Embossing Material for Embossing Lithography

The invention relates to an embossing material as well as a use of the 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 an aspect, there is provided a combination of a stamp with a hydrophobic stamp surface and an embossing material that can be hardened and used for embossing

lithography with a hydrophobic surface, the embossing material consisting of a mixture of at least one polymerizable main component which is/are in particular inorganic and which is/are preferably based on silicon oxide, and at least one secondary component for setting hydrophilicity and/or respective hydrophobicity, an initiator, and a solvent, wherein in a case of activation of the initiator only, the at least one main component polymerizes, wherein the inorganic main component(s) is/are formed from at least one of the following materials: Polyhedral, oligomeric silsesquioxane (POSS), and Poly(organo)siloxane (silicone).

Disclosed herein is a use of the above embossing material for the primary forming of an embossing form, wherein the embossing material is used as a protective material or as an encapsulating material.

Disclosed herein is a use of the above embossing material for the primary forming of an embossing form, wherein the embossing material is used as a basic material for functional units.

Disclosed herein is a use of the above embossing material for the primary forming of an embossing form, wherein the embossing material is used for the production of optical elements.

Disclosed herein is a use of the above embossing material for the primary forming of an embossing form, wherein the embossing material is used as a mask for a transfer etching process.

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 embodiments of 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 stamp with a hydrophobic stamp surface and an embossing material that can be hardened and used for embossing lithography with a hydrophobic surface, the embossing material consisting of a mixture of:

- at least one polymerizable main component which is/are in particular inorganic and which is/are preferably based on silicon oxide, and
- at least one secondary component for setting hydrophilicity and/or respective hydrophobicity,
- an initiator, and
- a solvent,

wherein in a case of activation of the initiator only, the at least one main component polymerizes, wherein the inorganic main component(s) is/are formed from at least one of the following materials:

- Polyhedral, oligomeric silsesquioxane (POSS), and
- Poly(organo)siloxane (silicone).

2. Combination according to Claim 1, whereby the secondary component(s), which is/are in particular organic, consists of at least one of the following compounds:

- Polyacrylate,
- Ether, and
- Epoxy resins.

3. Combination according to one of Claims 1 or 2, wherein the embossing material consists of a chain of polymerized monomers, in particular with a chain length of at least two monomers, preferably at least 10 monomers, more preferably at least 100 monomers, and even more preferably at least 1,000 monomers.

4. Combination according to one of the preceding Claims, whereby the embossing material comprises a proportion by weight of the main component(s) of between 50% and less than 100%, preferably between 52% and 90%, more preferably between 54% and 80%, most preferably between 56% and 70%, and the secondary component(s) comprise(s) 100% minus the proportion by weight of the main component(s).