requirements for forming tools in certain different manufacturing processes, e.g. in the hot forming of glass substrates regarding structural uniformity as well as chemical composition. Structural non-uniformities, which can arise because of casting conditions, e.g. pores, holes, grain size variations, texture variations, mounds or protruding accumulations, can be disadvantageously copied into the substrate during the forming process with the forming tool.

[0006] Forming tools are thus typically forged with high structural uniformity since clearly more uniform forming thereby results.

[0007] Another process for guaranteeing high structural uniformity comprises making blocks by a HIP method. Materials are encapsulated and sealed in a vacuum-tight manner in a sheet structure in the HIP process (hot-isostatic-press). Subsequently the base block for the forming tool arises because of the applied high pressure and temperature. The combination "solid-powder" is an example of a possible material combination. That means that a supporting material is processed into a desired form (shape) and after that a capsule with an internal chamber is provided over the resulting body. The interior chamber is filled with powder after that. In the HIP process then the powder is sintered together and combines with the supporting material forming a diffusion zone.

[0008] An extremely high quality surface structure is obtained in the HIP process based on small powder grain size up to the nm size and on the sintering without melt phase.

[0009] The disadvantage of both these manufacturing methods is that in order to obtain a high degree of structural uniformity final shaping from initially prepared blocks and/or rounded blanks must be performed disadvantageously mechanically. This is very expensive, particularly for wear

and corrosion-resistant materials, such ceramics, high temperature alloys. Also structures in the μm -range cannot be made economically on these tool surfaces.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to conduct the processes of the above-described type so that the finally shaped forming tools are better than those of the prior art, both in regard to their geometric form (contour) and also the surface quality, including their roughness and structure, and also so that they have higher surface uniformity with distinctly reduced processing work.

[0011] This object is attained by a process of the above-described kind for making finally shaped forming tools with the structured forming surfaces with a high surface uniformity comprising the following steps:

[0012] a) making a glass or plastic mold having a molding surface for the finally shaped forming tool that is formed as the negative of the structured forming surface for the forming tool with predetermined dimensions with a surface quality, as required by the forming surface of the forming tool;

[0013] b) coating the molding surface of the glass or plastic mold with at least one material selected specifically according to the structured forming surface of the forming tool so as to form a cladding body in the glass or plastic mold, the cladding body being provided with the structured forming surface of the forming tool,

[0014] c) releasing the cladding body with the structured forming surface from the glass or plastic mold; and

[0015] d) bonding the cladding body to a base body with a non-structured surface thereof in contact with the base body to form the finally shaped forming tool with the forming surface.

[0016] A finally shaped forming tool according to the invention can be manufactured comparatively economically both with the required geometric shape and surface quality, especially the surface roughness and structuring. At the same time uniform structural properties are obtained.

[0017] These methods can produce layered systems or material gradients and three dimensional structures in the μm -range on the working surfaces besides processing an exceptionally large number of material compositions, including metallic materials and also ceramic materials.

[0018] These advantages are present, particularly when thermal spraying technology is used to provide the negative coating on the negative mold. Other coating technologies can also be utilized.

[0019] According to various embodiments of the method according to the invention the negative mold is a plastic body structured by means of lithography methods.

[0020] In other embodiments mechanical methods or methods based on thermal principles are used to structure the negative mold.

[0021] The thermal spraying occurs according to a first embodiment of the invention preferably by flame spraying methods, especially by a HVOF method. This method permits a layer structure with a high structural uniformity.

[0022] A second embodiment of the process according to the invention, in which the thermal spraying comprises plasma spraying, also provides this latter advantage. The preferred plasma spraying method is a VPS or LPPS method. These methods have the additional advantage that a wide range of materials, especially hard alloys and hard materials, such as carbides, can be sprayed.

[0023] The foregoing methods permit the spraying of both single-phase materials and also material combinations, in order to form layered systems or material gradients. Thus in the method according to the invention the materials for the structured forming surface of the forming tool can be adjusted in a simple way.

[0024] The above-described methods permit a predetermined coating thickness to be applied to the negative mold. This coating thickness is selected so that the coating body released from the negative mold can be bonded with the supporting material or body of the forming tool.

[0025] When the coating thickness according to a first embodiment is from 100 μm to 5 mm, the manufacture of the forming body is performed, preferably so that the coating or cladding body released from the negative mold is bonded with another material as part of a HIP capsule by an HIP method to make the forming tool. These methods guarantee a permanent intimate material bond between the separately made structured coating or cladding body and the base or supporting material of the forming tool.

[0026] When the coating thickness is sufficiently large, up to 20 mm, the cladding body can be used directly to provide the forming surface of the forming tool, since the cladding body released from the negative mold can be combined mechanically with a based body to form the forming tool.

[0027] A first layer made by thermal spraying can be reinforced or built up by bonding to a large layer thickness, which speeds up the making of thick coatings.

[0028] In regard to the finally shaped forming tool with the structured forming surface of high structural uniformity the above-described objects of the invention are attained by a structured forming surface, which is formed by a separately produced coating body or cladding body made by thermal spraying, which is bonded with supporting material to form the forming tool.

[0029] The forming tool should be structured so that the separately produced coating body has a thickness of up to 20 mm and is mechanically bonded with the supporting material, or so that the separately produced cladding body has a thickness of from 500 μm to 5 mm and is a part of a HIP capsule, which is bonded, connected or attached by means of an HIP method with the base material.

BRIEF DESCRIPTION OF THE DRAWING

[0030] The objects, features and advantages of the invention will now be illustrated in more detail with the aid of the following description of the preferred embodiments, with reference to the accompanying figures in which:

[0031] FIG. 1 is a schematic longitudinal cross-sectional view through a mold acting as a pattern for the later-formed forming tool, in which the negative of the structure of the later-formed forming tool is incorporated,

[0032] FIG. 2 is a schematic longitudinal cross-sectional view illustrating the step of making a coating or cladding body in the mold shown in FIG. 1 with a given material by thermal spraying methods,

[0033] FIG. 3 is a schematic longitudinal cross-sectional view showing the mechanical attachment of the cladding body released from the mold with a based body to form a forming tool, and

[0034] FIG. 4 is a schematic longitudinal cross-sectional view showing the bonding of the cladding body or coating released from the mold in a HIP capsule by means of a HIP process with a base and/or supporting material to form the forming tool.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] A preferred embodiment of the method for making a finally shaped forming tool with a structured forming surface, which guarantees a very high uniformity of the surface structure, is illustrated in the drawing.

[0036] In a first step shown in FIG. 1 a mold 1 is provided having a pattern for forming the forming tool with the structured surface, i.e. the mold 1 has a negative shape corresponding to the structured surface of the forming tool to be made. In order to simplify the illustration of the mold and the corresponding forming body the mold is shown with only a comparatively simple surface structure including a straight section 1a and two curved sections 1b separated from the straight section 1a by two cavities 1c.

[0037] In the case of actual embodiments of the forming tool the negative structure of the mold is worked according to the surface structure of the forming tool to be made. The dimensions of the negative structure in the mold must be guided by dimensions, which depend on the forming process performed with the later-formed forming tool. In the hot-forming the dimensions of the surface structure of the forming tool change, for example, because of the unavoidable thermal expansion occurring during the hot-forming process, which must be taken into consideration in selection of the dimensions for the negative structure of the mold according to FIG. 1.

[0038] The making of the negative mold 1 can occur in different ways. One way is the so-called prototyping. In this method the negative mold with the desired geometric contour/structure is made by means of lithography methods (mask engineering in connection with photo lacquer) from a plastic body and the required surface quality is guaranteed. These lithography methods are basically known and need not be explained in further detail.

[0039] Another method for making the forming tool consists in grinding, sandblasting, machining or structuring with methods that operate by thermal action principles, such as erosion or laser machining so that a base body is provided with the negative structure of the forming tool.

[0040] In the following process step shown in FIG. 2 the negative mold 1, preferably coated by means of thermal spraying technology, is provided with a coating 2 of a predetermined thickness as indicated by the arrows in FIG. 2.

[0041] Thermal spraying methods include flame spraying, electric arc spraying, plasma spraying and special spraying methods, such as detonation coating and condensation spraying. These methods are also known basically and do not need to be explained further herein. The plasma spraying is particularly significant for the present application, because of the high quality of the coating formed by it, especially in regard to uniformity, and because the method permits the processing of high melting metallic and ceramic materials, which are required in the structuring of glass on account of the required heat and corrosion resistance. Alloys of nickel/chromium, cobalt-based alloys and carbides are included in these materials.

[0042] The so-called HVOF method (high velocity oxide fuel flame spraying) in flame spraying and the so-called VPS method (vacuum plasma spraying) or the LPPS method (low pressure plasma spraying) in plasma spraying have special significance. Surfaces having very slight porosity and high uniformity are obtained immediately in these processes.

[0043] The effectiveness of the process of thermal spraying depends in a known way decisively on the parameters of the process during coating, here of the negative mold 1. Those parameters are, for example, the carrier gas supply, the spacing of the burner nozzle from the negative mold, the temperature, etc. These parameters are varied according to the material to be sprayed and the desired geometry of the negative mold. They are determined in the case of particular embodiments by one skilled in the art.

[0044] A coating 2 made from a predetermined material with a predetermined thickness is provided on the negative mold 1 at the end of the thermal spraying step, which has the desired finally shaped structure in regard to geometry and surface quality with the high structural uniformity on the contacting surface of the negative mold.

[0045] This coating 2 is removed from the negative mold 1 to make the forming tool. The release of the coating 2 can be made easy by suitable pre-treatment of the surface of the negative mold 1 to be coated prior to the coating.

[0046] The released coating 2 can then be processed in different ways for forming the surface structure of the forming tool.

[0047] According to a first possibility the coating can be formed so thick, about 1 to 20 mm, that the outer shape of the outer layer of the forming tool is obtained as a coating or cladding body. After release from the mold 1 this cladding body, as shown in FIG. 3, can be clamped on the base body 3 for the forming tool, e.g. by a suitable die, in order to provide a mechanically stable forming tool.

[0048] According to another possibility a coating 2 with a thickness of about 1 to 5 mm is produced. This coating is released from the negative mold, as shown in FIG. 4, to form a part of an HIP capsule 4, which is filled with a powder for pressing, if necessary in connection with an embedded solid material or body. The thickness of the coating body 2 forming the part of the HIP capsule should be larger than, for example at least twice as large as, that of the remaining capsule half. The shrinking or changing of the surface can be prevented because of that feature. Only the edges are warped or twisted by the HIP process.

[0049] A working device forming the forming tool is available in which the coating body 2 provides a structuring

surface, which comes into working contact, e.g., with the glass or plastic substrate and which has the negative of the structure to be formed on its surface after performing the above-described HIP method, alternatively also after a bonding process. The negative structuring surface of the forming tool comprises a straight section 2a, the two curved sections 2b and the raised structures 2c.

[0050] Instead of the coating consisting of only a single layer of material the coating 2 can be made up of several layers of different materials applied one over the other. Also several materials can be simultaneously sprayed to form the coating.

[0051] Preferably the sprayed coating body is sealed by a subsequent HIP process.

[0052] The disclosure in German Patent Application 100 34 508.5-16 of Jul. 15, 2000 is incorporated here by reference. This German Patent Application describes the invention described hereinabove and claimed in the claims appended hereinbelow and provides the basis for a claim of priority for the instant invention under 35 U.S.C. 119.

[0053] The wording "surface corresponding to the negative of the structure to be provided in the glass or plastic substrate" means simply that the surface is shaped or structured so as to produce the article from the glass or plastic substrate with a desired or predetermined shape.

[0054] The term "negative mold" for the forming tool means that the mold is shaped with a surface contacting the forming tool during the molding which is the negative of the surface formed on the forming tool, i.e. the mold is shaped to produce the desired predetermined surface on the forming tool. Of course during the molding this means that there are no gaps or spaces between the structuring surface on the forming tool and the contacting surface of the mold. This is the usual situation for a mold and an article molded by means of the mold.

[0055] While the invention has been illustrated and described as embodied in an end-contoured shaping forming tool with a forming surface and method of forming same, it is not intended to be limited to the details shown, since various modifications and changes may be made without departing in any way from the spirit of the present invention.

[0056] Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

[0057] What is claimed is new and is set forth in the following appended claims.

We claim:

1. A method for making a finally shaped forming tool with a structured forming surfaces having a uniform surface structure, said method comprising the following steps:

- a) making a glass or plastic mold (1) having a molding surface for forming the structured forming surface of the forming tool, said molding surface being a negative of the structured forming surface for the forming tool with predetermined dimensions and a surface quality in

accordance with specifications of the structured forming surface of the forming tool;

b) coating the molding surface of the glass or plastic mold (1) with at least one material selected specifically according to said specifications for the structured forming surface of the forming tool so as to form a cladding body (2) in the glass or plastic mold, the cladding body being provided with the structured forming surface of the forming tool,

c) releasing the cladding body (2) with the structured forming surface from the glass or plastic mold (1); and

d) bonding the cladding body to a base body with a non-structured surface of the cladding body (2) in contact with the base body to form the finally shaped forming tool with the structured forming surface.

2. The method as defined in claim 1, further comprising making said mold by structuring a plastic body by means of a lithographic method

3. The method as defined in claim 1, further comprising making said mold by structuring a glass or plastic body by means of a mechanical process.

4. The method as defined in claim 1, further comprising making said mold by structuring a glass or plastic body by means of a thermal method.

5. The method as defined in claim 1, wherein the coating of the molding surface of said mold occurs by means of a thermal spraying method.

6. The method as defined in claim 5, wherein said thermal spraying method comprises a flame spraying method.

7. The method as defined in claim 6, wherein said flame spraying method comprises a high velocity oxide fuel flame spraying method.

8. The method as defined in claim 5, wherein said thermal spraying method comprises a plasma spraying method.

9. The method as defined in claim 8, wherein said plasma spraying method comprises a vacuum plasma spraying or low pressure plasma spraying method.

10. The method as defined in claim 1, wherein said coating of the molding surface of the glass or plastic mold comprises spraying a single phase material on the molding surface.

11. The method as defined in claim 1, wherein said coating of the molding surface of the glass or plastic mold

comprises spraying a material combination in a layered structure or to provide a material gradient.

12. The method as defined in claim 1, wherein the coating of the molding surface of the mold takes place to provide a coating thickness of from 100 μm to 5 mm.

13. The method as defined in claim 1, wherein the coating of the molding surface of the mold takes place to provide a coating thickness of up to 20 mm.

14. The method as defined in claim 13, wherein the coating of the molding surface takes place by a thermal spraying method to form a coating member and further comprising reinforcing or building up said coating member by a bonding process.

15. The method as defined in claim 1, wherein said cladding body (2) released from said mold (1) is combined with said base body (3) by mechanical means to form said forming tool.

16. The method as defined in claim 1, wherein said cladding body (2) released from said mold (1) is combined as a part of a hot-isostatic-press capsule with another material by means of a hot-isostatic-press process to form the forming tool.

17. A finally shaped forming tool with a forming surface, said forming tool comprising a base or supporting body (3; 4; 5) and a cladding body (2) bonded to the base or supporting body, said cladding body (2) being separately formed from said base or supporting body with said forming surface.

18. The finally shaped forming tool as defined in claim 17, wherein said forming surface is uniformly structured.

19. The finally shaped forming tool as defined in claim 17, wherein said cladding body (2) has a thickness of up to 20 mm and is mechanically bonded with the base or supporting body.

20. The finally shaped forming tool as defined in claim 17, wherein cladding body (2) has a thickness of from 100 μm to 5 mm and is part of a hot-isostatic-press capsule and is combined with another material by means of a hot-isostatic-press process or by bonding to form the forming tool.

21. The finally shaped forming tool as defined in claim 15, wherein the cladding body is formed by a method comprising thermal spraying.

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