METHODS FOR MAKING DIFFERENTIALLY PATTERN CURED MICROSTRUCTURED ARTICLES

BACKGROUND

[0001] Methods for using a patterned tool to replicate a complementary pattern in the surface of a film are well known. However, in many instances the pattern resulting from the replication method may be limited by the tool (e.g., certain pattern configurations do not lend themselves to being replicated by conventional replication methods).

SUMMARY

[0002] What is needed is a method, preferably that is relatively rapid and relatively low-cost, for creating a variety of differentially pattern cured microstructured articles without permanent physical modification of a microreplication tool.

[0003] In general, the present disclosure describes methods for generating microstructured articles having differentially pattern cured regions that have different properties (e.g., having at least two regions that have differences in their optical, mechanical, or adhesive properties) by using various combinations of molding tools, radiation curable resins, and patterned radiation sources (e.g., masked light-emitting diodes, masked ultraviolet lamps, masked e-beam, lasers, and projected images). By applying a radiation curable resin to a microstructured molding tool in combination with irradiating the radiation curable resin with various patterned and non-patterned irradiation techniques, a wide variety of differentially pattern cured microstructured articles can be produced, without having to provide a different molding tool for each different pattern.

[0004] ~~In a first aspect, the present disclosure describes a method of making an article, the method comprising providing a molding tool having a microstructured surface including a plurality of cavities; at least partially filling the plurality of cavities with a first radiation curable resin; exposing the first radiation curable resin to a first, patterned irradiation to provide a correspondingly patterned partially cured resin comprising at least one first region and at least one second region, wherein the at least one first region is irradiated by the first, patterned irradiation and the at least one second region is not irradiated by the first, patterned irradiation; exposing both the at least one first region and the at least one second region to a second irradiation to provide an article having a microstructured surface and a differentially cured pattern therein; and separating the article having a microstructured surface and a differentially cured pattern therein from the molding tool.~~In a first aspect, the present disclosure describes a method of making a composite article, the method comprising: providing a molding tool having a microstructured surface including a plurality of cavities; at least partially filling the plurality of cavities with a first radiation curable resin; exposing the first radiation curable resin to a first, patterned irradiation to provide a correspondingly patterned partially cured resin comprising at least one first region and at least one second region, wherein the at least one first region is irradiated by the first, patterned irradiation and the at least one second region is not irradiated by the first, patterned irradiation; applying a second radiation curable resin over the partially cured resin; exposing both the at least one first region and the at least one second region, and the second radiation curable resin to a second irradiation to provide a composite article having a microstructured surface and a differentially cured pattern therein; and separating the composite article having a microstructured surface and a differentially cured pattern therein from the molding tool, wherein the patterned irradiation comprises at least one of irradiating through transparent regions of a mask, guiding a beam of light, guiding a beam of electrons, or projecting a digital image.

[0005] In a second aspect, the present disclosure describes a method of making a composite~~an~~ article, the method comprising providing a first molding tool having a first microstructured surface including

a plurality of cavities; at least partially filling the plurality of cavities with a radiation curable resin disposed on a first major surface of an overlay element; exposing the radiation curable resin to a first, patterned irradiation to provide a partially cured composite comprising the overlay element adhered to a correspondingly patterned partially cured resin comprising at least one first region and at least one second region, wherein the at least one first region is irradiated by the first, patterned irradiation and the at least one second region is not irradiated by the first, patterned irradiation; separating the partially cured composite from the molding tool, such that at least a portion of curable resin from the at least one second region remains in the molding tool, providing the separated partially cured composite with a surface that lacks microstructure in the at least one second region; and exposing the partially cured composite that was separated from the molding tool to a second irradiation, to provide a composite article having a first microstructured surface and a differentially cured pattern therein.

[0006] In some embodiments of the method of the second aspect, the method further comprises providing a second molding tool having a second microstructured surface including a second plurality of cavities; at least partially filling the second plurality of cavities with a second radiation curable resin disposed on a second major surface of the overlay element of the composite article having a first microstructured surface and a differentially cured pattern therein; exposing the second radiation curable resin to a third irradiation, to provide an article having the first microstructured surface and the differentially cured pattern therein on the first major surface and a second microstructured surface on the second major surface; and separating the article from the second molding tool.

[0007] In a third aspect, the present disclosure describes a method of making a composite article, the method comprising providing a molding tool having a microstructured surface including a plurality of cavities; at least partially filling the plurality of cavities with a radiation curable resin disposed on a major surface of an overlay element; exposing the radiation curable resin to a patterned irradiation to provide a partially cured composite comprising the overlay element adhered to a correspondingly patterned partially cured resin comprising at least one first region and at least one second region, wherein the at least one first region is irradiated by the patterned irradiation and the at least one second region is not irradiated by the patterned irradiation; separating the partially cured composite from the molding tool; and removing the

radiation curable resin from the at least one second region to provide a composite article having a microstructured surface, wherein the patterned irradiation comprises at least one of irradiating through transparent regions of a mask, guiding a beam of light, guiding a beam of electrons, or projecting a digital image.

[0007a] In a fourth aspect, the present disclosure describes a method of making a composite article, the method comprising: providing a molding tool having a microstructured surface including a plurality of cavities; at least partially filling the plurality of cavities with a first radiation curable resin; contacting an overlay element to the first radiation curable resin; exposing the first radiation curable resin to a patterned irradiation to provide a correspondingly patterned first partially cured resin comprising at least one first region and at least one second region, wherein the at least one first region is irradiated by the first, patterned irradiation and the at least one second region is not irradiated by the first, patterned irradiation; exposing the first partially cured resin to a first blanket irradiation to provide a first further cured resin, wherein the first further cured resin is adhered to the overlay element; separating at least a portion of the first further cured resin from the molding tool; at least partially filling the plurality of cavities with a second radiation curable resin; contacting the first further cured resin with the second radiation curable resin; exposing the second radiation curable resin to a second patterned irradiation to provide a correspondingly patterned second partially cured resin comprising at least one third region and at least one fourth region, wherein the at least one third region is irradiated by the second, patterned irradiation and the at least one fourth region is not irradiated by the first, patterned irradiation; exposing the second partially cured resin to a second blanket irradiation to provide a composite article wherein the second further cured resin is adhered to the first further cured resin and the first further cured resin is adhered to the overlay element; and separating the composite article from the molding tool.

[0007b] In a fifth aspect, the present disclosure describes a method of making a composite article, the method comprising: providing a molding tool having a microstructured surface including a plurality of cavities; partially filling the plurality of cavities with a first radiation curable resin; exposing the first radiation curable resin to a patterned irradiation to provide a correspondingly patterned first partially cured resin comprising at least one first region and at least one second region, wherein the at least one first region is irradiated by the first, patterned irradiation and the at least one second region is not irradiated by the first, patterned irradiation;

exposing the first partially cured resin to a first blanket irradiation to provide a first further cured resin; contacting a second radiation curable resin to the first further cured resin in the plurality of cavities; contacting an overlay element to the second radiation curable resin; exposing the second radiation curable resin to a second patterned irradiation to provide a correspondingly patterned second partially cured resin comprising at least one third region and at least one fourth region, wherein the at least one third region is irradiated by the second, patterned irradiation and the at least one fourth region is not irradiated by the first, patterned irradiation; exposing the second partially cured resin to a second blanket irradiation to provide a composite article wherein the first further cured resin is adhered to the second further cured resin and the second further cured resin is adhered to the overlay element; and separating the composite article from the molding tool.

[0008] These methods are useful for providing a broad array of differentially pattern cured microstructured articles from a given molding tool, without requiring modification of the molding tool.

[0009] "Blanket irradiation" refers to a non-patterned irradiation.