state. The heat processing can be carried out in such a way that the structural integrity of the ultrathin layer stack is not substantially altered in the processed area(s).

~~The~~ An aspect of the present ~~application~~ invention therefore ~~discloses~~provides~~, *inter alia*,~~ an optical article~~s~~ that includes a retarder film providing a first light retardation and comprising an effective medium stack of contiguous ultrathin layers configured to provide an effective optical medium for visible light. The ultrathin layers are arranged into a plurality of optical repeat units each of which has an optical thickness of less than 190 nm, the ultrathin layers including different first and second ultrathin layers. The first ultrathin layers comprise a first polymer material exhibiting a first intrinsic birefringence, and the second ultrathin layers comprise a second polymer material different from the first polymer material. The retarder film also has a first absorption characteristic that is suitable to, upon exposure to a first radiant beam, absorptively heat the effective medium stack by an amount sufficient to change the first light retardation to a second light retardation, different from the first light retardation, while maintaining a structural integrity of the effective medium stack. The stack of contiguous ultrathin layers includes the first ultrathin layers alternating with the second ultrathin layers, and wherein each of the optical repeat units include one of the first ultrathin layers and one of the second ultrathin layers. The second polymer material exhibits a second intrinsic birefringence different from the first intrinsic birefringence, and the first and second ultrathin layers are configured such that upon exposure of the retarder film to a second radiant beam different from the first radiant beam, the effective medium stack is heated by an amount sufficient to change the first light retardation to a third light retardation, different from the first and second light retardations, while maintaining the structural integrity of the effective medium stack. One or both of the first and second light retardations of the optical article may be substantially attributable to corresponding light retardations of the effective optical medium, or one or both may be attributable to corresponding light retardations of the effective optical medium in combination with those of other layer(s) of the optical article, such as one or more optically thick protective boundary layer(s) and/or one or more optically thick skin layer(s).

The stack of contiguous ultrathin layers may include the first ultrathin layers alternating with the second ultrathin layers, and each of the optical repeat units may include, and may consist essentially of, one of the first ultrathin layers and one of the second ultrathin layers. The second polymer material, in some cases, is substantially isotropic.

The effective medium stack of the retarder film may in some cases exhibit no substantial form birefringence. In such cases, the retardation due to form birefringence is less than a threshold value such as 10 nanometers, or the retardation due to form birefringence is less than a given percentage, e.g. 5%, of an average out-of-plane (z-index) birefringence, e.g. as described further in connection with equations (10a) and (10b) below. Here, the reader is cautioned to not necessary

assume that just because the stack exhibits no substantial form birefringence that the stack also exhibits no birefringence at all. The stack can in all cases be characterized by effective indices nx, ny, nz along the principal x-, y-, and z-axes. The question of whether the stack exhibits any birefringence at all is answered by determining whether the effective refractive indices nx, ny, and nz are equal or substantially equal to each other. If they are substantially equal, the stack exhibits no birefringence, and otherwise the stack does exhibit birefringence. Form birefringence, if present, contributes to the value of the effective refractive index nz of the stack.

~~We also disclose~~Another aspect of the present invention provides a methods that includes providing a retarder film having a first light retardation, and exposing an area of the retarder film to a first radiant beam. The retarder film includes an effective medium stack of contiguous ultrathin layers configured to provide an effective optical medium for visible light, the ultrathin layers including different first and second ultrathin layers, the first ultrathin layers comprising a first polymer material exhibiting a first intrinsic birefringence, and the second ultrathin layers comprising a second polymer material. The ultrathin layers are arranged into a plurality of optical repeat units each of which has an optical thickness of less than 190 nm. The exposing may be carried out to absorptively heat the retarder film by an amount sufficient to change the first light retardation to a second light retardation, different from the first light retardation, in the area of exposure. The method may be carried out such that the second light retardation is greater than the first light retardation. The effective medium stack includes the first ultrathin layers alternating with the second ultrathin layers, the first polymer material exhibiting a first intrinsic birefringence, the second polymer material exhibiting a second intrinsic birefringence different from the first intrinsic birefringence, the first and second polymer materials having different melting temperatures, and wherein the exposing step is carried out to preferentially reduce intrinsic birefringence in the first ultrathin layers rather than in the second ultrathin layers. The method further comprises exposing a second area of the film to a second radiant beam, the second radiant beam being effective to substantially reduce intrinsic birefringence in both the first ultrathin layers and the second ultrathin layers to provide a third light retardation different from the first and second light retardations.

In some cases, a non-exposed area (untreated area) of the retarder film, having the first light retardation, may be a window film, and the exposed area (treated area) of the retarder film, having the second light retardation, may be a c-plate retarder. In some cases, a non-exposed area of the retarder film, having the first light retardation, may be a window film, and the exposed area of the retarder film, having the second light retardation, may be an a-plate retarder.

In some cases, the first light retardation may be an insignificant retardation for visible light, e.g., less than 20 nm over a wavelength range from 380 to 780 nm, and the second light retardation may be a significant retardation for visible light, e.g., at least 95 nm over the 380 to 780 nm wavelength range. The second light retardation may correspond to a quarter wave plate for at least one wavelength in the 380 to 780 nm wavelength range. The second light retardation may correspond to a half wave plate for at least one wavelength in the 380 to 780 nm wavelength range.

The exposing step may be carried out to provide indicia defined by one or more first areas having the first light retardation and one or more second areas having the second light retardation. The method may include attaching the retarder film to a security document. The method may

include, after the exposing step, inspecting the retarder film using at least one polarizer.The effective medium stack may include the first ultrathin layers alternating with the second ultrathin layers. The second polymer material may in some cases be isotropic, but in some cases it may exhibit a second intrinsic birefringence different from the first intrinsic birefringence, and the first and second polymer materials may have different melting temperatures. In such a case, the exposing step may be carried out to preferentially reduce intrinsic birefringence in the first ultrathin layers rather than in the second ultrathin layers. Furthermore, a second exposing step may be carried out in one or more second areas or zones of the film. In the second exposing step, the second area of the film may be exposed to a second radiant beam, the second radiant beam being effective to substantially reduce intrinsic birefringence in both the first ultrathin layers and

CLAIMS

1. An optical article, comprising:

a retarder film providing a first light retardation and comprising an effective medium stack of contiguous ultrathin layers configured to provide an effective optical medium for visible light, the ultrathin layers arranged into a plurality of optical repeat units each of which has an optical thickness of less than 190 nm, the ultrathin layers including different first and second ultrathin layers, the first ultrathin layers comprising a first polymer material exhibiting a first intrinsic birefringence, and the second ultrathin layers comprising a second polymer material;

wherein the retarder film has a first absorption characteristic suitable to, upon exposure to a first radiant beam, absorptively heat the effective medium stack by an amount sufficient to change the first light retardation to a second light retardation, different from the first light retardation, while maintaining a structural integrity of the effective medium stack~~,~~

wherein the stack of contiguous ultrathin layers includes the first ultrathin layers alternating with the second ultrathin layers, and wherein each of the optical repeat units include one of the first ultrathin layers and one of the second ultrathin layers,

wherein the second polymer material exhibits a second intrinsic birefringence different from the first intrinsic birefringence, and

wherein the first and second ultrathin layers are configured such that upon exposure of the retarder film to a second radiant beam different from the first radiant beam, the effective medium stack is heated by an amount sufficient to change the first light retardation to a third light retardation, different from the first and second light retardations, while maintaining the structural integrity of the effective medium stack.

~~2. The article of claim 1, wherein the stack of contiguous ultrathin layers includes the first ultrathin layers alternating with the second ultrathin layers, and wherein each of the optical repeat units include one of the first ultrathin layers and one of the second ultrathin layers.~~

~~3. The article of claim 2, wherein the second polymer material is substantially isotropic.~~

~~4. The article of claim 2, wherein the effective medium stack exhibits no substantial form birefringence.~~

~~5. The article of claim 2, wherein the second polymer material exhibits a second intrinsic birefringence different from the first intrinsic birefringence.~~

~~6~~2. The article of claim ~~1~~5, wherein the second intrinsic birefringence is opposite in sign relative to the first intrinsic birefringence.

~~73~~. The article of claim ~~51~~, wherein the second light retardation is greater than the first light retardation.

~~84~~. The article of claim ~~73~~, wherein the first light retardation is an insignificant retardation for visible light, the insignificant retardation being less than 20 nm over a wavelength range from 380 to 780 nm, and the second light retardation is a significant retardation for visible light, the significant retardation being at least 95 nm over the 380 to 780 nm wavelength range.

95. The article of claim 51, wherein the second polymer material has a melting temperature different from that of the first polymer material such that upon exposure of the retarder film to the first radiant beam, the absorptive heating is sufficient to change the first intrinsic birefringence of the first ultrathin layers without substantially changing the second intrinsic birefringence of the second ultrathin layers.

~~10. The article of claim 5, wherein the first and second ultrathin layers are configured such that upon exposure of the retarder film to a second radiant beam different from the first radiant beam, the effective medium stack is heated by an amount sufficient to change the first light retardation to a third light retardation, different from the first and second light retardations, while maintaining the structural integrity of the effective medium stack.~~

116. The article of claim 1, wherein the first ultrathin layers, the second ultrathin layers, or both the first and second ultrathin layers include a radiant energy absorbing agent.

127. The article of claim 1, wherein the effective medium stack comprises at least 10 contiguous ultrathin layers.

138. The article of claim 1, further comprising:

a diffuse reflective layer; and

a polarizer;

wherein the polarizer is disposed between the diffuse reflective layer and the retarder film.

149. A security document comprising the article of claim 1, wherein the retarder film comprises indicia defined by one or more first areas having the first light retardation and one or more second areas having the second light retardation.

1510. The security document of claim 149, wherein the security document is or comprises at least one of an ID document, a passport, a vehicle license plate, a product package, an identification badge, a license, a card, a pass, a label, a certificate, a bond, a title document, a negotiable instrument, and currency.

11. The article of claim 1, wherein the retarder film having the first light retardation is a first biaxial retarder film, and the second light retardation is that of a second biaxial retarder film.

12. The article of claim 1, wherein the retarder film having the first light retardation is a c-plate retarder film, and the second light retardation is that of an a-plate retarder film.

13. The article of claim 1, wherein the retarder film having the first light retardation is a biaxial retarder film, and the second light retardation is that of a c-plate retarder film or an a-plate retarder film.

14. The article of claim 1, wherein the retarder film having the first light retardation is an a-plate retarder film, and the second light retardation is that of a c-plate retarder film.

~~16~~15. A method, comprising:

providing a retarder film having a first light retardation, the retarder film comprising an effective medium stack of contiguous ultrathin layers configured to provide an effective optical medium for visible light, the ultrathin layers including different first and second ultrathin layers, the first ultrathin layers comprising a first polymer material exhibiting a first intrinsic birefringence, and the second ultrathin layers comprising a second polymer material, the ultrathin layers being arranged into a

plurality of optical repeat units each of which has an optical thickness of less than 190 nm;

exposing an area of the retarder film to a first radiant beam effective to absorptively heat the retarder film by an amount sufficient to change the first light retardation to a second light retardation, different from the first light retardation, in the area;

wherein the second light retardation is greater than the first light retardation.,

wherein the effective medium stack includes the first ultrathin layers alternating with the second ultrathin layers, the first polymer material exhibiting a first intrinsic birefringence, the second polymer material exhibiting a second intrinsic birefringence different from the first intrinsic birefringence, the first and second polymer materials having different melting temperatures, and wherein the exposing step is carried out to preferentially reduce intrinsic birefringence in the first ultrathin layers rather than in the second ultrathin layers, and

the method further comprising exposing a second area of the film to a second radiant beam, the second radiant beam being effective to substantially reduce intrinsic birefringence in both the first ultrathin layers and the second ultrathin layers to provide a third light retardation different from the first and second light retardations.

~~17. The method of claim 16, wherein the retarder film having the first light retardation is a window film, and the second light retardation is that of a c-plate retarder film.~~

~~18. The method of claim 16, wherein the retarder film having the first light retardation is a window film, and the second light retardation is that of an a-plate retarder film.~~

~~19~~16. The method of claim ~~16~~15, wherein the first light retardation is an insignificant retardation for visible light, the insignificant retardation being less than 20 nm over a wavelength range from 380 to 780 nm, and the second light retardation is a significant retardation for visible light, the significant retardation being at least 95 nm over the 380 to 780 nm wavelength range.

~~20. The method of claim 16, wherein the effective medium stack includes the first ultrathin layers alternating with the second ultrathin layers, the first polymer material exhibiting a first intrinsic birefringence, the second polymer material exhibiting a second intrinsic birefringence different from the first intrinsic birefringence, the first and second polymer materials having different melting temperatures, and wherein the exposing step is carried out to preferentially reduce intrinsic birefringence in the first ultrathin layers rather than in the second ultrathin layers.~~

~~21. The method of claim 20, further comprising:~~

~~exposing a second area of the film to a second radiant beam, the second radiant beam being effective to substantially reduce intrinsic birefringence in both the first ultrathin layers and the second ultrathin layers to provide a third light retardation different from the first and second light retardations.~~

~~22~~17. The method of claim ~~19~~16, wherein the second light retardation corresponds to a quarter wave plate for at least one wavelength in the 380 to 780 nm wavelength range.

~~23~~18. The method of claim ~~19~~16, wherein the second light retardation corresponds to a half wave plate for at least one wavelength in the 380 to 780 nm wavelength range.

2419. The method of claim 1615, wherein the exposing step is carried out to provide indicia defined by one or more first areas having the first light retardation and one or more second areas having the second light retardation, the method further comprising:

attaching the retarder film to a security document.

2520. The method of claim 2419, further comprising, after the exposing step, inspecting the retarder film using at least one polarizer.