(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 August 2003 (28.08.2003)

PCT

(10) International Publication Number
WO 03/070846 A2

(51) International Patent Classification[7]: C09F

(21) International Application Number: PCT/US03/04698

(22) International Filing Date: 14 February 2003 (14.02.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/357,756 15 February 2002 (15.02.2002) US
60/358,622 20 February 2002 (20.02.2002) US

(71) Applicant: **SUPERCRITICAL SYSTEMS INC.** [US/US]; 2120 W. Guadalupe Road, Gilbert, AZ 85223 (US).

(72) Inventors: **ARENA-FOSTER, Chantal, J.**; 3847 East Ivyglen Circle, Mesa, AZ 85205 (US). **AWTREY, Allan, Wendell**; 2800 Green Ridge, Fort Worth, TX 76133 (US). **RYZA, Nicholas, Alan**; 2900 Sunridge Drive #716, Austin, TX 78741 (US). **SHILLING, Paul**; 8407 Seeno Avenue, Granite Bay, CA 95746 (**).

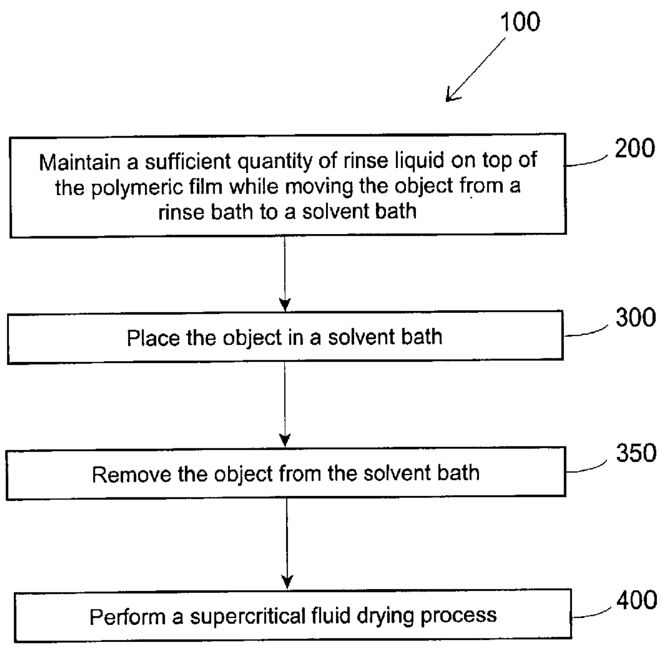
(74) Agents: **HAVERSTOCK, Thomas, B.** et al.; Haverstock & Owens LLP, 162 N. Wolfe Road, Sunnyvale, CA 94086 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: DRYING RESIST WITH A SOLVENT BATH AND SUPERCRITICAL CO_2



(57) **Abstract:** A method for drying an object, having a polymeric film, wherein the object is submerged in a rinse liquid. The object is removed from the rinse liquid and the object is placed in a solvent bath before a sufficient amount of the rinse liquid can evaporate from the object. The density of a solvent in the solvent bath depends on a direction of orientation of the polymeric film with respect to a force. The object is removed from the solvent bath. A drying process is performed.

WO 03/070846 A2

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DRYING RESIST WITH A SOLVENT BATH AND SUPERCRITICAL CO_2

RELATED APPLICATIONS

This Patent Application claims priority under 35 U.S.C. §119(e) of the co-pending, co-owned United States Provisional Patent Application, Serial No. 60/357,756, filed February 15, 2002, entitled "DRYING RESIST WITH A SOLVENT BATH AND SUPERCRITICAL CO2, AND DEVELOPING RESIST WITH SUPERCRITICAL FLUID AND DISSOLVED TMAH," and the co-pending, co-owned United States Provisional Patent Application, Serial No. 60/358,622, filed February 20, 2002, entitled "SUPERCRITICAL FLUID USED IN THE POST-DEVELOP RINSE," which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates to the field of drying a polymeric film. More particularly, the present invention relates to the field of drying photoresist, without pattern collapse or deformation, using a solvent bath and supercritical carbon dioxide.

BACKGROUND OF THE INVENTION

Fabrication of integrated circuits includes the formation of patterned layers on a semiconductor wafer that form electrically active regions in and on the wafer surface. As part of the manufacturing process, a masking process referred to as photolithography or photomasking is used to transfer a pattern onto the wafer. Masking involves applying a photoreactive polymer or photoresist onto the wafer by any suitable means such as by spinning of the wafer to distribute liquid photoresist uniformly on its surface. In a typical semiconductor manufacturing process, several iterations of the masking process are employed. Layers of either positive or negative photoresist can be used in various combinations on the same wafer.

Typically, the wafer is heated or "soft baked" such as on a hot plate to improve adhesion of the photoresist to the substrate surface. A photo aligner aligns the wafer to the photomask and then portions of the photoresist coated wafer are exposed to high-energy light so that a pattern is formed as a latent image in the photoresist layer. A developing agent is then applied to develop the portions of the photoresist which were exposed. When positive resist is used, the developed portions of the resist are solubilized by the exposure to high-energy light. Conversely, when negative resist is used, the undeveloped portions of the resist are solubilized. Washing and rinsing steps are carried out that selectively remove the solubilized photoresist. A drying step is carried out.

In the fabrication of semiconductor devices, typically increases in operational speeds of integrated circuits parallel decreases in device feature sizes. As device feature sizes shrink, the thickness of the resist is constant while the width of the pattern decreases. This results in a higher aspect ratio of height to width of photoresist lines. In actual practice, as the aspect ratio increases, the mechanical stability of the resist lines decreases. A serious problem emerges when the mechanical stability of the resist lines is too weak to compensate for capillary forces exerted by the liquid during the drying step. During drying, unbalanced capillary forces exert a net force on the pattern that deforms the resist lines. When the capillary forces exceed the elastic restoring force of the polymer, collapse of the photoresist structure occurs. The collapse of high-aspect-ratio photoresist structures is related to the surface tension of the rinse solution (capillary forces scale with the surface tension of the rinse solution) and is a function of both the density (spacing) and aspect ratio of resist lines. This becomes an increasingly serious problem as device feature sizes continue to shrink while relative vertical height increases to accommodate more complex interconnect structures.

As noted in the literature, *collapse* of photoresist structures is a generic term that refers to the deformation (bending), fracture, and/or peeling of resist from the substrate, in response to capillary forces present during the drying stage of a lithographic process. D. Goldfarb et. al, Aqueous-Based Photoresist Drying Using Supercritical Carbon Dioxide to Prevent Pattern Collapse, J. Vacuum Sci. Tech. B 18(6), 3313 (2000). Several parameters have been identified which influence the pattern collapse behavior, e.g., the mechanical stiffness of the resist lines are dominated by the Young's modulus (the force per unit cross section of a given substance divided by the fractional increase in length resulting from the stretching of a standard rod or wire of the substance). In addition, due to the different resist chemistries of various vendors, there are different critical aspect ratio of collapse.

A variety of strategies to overcome some of the issues bearing on pattern collapse are published. Conceptually speaking, the simplest method to reduce pattern collapse is to reduce the resist film thickness. However, this method is beginning to show the fundamental limits of the materials constituting the polymeric film. Instead of decreasing the film thickness, a different strategy could be to increase the resist stiffness such as by resist heating during rinsing to harden the resist structures, in order to eliminate or minimize collapse. Another strategy could be to use a supercritical fluid to dry resist patterns after rinsing. Supercritical fluids are characterized by high solvating and solubilizing properties that are typically associated with compositions in the liquid state. Supercritical fluids also have a low viscosity that is characteristic of compositions in the gaseous state. The conventional supercritical fluid drying methods commonly employ alcohol, e.g., ethanol, for rinsing. The ethanol rinse liquid can be directly replaced with carbon dioxide (CO_2). However, a strategy of using conventional supercritical fluid drying methods to dry resist patterns would have to overcome the additional problem of water contamination. Typically, resist systems are designed to employ aqueous-based developers and, for some resist systems, water is used for rinsing, for example, after development in an aqueous solution of tetramethyl ammonium hydroxide (TMAH). Moreover, polar organic compounds such as ethanol employed in conventional supercritical drying can not be used to dry water-rinsed resists because they dissolve the resist. When water is used for rinsing, e.g., for resists developed in an aqueous solution of TMAH, the presence of moisture in the atmosphere can not be avoided. This presents a serious problem because moisture in the atmosphere can cause acrylate-type resist to swell and pattern deformation can occur.

The impetus for the recent explorations of supercritical fluid to dry resist patterns is the philosophy that pattern collapse can be minimized by reducing the surface tension of the rinse solution. It is commonly known that one of the mechanisms of pattern collapse is the presence of capillary forces. Moreover, it is known that capillary forces scale with the surface tension of the rinse solution. In mathematical terms, the Laplace equation $F=\gamma/r$ relates the force (F) acting on the resist walls to the surface tension (γ) of the rinse liquid and the radius (r) of the meniscus in between the patterns. By the equation, decreases in the surface tension relate to decreases in the capillary force acting on the resist walls. D. Goldfarb et. al, Aqueous-Based Photoresist Drying Using Supercritical Carbon Dioxide to Prevent Pattern Collapse, J. Vacuum Sci. Tech. B 18(6), 3313 (2000). Accordingly, there is a need for effective methods for supercritical resist drying to eliminate or minimize the capillary forces present during resist drying.

Two methods of supercritical resist drying using CO_2 that were developed for water-rinsed resist patterns are described in H. Namatsu et al., J. Vacuum Sci. Tech. B 18(6), 3308 (2000) (hereinafter, "Namatsu"). As stated in Namatsu, supercritical resist drying in principle should not generate any surface tension. This is because, in the phase diagram for the drying process, the phase does not cross the liquid-vapor equilibrium curve; and consequently, there is no liquid-gas interface where surface tension could be generated. Namatsu, citing, H. Namatsu et al., J. Microelectron. Eng., 46, 129 (1998), and H. Namatsu et al., J. Vacuum Sci. Tech. B 18(2), 780 (2000). In the first method as described in Namatsu, a solution of *n*-hexane, a CO_2-philic liquid (in terms of their solubility in CO_2, polymers have been classified as CO_2-philic and CO_2-phobic) and a surfactant, sorbitan fatty acid ether, first replaces the water and, in turn, is replaced with liquid CO_2 before supercritical resist drying (SRD) is performed. In this method, the addition of a compound with a high hydrophilic-lipophilic balance to the surfactant compensates for the poor miscibility of water in a solution of *n*-hexane and sorbitan fatty acid ether. In the second method, which does not require a CO_2-philic liquid, the water is replaced directly with the liquid CO_2 containing a surfactant, fluoroether carboxylate, which makes water miscible in CO_2, and then SRD is performed.

One disadvantage of the supercritical resist drying methods set forth in Namatsu is that their effectiveness is based on the use of a surfactant to enable rinse water to be replaced with CO_2 before the drying step is carried out, resulting in additional chemicals other than CO_2 needed for the process. Certain surfactants can dissolve the resist patterns, while various other surfactants can result in the formation of a haze on the surface of the photoresist.

There is a need for effective methods for supercritical resist drying to dry semiconductor wafers with no pattern collapse of the photoresist.

SUMMARY OF THE INVENTION

A first embodiment of the present invention is for a method of drying an object, having a polymeric film, wherein the object is submerged in a rinse liquid. The object is removed from the rinse liquid and the object is placed in a solvent bath before a sufficient amount of the rinse liquid can evaporate from the object. The density of a solvent in the solvent bath depends on a direction of orientation of the polymeric film with respect to a force (e.g., force of gravity or centripetal force). The object is removed from the solvent bath. A drying process is performed.

A second embodiment of the invention is for a method of drying an object having a polymeric film. A sufficient quantity of rinse liquid is maintained on top of the polymeric film while moving the object from a rinse bath to a solvent bath. The object is placed in the solvent bath. The density of a solvent in the solvent bath depends on a direction of orientation of the polymeric film with respect to a force. The object is removed from the solvent bath. A supercritical fluid drying process is performed.

A third embodiment is for an apparatus for drying an object having a polymeric film including: a rinse bath; a solvent bath; means for maintaining a sufficient quantity of rinse liquid on top of the polymeric film while moving the object from the rinse bath to the solvent bath; means for placing the object in the solvent bath; means for removing the object from the solvent bath; and means for performing a supercritical fluid drying process.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be better understood by reference to the accompanying drawings of which:

FIG. 1 is a flow chart showing a process flow for a method of drying an object having a polymeric film, wherein the object is submerged in a rinse liquid, in accordance with the present invention.

FIG. 2 is a flow chart showing a process flow for a method drying an object having a polymeric film in accordance with the present invention.

FIG. 3 is a schematic illustration of an apparatus for drying an object having a polymeric film in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description with reference to the accompanying drawing is illustrative of various embodiments of the invention. The present invention should not be construed as limited to the embodiments set forth herein. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined by the accompanying claims.

The present invention is directed to a process of drying an object having a polymeric film, such as a semiconductor substrate or wafer that has been fabricated in accordance with methods well known in the art of manufacturing semiconductor devices. The methods and apparatus in accordance with the present invention utilize the low viscosity and high solvating and solubilizing properties of supercritical carbon dioxide to assist in the cleaning process.

For purposes of the invention, "carbon dioxide" should be understood to refer to carbon dioxide (CO_2) employed as a fluid in a liquid, gaseous or supercritical (including near-supercritical) state. "Liquid carbon dioxide" refers to CO_2 at vapor-liquid equilibrium conditions. If liquid CO_2 is used, the temperature employed is preferably below 31.1° C. "Supercritical carbon dioxide" refers herein to CO_2 at conditions above the critical temperature (31.1° C) and critical pressure (1070.4 psi). When CO_2 is subjected to temperatures and pressures above 31° C and 1070.4 psi, respectively, it is determined to be in the supercritical state. "Near-supercritical carbon dioxide" refers to CO_2 within about 85% of absolute critical temperature and critical pressure.

Various objects can be dried using the processes of the present invention such as semiconductor wafers, substrates, and other media requiring photoresist drying. The present invention, though applicable to the semiconductor industry, is not limited thereto. For the purposes of the invention, "drying" should be understood to be consistent with its conventional meaning in the art.

As used herein, "substrate" includes a wide variety of structures such as semiconductor device structures with a deposited photoresist. A substrate can be a single layer of material, such as a silicon wafer, or can include any number of layers. A substrate can be comprised of various materials, including metals, ceramics, glass, or compositions thereof.

FIG. 1 is a flow chart showing a process flow (10) for a method of drying an object having a polymeric film, wherein the object is submerged in a rinse liquid. For purposes of the invention, "object" includes: a substrate consisting of metals, ceramics, glass, and composite mixtures thereof; a semiconductor wafer for forming integrated circuits; and other objects requiring photoresist drying. It should be appreciated that the surface of the object, or at least a portion thereof, is coated with a polymeric film such as photoresist.

In a preferred embodiment of the invention, the object is removed from the rinse liquid and placed in a solvent bath before a sufficient amount of the rinse liquid can evaporate from the object (20). It should be understood that "before a sufficient amount of the rinse liquid can evaporate from the object" means before the process of evaporation results in capillary forces that exert a net force on the pattern that deforms the resist lines. In one embodiment of the invention, the rinse liquid is water.

Preferably, the density of the solvent depends on the direction of orientation of the polymeric film with respect to a force, such as the force of gravity. Where an even greater force is desired, the object being dried can be placed into a centrifuge and force is a combination of gravity and a centripetal force. For example, in one embodiment, when the polymeric film is oriented in a direction that is opposite, or nearly opposite, to the direction of the force exerted on the object, a solvent is selected such that the density of the solvent is greater than the density of the rinse liquid. In an alternative embodiment, when the polymeric film is oriented in a direction that is the same, or nearly the same, as the direction of the force exerted on the object, a solvent is selected such that the density of the solvent is less than the density of the rinse liquid. Examples of solvents that can be used in the present invention include, but are not limited to, alkyl ethers R-O-R_1, where R = aliphatic hydrocarbons C_1-C_6 or R_1 = fluorinated hydrocarbons C_1-C_6, such as ethyl nonafluoroisobutyl ether and ethyl nonafluorobutyl ether, available under the product name HFE-7200 and other product names such as HFE-7100, from 3M Company, St. Paul, Minnesota 55144.

In one embodiment, the solvent includes a co-solvent and/or a surfactant. Examples of co-solvents that can be used in the present invention include, but are not limited to, aliphatic and aromatic hydrocarbons, and esters and ethers thereof, particularly mono and di-esters and ethers, alkyl and dialkyl carbonates, alkylene and polyalkylene glycols, and ethers and esters thereof, lactones, alcohols and diols, polydimethylsiloxanes, DMSO, and DMF. Examples of surfactants that can be used in the invention include, but are not limited to, anionic, cationic, nonionic, fluorinated and non-fluorinated surfactants.

In a preferred embodiment of the invention, the object is removed from the solvent bath (30) and a drying process is performed (40). Preferably, the drying process is a supercritical fluid drying process. In a supercritical fluid drying process the surface tension vanishes in the supercritical phase, which means that capillary forces are zero in the supercritical phase. Preferably, carbon dioxide is used as the fluid in the supercritical fluid drying process. The advantages of using carbon dioxide in the supercritical fluid drying process include that the critical point is relatively low, it is relatively inexpensive, is nontoxic, is chemically inert to various photoresists, and can solubilize organic solvents at moderate pressures. However, it should be understood that the methods and apparatus of the present invention are not limited to the use of carbon dioxide as the fluid in the supercritical fluid drying process. In one embodiment, the supercritical fluid drying process includes a spin dry process.

FIG. 2 is a flow chart showing a process flow (100) for a method of drying an object having a polymeric film. In one preferred embodiment of the present invention, a sufficient quantity of rinse liquid is maintained on top of the polymeric film while moving the object from a rinse bath to a solvent bath (200). For the purposes of the invention, "a sufficient quantity of rinse liquid" means a quantity of rinse liquid such that evaporation of the rinse liquid, while moving the object from a rinse bath to a solvent bath, does not result in capillary forces of sufficient magnitude to deform the resist lines. In one embodiment of the invention, the rinse liquid is water.

The object is placed in a solvent bath (300). In one preferred embodiment, the density of the solvent depends on the direction of orientation of the polymeric film with respect to a force, such as force of gravity or centripetal force. In one embodiment, when the polymeric film is oriented in a direction that is opposite, or nearly opposite, to the direction of the force exerted on the object, a solvent is selected such that the density of the solvent is greater than the density of the rinse liquid. In another embodiment, when the polymeric film is oriented in a direction that is the same, or nearly the same, as the direction of the force exerted on the object, a solvent is selected such that the density of the solvent is less than the density of the rinse liquid.

In a preferred embodiment of the invention, the object is removed from the solvent bath (350) and a supercritical fluid drying process is performed (400).

FIG. 3 is a schematic illustration of an apparatus for drying an object having a polymeric film, that includes both a rinse bath (500) and a solvent bath (700). There is means for removing the object (550) from the rinse bath (500), such as a robotic arm or operator using a wafer wand. A means for maintaining a sufficient quantity of rinse liquid on top of the polymeric film while moving the object (600) from the rinse bath (500) to the solvent bath (700), such as a rinse liquid flow, is provided. There is means for placing the object (650) in the solvent bath (700) such as a robotic arm or operator using a wafer wand. There is means for removing the object (750) from the solvent bath (700), such as a robotic arm or operator using a wafer wand. It should be understood that means (550), (650) and (750), although depicted as separate means in FIG. 3, can be the same means, such as the same robotic arm or operator using a wafer wand.

A means for performing a supercritical fluid drying process (800), such as a pressure chamber, is provided. The details concerning one example of a pressure chamber for supercritical processing are disclosed in co-owned and co-pending United States Patent Applications, Serial No. 09/912,844, entitled "HIGH PRESSURE PROCESSING CHAMBER FOR SEMICONDUCTOR SUBSTRATE," filed July 24, 2001, and Serial No. 09/970,309, entitled "HIGH PRESSURE PROCESSING CHAMBER FOR MULTIPLE SEMICONDUCTOR SUBSTRATES," filed October 3, 2001, which are incorporated by reference.

While the processes and apparatuses of this invention have been described in detail for the purpose of illustration, the inventive processes and apparatuses are not to be construed as limited thereby. It will be readily apparent to those of reasonable skill in the art that various modifications to the foregoing preferred embodiments can be made without departing from the spirit and scope of the invention as defined by the appended claims.

CLAIMS

1. A method of drying an object, having a polymeric film, wherein the object is submerged in a rinse liquid, comprising the steps of:

   a. removing the object from the rinse liquid and placing the object in a solvent bath before a sufficient amount of the rinse liquid can evaporate from the object, wherein the density of a solvent in the solvent bath depends on a direction of orientation of the polymeric film with respect to a force;

   b. removing the object from the solvent bath; and

   c. performing a drying process.

2. The method of claim 1 wherein the object is a semiconductor wafer for forming integrated circuits.

3. The method of claim 1 wherein the polymeric film is a photoresist film.

4. The method of claim 1 wherein the rinse liquid is water.

5. The method of claim 1 wherein the solvent includes at least one of a co-solvent and a surfactant.

6. The method of claim 1 wherein the force comprises at least one of force of gravity and centripetal force.

7. The method of claim 6 wherein the density of the solvent depends on a direction of orientation of the polymeric film with respect to the force comprises the density of the solvent is greater than the density of the rinse liquid when the polymeric film is oriented in an essentially opposite direction with respect to the force.

8. The method of claim 6 wherein the density of the solvent depends on a direction of orientation of the polymeric film with respect to the force comprises the density of the solvent is less than the density of the rinse liquid when the polymeric film is oriented inan essentially same direction with respect to the force.

9. The method of claim 1 wherein performing the drying process comprises performing a supercritical fluid drying process.

10. The method of claim 9 wherein performing the supercritical fluid drying process includes spinning the object.

11. A method of drying an object having a polymeric film comprising the steps of:

a. maintaining a sufficient quantity of rinse liquid on top of the polymeric film while moving the object from a rinse bath to a solvent bath;

b. placing the object in the solvent bath, wherein the density of a solvent in the solvent bath depends on a direction of orientation of the polymeric film with respect to a force;

b. removing the object from the solvent bath; and

c. performing a supercritical fluid drying process.

12. The method of claim 11 wherein the object is a semiconductor wafer for forming integrated circuits.

13. The method of claim 11 wherein the polymeric film is a photoresist film.

14. The method of claim 11 wherein the rinse liquid is water.

15. The method of claim 11 wherein the solvent includes at least one of a co-solvent and a surfactant.

16. The method of claim 11 wherein the force comprises at least one of force of gravity and centripetal force.

17. The method of claim 16 wherein the density of the solvent depends on a direction of orientation of the polymeric film with respect to the force comprises the density of the solvent is greater than the density of the rinse liquid when the polymeric film is oriented in an essentially opposite direction with respect to the force.

18. The method of claim 16 wherein the density of the solvent depends on a direction of orientation of the polymeric film with respect to the force comprises the density of the solvent is less than the density of the rinse liquid when the polymeric film is oriented in an essentially same direction with respect to the force.

19. The method of claim 11 wherein performing the supercritical fluid drying process includes spinning the object.

20. An apparatus for drying an object having a polymeric film comprising:

a. a rinse bath;

b. a solvent bath;

c. means for maintaining a sufficient quantity of rinse liquid on top of the polymeric film while moving the object from the rinse bath to the solvent bath;

d. means for placing the object in the solvent bath;

e. means for removing the object from the solvent bath; and

f. means for performing a supercritical fluid drying process.

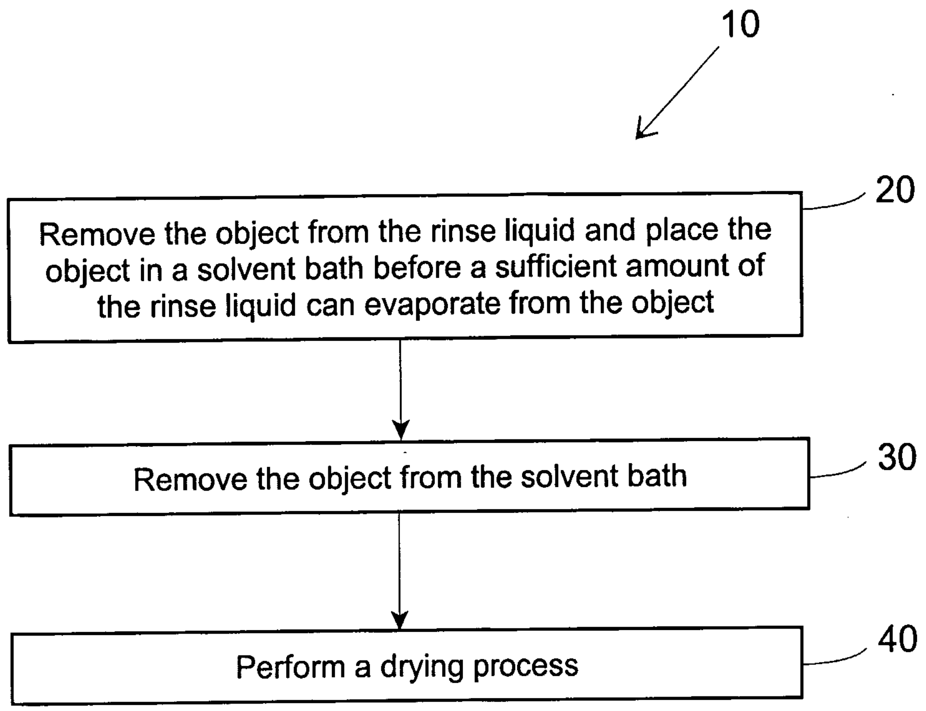

10
Remove the object from the rinse liquid and place the object in a solvent bath before a sufficient amount of the rinse liquid can evaporate from the object
20
Remove the object from the solvent bath
30
Perform a drying process
40

FIG. 1

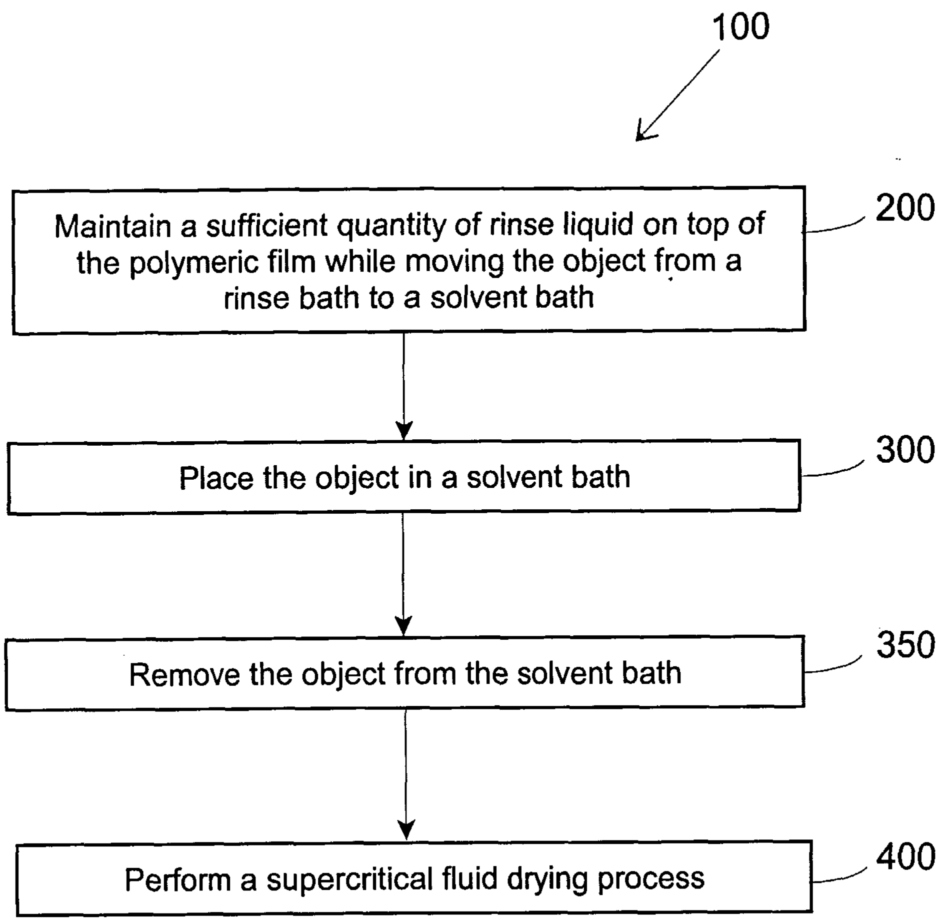

100
Maintain a sufficient quantity of rinse liquid on top of the polymeric film while moving the object from a rinse bath to a solvent bath
200
Place the object in a solvent bath
300
Remove the object from the solvent bath
350
Perform a supercritical fluid drying process
400

FIG. 2

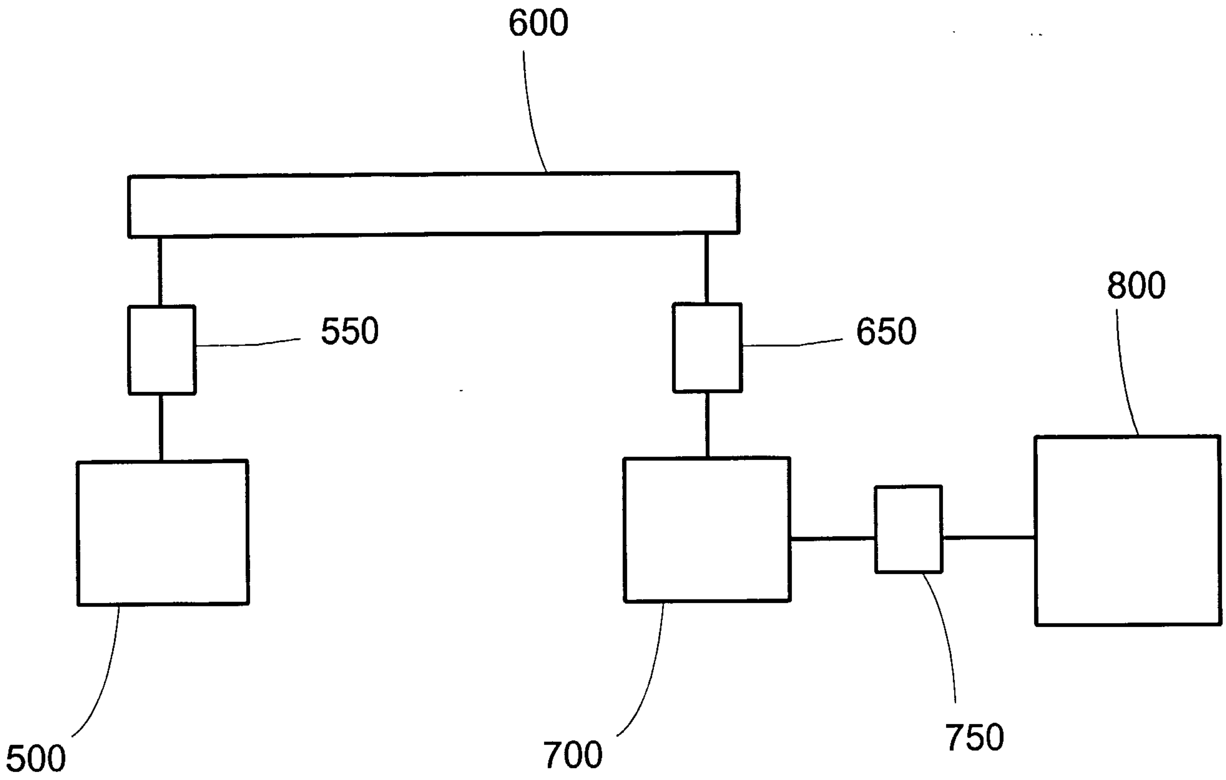


FIG. 3