Embossing Material for Embossing Lithography

The invention relates to an embossing material as well as a use of an embossing material.

In the semiconductor industry, embossing lithography methods are used increasingly to supplement or to replace standard optical lithography methods. By using microstructured and/or nanostructured embossing dies, a mechanical option of structuring viscous embossing materials, not limited to optical diffraction phenomena, is obtained. The structured, viscous embossing materials are cross-linked/hardened before and/or during the embossing process in order to remain dimensionally stable. In this case, the cross-linking is done in particular via electromagnetic radiation, preferably UV light, and/or by means of heat, i.e., thermally. After the cross-linking, the embossing die can be removed from the hardened embossing material. The remaining hardened embossing material either has a functional shape already or is further treated in subsequent process steps. A large amount of embossing material, primarily based on inorganic molecules, is heat-treated still at very high temperatures after the demolding step. The heat treatment ensures that the embossing material is irreversibly hardened. When using embossing materials with organic and inorganic molecules, the heat treatment primarily ensures that organic parts are removed from the embossing material and the inorganic molecules are cross-linked with one another. As a result, it is possible to structure an embossing material that consists of organic and inorganic molecules by die processes and to convert it after the die process into a completely inorganic material.

In order to carry out the structuring of the embossing material, special embossing dies are required. The embossing dies must meet extremely high requirements so that their micro- and/or nanometer-size structures can be transferred perfectly as negatives into the embossing material. In the state of the art, many different types of dies exist. A distinction is made in principle between hard and soft dies.

A hard die consists of metal, glass, or ceramic. It is less deformable, corrosion-resistant, wear-resistant, and very costly in production. The surface of the hard die is in most cases processed by electron beam lithography or laser beam lithography. These production methods

are in general very expensive. The advantage of the hard die lies primarily in the high wear resistance. A decisive disadvantage exists in the high level of bending resistance, which does not allow the embossing die to be pulled off in pieces from the embossing material, as is possible in the case of soft dies. The hard die can be raised from the embossing material by a normal force only over its entire surface.

A soft die is very often formed as a negative of a hard die. In most cases, it consists of a polymer, and it has a high elasticity and a low bending strength. In most cases, it is entropy-elastic. The reason is primarily a high level of adhesion between the embossing material and the soft die and/or a swelling of the soft die. Soft dies can be distinguished from hard dies by various chemical, physical, and technical parameters. A distinction based on the elasticity property would be conceivable. Soft dies have a deformation property based primarily on entropy elasticity, and hard dies have a deformation property based primarily on energy elasticity. In addition, the two types of dies can be distinguished by, for example, their hardness. Hardness is the resistance that a material puts up against a penetrating body. Since hard dies primarily consist of metals or ceramics, they have correspondingly high hardness values. There are various ways of indicating the hardness of a solid. A very common method is the indication of the hardness according to Vickers. Without going into detail, it can be roughly stated that hard dies are to have Vickers hardness values of greater than 500 HV. Theoretically, such soft dies should be removable very simply from the embossing material, which is often not the case, however. The greatest problems with the current embossing techniques thus consist primarily in the demolding step, i.e., in the separation of the embossing die, in particular a soft die, from the embossing material.

Embodiments of this invention provide an embossing material that can be better detached from the embossing die.

According to a first aspect of the present invention, there is provided a combination of a die with a hydrophobic die surface and an embossing material, usable for embossing lithography and that can be hardened, with a hydrophilic surface or combination of a die with a hydrophilic die surface and an embossing material, usable for embossing lithography and that can be hardened, with a hydrophobic surface, ~~the embossing material consisting of a mixture of at least~~

~~one polymerizable main component and at least one secondary component that is primarily responsible for the setting of hydrophilicity or hydrophobicity,~~ wherein the embossing material consists of a mixture of: at least one main component based on silicon oxide, at least one secondary component for setting the hydrophilicity or hydrophobicity, an initiator and a solvent, wherein during activation of the initiator only the at least one main component polymerizes, wherein the, inorganic, main component(s) is formed of at least one of the following materials: Polyhedral, oligomeric silsesquioxane (POSS) and Poly(organo)siloxane (silicone).

According to a second aspect of the present invention, there is provided a use of the above combination for the primary forming of an embossing form.

According to a third aspect of the present invention, there is provided an embossing material that can be hardened and used for embossing lithography, consisting of a mixture of: at least one polymerizable main component, and at least one secondary component that is primarily responsible for the setting of hydrophilicity or hydrophobicity, wherein the embossing material consists of a mixture of: at least one main component based on silicon oxide, at least one secondary component for setting the hydrophilicity or hydrophobicity, an initiator and a solvent, wherein during activation of the initiator only the at least one main component polymerizes, wherein the, inorganic, main component(s) is formed of at least one of the following materials: Polyhedral, oligomeric silsesquioxane (POSS) and Poly(organo)siloxane (silicone).

According to a fourth aspect of the present invention, there is provided a use of the above embossing material for the primary forming of an embossing form.

All combinations of at least two of the features indicated in the specification, the claims, and/or the figures also fall within the scope of the invention. In the indicated ranges of values, values that lie within the above-mentioned limits are also to be considered disclosed as boundary values and can be claimed in any combination.

Embodiments of the invention describe an embossing material for embossing lithography as well as applications/uses of the embossing material according to the invention. The embossing material is distinguished by a mixture of at least one main component, preferably consisting of inorganic and/or organic parts, and at least one secondary component, preferably an organic component, which is suitable/used in particular for

Claims:

1. Combination of a die with a hydrophobic die surface and an embossing material, usable for embossing lithography and that can be hardened, with a hydrophilic surface or ~~Combination~~ combination of a die with a hydrophilic die surface and an embossing material, usable for embossing lithography and that can be hardened, with a hydrophobic surface, ~~the embossing material consisting of a mixture of~~

~~at least one polymerizable main component and~~

~~at least one secondary component that is primarily responsible for the setting of hydrophilicity or hydrophobicity,~~

wherein the embossing material consists of a mixture of:

at least one main component based on silicon oxide,

at least one secondary component for setting the hydrophilicity or hydrophobicity,

an initiator, and

a solvent,

wherein during activation of the initiator only the at least one main component polymerizes, wherein the, inorganic, main component(s) is formed of at least one of the following materials:

Polyhedral, oligomeric silsesquioxane (POSS), and

Poly(organo)siloxane (silicone).

~~2. Combination according to claim 1, whereby the main component(s), which is/are inorganic and which is/are based on silicon oxide, is/are formed from at least one of the following materials:~~

~~Polyhedral, oligomeric silsesquioxane (POSS)~~

~~Polydimethylsiloxane (PDMS)~~

~~Tetraethylorthosilicate (TEOS)~~

~~Poly(organo)siloxane (silicone).~~

~~3~~2. Combination according to ~~one of~~ claims 1 ~~or 2~~, whereby the secondary component(s), which is/are organic, consist(s) of at least one of the following compounds:

Acrylic

Epoxides

Epoxy resins

Phenols

Alkane

Alkene

Alkyne

Benzene,

Polyacrylates

Ether.

~~4~~3. Combination according to claim 1, wherein the embossing material consists of a chain of polymerized monomers, with a chain length of at least two monomers.

~~5~~4. Combination according to ~~one of~~ claim~~s~~ 1 ~~to 3~~, wherein the embossing material consists of a chain of polymerized monomers, with a chain length of at least 10 monomers.

~~6~~5. Combination according to ~~one of~~ claim~~s~~ 1 ~~to 3~~, wherein the embossing material consists of a chain of polymerized monomers, with a chain length of at least 100 monomers.

~~7~~6. Combination according to ~~one of~~ claim~~s~~ 1 ~~to 3~~, wherein the embossing material consists of a chain of polymerized monomers, with a chain length of at least 1000 monomers.

~~8~~7. Combination according to one of the preceding claims, whereby the embossing material is designed to be hydrophobic upon impact with an embossing die that is

hydrophilic at an embossing surface, and the embossing material is designed to be hydrophilic upon impact with an embossing die that is hydrophobic at an embossing surface.

~~9~~8. Use of combination according to one of the preceding claims for the primary forming of an embossing form (4, 4', 4", 4"', 4IV).

~~10~~9. Embossing material that can be hardened and used for embossing lithography, consisting of a mixture of:

at least one polymerizable main component,

at least one secondary component that is primarily responsible for the setting of hydrophilicity or hydrophobicity,

an initiator, and

a solvent,

wherein during activation of the initiator only the at least one main component polymerizes, wherein the, inorganic, main component(s) is formed of at least one of the following materials:

Polyhedral, oligomeric silsesquioxane (POSS), and

Poly(organo)siloxane (silicone).

~~11. Embossing material according to claim 10, whereby the main component(s), which is/are inorganic and which is/are based on silicon oxide, is/are formed from at least one of the following materials:~~

~~Polyhedral, oligomeric silsesquioxane (POSS)~~

~~Polydimethylsiloxane (PDMS)~~

~~Tetraethylorthosilicate (TEOS)~~

~~Poly(organo)siloxane (silicone).~~

~~12~~10. Embossing material according to ~~one of~~ claim~~s 10 or 1~~9, whereby the secondary component(s), which is/are organic, consist(s) of at least one of the following compounds:

Acrylic

Epoxides

Epoxy resins

Phenols

Alkane

Alkene

Alkyne

Benzene.

~~13~~11. Embossing material according to one of claim ~~10~~9, which consists of a chain of polymerized monomers, with a chain length of at least two monomers.

~~14~~12. Embossing material according to claim ~~10~~9, which consists of a chain of polymerized monomers, with a chain length of at least 10 monomers.

~~15~~13. Embossing material according to claim 9~~10~~, which consists of a chain of polymerized monomers, with a chain length of at least 100 monomers.

~~16~~14. Embossing material according to claim 9~~10~~, which consists of a chain of polymerized monomers, with a chain length of at least 1,000 monomers.

~~17~~15. Embossing material according to claim 9~~11~~, whereby the embossing material is designed to be hydrophobic upon impact with an embossing die that is hydrophilic at an embossing surface, and the embossing material is designed to be hydrophilic upon impact with an embossing die that is hydrophobic at an embossing surface.

~~18~~16. Use of an embossing material according to one of Claims 9~~10~~ to 15~~17~~ for the primary forming of an embossing form (4, 4', 4", 4"', 4IV).