Optical Grating

FIELD OF INVENTION

The invention relates generally to an optical grating.

BACKGROUND

It has been demonstrated that nanowire grid polarizers comprising a metal grating, traditionally fabricated on glass substrates, can also be fabricated on plastic films. Compared to glass, plastic is cheap, allows fabrication over a large area with high throughput and finds use in applications which need to be lightweight and flexible (e.g. printed electronics, wearable electronics).

For example, the publications "Large flexible nanowire grid visible polarizer made by nanoimprint lithography" (by Chen, L., Wang, J. J., Walters, F., Deng, X. G., Buonanno, M., Tai, S. & Liu, X. M. (2007) Applied Physics Letters, 90) and "Direct imprinting on a polycarbonate substrate with a compressed air press for polarizer applications" (by Lin, C. H., Lin, H. H., Chen, W. Y. & Cheng, T. C. (2011), Microelectronic Engineering, 88, 2026-2029) disclose optical element structures that have non-flat spectral response of light over a visible wavelength range. This non-flat spectral response results in an undesirable reddish artifact for plastic nanowire grid polarizer operating in transmission mode. A further discussion on the operating principle of a nanowire grid polarizer is described further below, with reference to Figure 10A.

A need therefore exists to provide an optical element and its method of fabrication that can address the undesirable attributes, such as the associated reddish artifact, of optical element structure fabricated from existing plastic nanowire grid polarizers.

SUMMARY

According to one aspect of the invention, there is provided an optical grating comprising a substrate comprising a plurality of protrusions with a space in between any two adjacent protrusions; and a cap provided on at least one of the plurality of protrusions at an end that is furthest from the substrate, wherein the cap has a higher degree of optical attenuation compared to the substrate material ~~and~~, wherein the combination of each protrusion and the respective cap thereon has a generally

symmetric cross-sectional profile, and wherein the cap is made of material that is opaque and non-reflective.

According to another aspect of the invention, there is provided a method of forming an optical grating, the method comprising providing a substrate; forming a plurality of protrusions on the substrate with a space in between any two adjacent protrusions, providing a cap on at least one of the plurality of protrusions at an end that is furthest from the substrate, wherein the cap has a higher degree of optical attenuation compared to the substrate material ~~and~~, wherein the combination of each protrusion and the respective cap thereon has a generally symmetric cross-sectional profile, and wherein the cap is made of material that is opaque and non-reflective.

BRIEF DESCRIPTION OF THE DRAWINGS

Example embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention, in which:

Figure 1A shows the cross-sectional structure of an optical grating according to a first embodiment.

Figure 1B shows the cross-sectional structure of an optical grating having a non-symmetric cross-sectional profile.

Figure 2 shows the cross-sectional structure of an optical grating according to a preferred embodiment.

Figure 3 shows a flowchart of a method to fabricate an optical grating according to the first embodiment shown in Figure 2.

Figures 4A to 4C show an exemplary process to fabricate the preferred embodiment of an optical grating directly onto a substrate, with Figure 4D providing a schematic of the fabricated optical grating.

Figure 5A shows the cross-section of a structure of an optical grating fabricated using the method described with respect to Figures 4A to 4C.

Figures 5B and 5C show the cross-section of a conventional optical grating.

Figure 6A shows a plot of the measured transmission spectrum of TM polarized light (T_{TM}) against the visible light wavelength range from 400nm to 800nm for a fabricated optical grating in accordance to the preferred embodiment and the conventional optical grating shown in Figures 5A and 5C respectively.

CLAIMS

1. An optical grating comprising

a substrate comprising

a plurality of protrusions with a space in between any two adjacent protrusions; and

a cap provided on at least one of the plurality of protrusions at an end that is furthest from the substrate, wherein the cap has a higher degree of optical attenuation compared to the substrate material ~~and~~, wherein the combination of each protrusion and the respective cap thereon has a generally symmetric cross-sectional profile, and wherein the cap is made of material that is opaque and non-reflective.

2. The optical grating of claim 1, wherein the combination of each protrusion and the respective cap thereon is generally symmetric about a longitudinal axis extending along a centre and intersecting a base of the respective protrusion.

3. The optical grating of claim 1 or 2, wherein the plurality of protrusions are arranged in an array.

4. The optical grating of any one of the preceding claims, wherein the cap provides each of the plurality of protrusions with sidewalls having a cross-sectional arc profile along at least a portion of the sidewalls

5. The optical grating of claim 4, wherein the cross-sectional arc profile of each of the sidewalls has a convex shape relative to a longitudinal axis extending along a centre and intersecting a base of the respective protrusion.

6. The optical grating of any one of the preceding claims, wherein the cap comprises different material from the substrate.

~~7. The optical grating of any one of the preceding claims, wherein the cap is opaque.~~

~~8. The optical grating of any one of the claims 1 to 7, wherein the cap comprises one or more metals.~~

~~9~~7. The optical grating of any one of the preceding claims ~~1 to 7~~, wherein the cap comprises dielectric materials with a light-absorbent additive.

~~10~~8. A method of forming an optical grating, the method comprising

providing a substrate;

forming a plurality of protrusions on the substrate with a space in between any two adjacent protrusions,

providing a cap on at least one of the plurality of protrusions at an end that is furthest from the substrate, wherein the cap has a higher degree of optical attenuation compared to the substrate material, ~~and~~ wherein the combination of each protrusion and the respective cap thereon has a generally symmetric cross-sectional profile, and wherein the cap is made of material that is opaque and non-reflective.

~~11~~9. The method of claim ~~10~~8, wherein the cap provides each of the plurality of protrusions with sidewalls having a cross-sectional arc profile along at least a portion of the sidewalls.

~~12~~10. The method of claim ~~10 8~~ or ~~11~~9, wherein the cap comprises different material from the substrate.

~~13. The method of any one of claims 10 to 12, wherein the cap is opaque.~~

~~14~~11. The method of any one of claims ~~10 8~~ to ~~13~~10, wherein the cap is provided by forming a portion of the cap on one sidewall of each protrusion and forming a remainder of the cap on an opposite sidewall of the same protrusion.

~~15~~12. The method of claim ~~14~~11, wherein forming the cap on the sidewalls comprises

tilting the substrate in a first direction; and

forming the portion of the cap on the one sidewall;

and forming the remainder of the cap on the opposite sidewalls comprises

tilting the substrate in a second direction that is opposite to the first direction; and

forming the remainder of the cap on the opposite sidewall.

~~16~~13. The method of claim ~~15~~12, wherein an angle at which the substrate is tilted in the first direction is approximately the same as angle at which the substrate is tilted in the second direction.

~~17~~14. The method of any one of claims ~~14~~ 11 to ~~16~~13, wherein the cap is formed by any one or more of the following techniques: evaporation, deposition and sputter.

~~18~~15. The method of claim ~~16~~ 13 or ~~17~~14, wherein the angle of tilt ranges from 1° to 89°.

~~19~~16. The method of any one of claims ~~10~~ 8 to ~~18~~15, wherein the substrate is fabricated from flexible material.

~~20~~17. The method of any one of claims ~~10~~ 8 to ~~19~~16, wherein the substrate comprises any one or more of the following materials: plastic, polymethylmethacrylate, polycarbonate and polyethylene.

~~21~~18. The method of any one of claims ~~10~~ 8 to ~~20~~17, wherein the plurality of protrusions is formed by any one or more of the following techniques: imprinting and nanopatterning.

~~22~~19. The method of any one of claims ~~10~~ 8 to ~~21~~18, wherein the formation of the plurality of protrusions and the provision of the cap is performed in an integrated system.

~~23~~20. An auto-stereoscopic display comprising the optical grating of any one of claims 1 to ~~9~~7.

~~24~~21. An optical film comprising the optical grating of any one of claims 1 to ~~9~~7.