

FLASH PHOTOGRAPHY APPARATUS AND METHOD OF MANUFACTURING THEREOF

Technical Field

5 The present disclosure relates generally to a flash photography apparatus and a method of manufacturing thereof. More particularly, embodiments of the present disclosure are directed an apparatus including a plurality of lens provided over a plurality of light sources provided circumferentially about a camera aperture of an image capture device. Methods of manufacturing are also described in the present disclosure as to the provision of a lens
10 assembly for such flash photography apparatus.

Background

Handheld cameras, or point and shoot cameras, provide much portability and convenience for everyday users and enthusiasts who do not have to worry too much about the advanced technicalities involved in acquiring a perfect shot, but have technology and accessibility in a
15 small device to capture an image quickly.

Flash photography involves the provision of a light source for such that a target is sufficiently illuminated to obtain an image capture. Whether with film exposure or a digital image sensor, the amount of light provided significantly affects the resultant image captured. Too much light and the picture is overexposed and excessively bright; too little light and the picture is
20 underexposed and details cannot be made out in the darkness of the picture.

Further, mobile phones have made great ingress into the area of portable photography, allowing smartphone users the convenience of whipping out their phone cameras to take pictures of encountered events or anything else that captures their fancy.

Point and shoot cameras and mobile phone cameras are usually provided with in-built camera
25 flash apparatus for the provision of sufficient illumination in the taking of pictures. Such flash apparatus are typically provided at a top corner, usually the left corner, of the point and shoot handheld camera. For mobile phones, a small flash is provided on a side of the camera aperture on the handheld device or the mobile phone camera. However, such side located flashes are displaced from the center of the camera aperture, which may lead to illumination

projecting on a target that leads to a slight offset shadow being captured with the image of the target. Such shadows are typically not desirable in pictures that are taken.

Summary

According to an aspect of the present disclosure, there is provided a flash photography
5 apparatus for use with an image capture device, comprising: a plurality of light sources
provided circumferentially about a camera aperture of the image capture device; a plurality of
lens provided over the plurality of light sources to affect the projection of light generated
from the plurality of light sources, each of the plurality of lens comprising a Fresnel lens
formation provided over one of the plurality of light sources, the Fresnel lens formation
10 comprising: a plurality of curvilinear elongate raised prisms provided on a lens base plane,
each prism provided with an angular flat surface for the refraction of light generated by the
one of the plurality of light sources, each of the plurality of curvilinear elongate raised prisms
comprising a first end extending distally to a curved apex and towards a second end at which
the prism terminates, the prism forming a U-shaped structure, and where the first ends and
15 the second ends of the plurality of curvilinear elongate raised prisms are directed towards the
camera aperture.

Brief description of drawings

Embodiments of the present disclosure are explained, by way of example, and with reference
to the accompanying drawings. It is to be noted that the appended drawings illustrate only
20 examples of embodiments of this disclosure and are therefore not to be considered limiting of
its scope, for the disclosure may admit to other equally effective embodiments.

FIG. 1 illustrates a handheld camera with a flash photography apparatus according to an
embodiment of the present disclosure.

FIG. 2a illustrates a magnified cut-out of the light source and corresponding lens of FIG. 1.

25 FIG. 2b illustrates a cross-sectional view of the light source and corresponding lens of FIG.
2a.

FIG. 3a illustrates a front face of a mobile telephone with a built-in camera and a flash
photography apparatus according to another embodiment of the present disclosure.

FIG. 3b illustrates a rear view of the mobile telephone of FIG. 3a.

FIG. 4a illustrates a close up view of a flash photography apparatus according to an embodiment.

FIG. 4b illustrates a cross-sectional view of the camera and flash apparatus of FIG. 4a.

5 FIG. 5a-f illustrate a plurality of lens arrangements according to various embodiments of the present disclosure.

FIG. 6 provides a block diagram of a method of manufacturing according to an embodiment of the present disclosure.

Detailed Description

10 In the following, reference is made to embodiments of the disclosure. However, it should be understood that the disclosure is not limited to specific described embodiments. Instead, any combination of the following features and elements, whether related to different embodiments or not, is contemplated to implement and practice the disclosure.

Furthermore, in various embodiments the disclosure provides numerous advantages over the
15 prior art. However, although embodiments of the disclosure may achieve advantages over other possible solutions and/or over the prior art, whether or not a particular advantage is achieved by a given embodiment is not limiting of the disclosure. Thus, the following aspects, features, embodiments and advantages are merely illustrative and are not considered elements or limitations of the appended claims except where explicitly recited in a claim(s).

20 Likewise, any reference to "the invention" shall not be construed as a generalization of any inventive subject matter disclosed herein and shall not be considered to be an element or limitation of the appended claims except where explicitly recited in a claim(s).

According to an aspect of the present disclosure, there is provided a flash photography apparatus for use with an image capture device, comprising: a plurality of light sources
25 provided circumferentially about a camera aperture of the image capture device; a plurality of lens provided over the plurality of light sources to affect the projection of light generated from the plurality of light sources, each of the plurality of lens comprising a Fresnel lens formation provided over one of the plurality of light sources, the Fresnel lens formation comprising: a plurality of curvilinear elongate raised prisms provided on a lens base plane,

each prism provided with an angular flat surface for the refraction of light generated by the one of the plurality of light sources, each of the plurality of curvilinear elongate raised prisms comprising a first end extending distally to a curved apex and towards a second end at which the prism terminates, the prism forming a U-shaped structure, and where the first ends and
5 the second ends of the plurality of curvilinear elongate raised prisms are directed towards the camera aperture.

Such an apparatus can provide an image capture device with a capability of providing sufficient illumination for flash photography, and which limits an adversely effect on a captured image by reducing offset shadowing. Further, the provision of a plurality of light
10 sources about an aperture of a capture device allows the generation of a stronger and focused illumination, whilst at the same time providing peripheral illumination, of the photographic target.

The present apparatus, in particular the plurality of U-shaped curvilinear elongate raised prisms in the Fresnel lens formation, allows for the refraction and direction of more focused
15 light beams onto the intended photographic target. The lens allow a portion of generated light from the plurality of light sources to be unaffectedly directed towards the target, and disperses another portion of generated light away from the target for peripheral illumination.

According to an embodiment, the plurality of curvilinear elongate raised prisms comprise a first prism forming a U-shaped structure and a second prism forming a similar U-shaped
20 structure enlarged and substantially encompassing the first prism.

According to an embodiment, the second prism is parallel to the first prism.

According to an embodiment, the plurality of curvilinear elongate raised prisms comprise angular flat surfaces of varying angles.

According to an embodiment, the angles of the angular flat surfaces of the plurality of
25 curvilinear elongate raised prisms increasingly vary based on a distance to the one of the plurality of light sources.

According to an embodiment, the plurality of curvilinear elongate raised prisms comprise at least three curvilinear elongate raised prisms.

According to an embodiment, the plurality of light sources comprise any from two to eight light sources, each with an overlaid lens.

According to an embodiment, the Fresnel lens formations of the plurality of lens comprise the same number of curvilinear elongate raised prisms.

- 5 According to an embodiment, the light source is any of a spot LED and a U-shaped LED.

According to a second aspect of the present disclosure, there is provided a method of manufacturing a lens for use in a flash photography apparatus for an image capture device, the method comprising: machining a blank with a computer numerical control (CNC) machine tool to obtain a master, the master machined to provide a structural reproduction of a
10 Fresnel lens formation, the Fresnel lens formation comprising: a plurality of curvilinear elongate raised prisms provided on a lens base plane, each prism provided with an angular flat surface for the refraction of light generated by a light sources, each of the plurality of curvilinear elongate raised prisms comprising a first end extending distally to a curved apex and towards a second end at which the prism terminates, the prism forming a U-shaped
15 structure; carrying out a nickel electroforming process in allowing a nickel deposit to build up over the master during the nickel electroforming process; separating the deposited nickel from the master after the nickel electroforming process to obtain an insert for a mold; loading the insert into the mold; and injecting a molten solid into the mold and allowing the molten solid to harden and take the shape of the insert within the mold in forming a lens with a
20 Fresnel lens formation.

The provision of such a method of manufacturing provides an advantageous and cost-effective way of fabricating such lens in use in image capture devices. By creating a master via CNC tooling, and then forming an insert via electroforming, a relatively accurate lens mold can be produced. Further, the electroforming process provides an extremely cost-
25 effective way for multiple inserts to be formed for provision into a mold.

This is in comparison to an industry standard of using diamond tooling in obtaining molds for lens manufacturing and replication. Diamond tooling provides excellent accuracy when producing circular and symmetrical features, as a diamond cutter is provided to plunge into and cut into a blank while the blank is rotating. However, such a process is prohibitively
30 expensive, especially when a plurality of separate formations is required in a mold. For example, to carry out four iterations of diamond tooling to obtain four similar inserts for a

mold might cost about US\$16k (where each insert costs about US\$4k), while carrying out a method of manufacturing according to the present disclosure to obtain a single insert with four lens with Fresnel formations might only cost US\$5k.

5 According to an embodiment, the method further comprises carrying out a number of iterations of the nickel electroforming process to obtain a plurality of inserts, wherein the plurality of inserts are loaded into the mold for forming a lens with a plurality of Fresnel lens formations.

According to an embodiment, the method comprising carrying out the nickel electroforming process on a plurality of masters, so as to obtain a plurality of different inserts.

10 According to an embodiment, the blank comprises any one of stainless steel, silver, metallic alloy, plastic, glass, and wood.

According to an embodiment, the molten solid is any of plastics, glass, and polymer compound.

15 In the present disclosure, depiction of a given element or consideration or use of a particular element number in a particular FIG. or a reference thereto in corresponding descriptive material can encompass the same, an equivalent, or an analogous element or element number identified in another FIG. or descriptive material associated therewith. The use of “/” herein means “and / or” unless specifically indicated otherwise.

20 As used herein, the term “set” corresponds to or is defined as a non-empty finite organization of elements that mathematically exhibits a cardinality of at least 1 (i.e., a set as defined herein can correspond to a singlet or single element set, or a multiple element set), in accordance with known mathematical definitions (for instance, in a manner corresponding to that described in *An Introduction to Mathematical Reasoning: Numbers, Sets, and Functions*, “Chapter 11: Properties of Finite Sets” (e.g., as indicated on p. 140), by Peter J. Eccles, 25 Cambridge University Press (1998)). In general, an element of a set can include or be a system, an apparatus, a device, a structure, a structural feature, an object, a process, a physical parameter, or a value depending upon the type of set under consideration.

The terms “group” and “gang” as used herein correspond to or are defined as an organization of two or more elements, e.g., a group or gang can be defined as a set having at least two

components. The term “subgroup” as used herein corresponds to or is defined as a portion of a group or gang, and hence corresponds to or can be defined as an organization of at least one element, e.g., a subgroup can be defined as a set having at least one component.

FIG. 1 illustrates a handheld camera with a flash photography apparatus according to an embodiment of the present disclosure. Camera 100 includes a camera shutter 104 provided roughly in the center of a camera body 102, the camera body 102 housing electronic circuitry, mechanical functionality and optical capabilities for the operation of an image capture device. In the present embodiment, the camera 100 is a digital camera with advanced processing capabilities to assist a user with image capturing. In other embodiments, the camera may be a manual camera with no electronic functions and instead captures image on a photographic film.

Camera shutter 104 includes a mechanically actuated feature of opening and shutting two opposing leaf panels 106, 108 to reveal a camera aperture 110 provided together with photography optics for the capture of light rays resulting in an image capture, the image captured on an internally mounted Complementary Metal-oxide-semiconductor (CMOS) image sensor. Alternatively the image is captured on photographic film.

In the camera 100 of the present embodiment, adequate controls are also provided for a user to adapt a plurality of functions pertaining to the capture of a photographic image, for example, aperture shutter speed, exposure time, adjustable focus lens, image sensor light sensitivity, etc. This allows the configuration of the camera 100 with respect to the plurality of functions by the user, such as to capture an image in accordance to a user’s preferences and settings. In the embodiment, a function is also provided as to adjustment of flash illumination characteristics, such as flash duration, flash intensity, flash patterns, if any.

Camera 100 is provided with flash photography apparatus 120 for the provision of illumination in the capture of an image including a photography target. Flash photography apparatus, in the present embodiment, is a ring-shaped attachment 122, arranged to circumscribe the camera shutter 104 and the camera aperture 110 of the camera. The ring-shaped attachment 122 is arranged for removable mounting on the camera body 102, which allows for the ring-shaped attachment to be decoupled and another ring-shaped attachment to be inserted into a mechanical coupling (not shown) arranged for keeping the ring-shaped attachment 122 or another similar attachment in secure coupling with the camera body.

Ring-shaped attachment 122 houses a plurality of light sources 124, 126, 128, 130 provided circumferentially about the camera shutter 104 and camera aperture 110 of the camera 100. In the embodiment, four light sources 124, 126, 128, 130 are provided for photographic target illumination, but in other embodiments, other numbers of light sources may be provided
5 circumferentially about the camera aperture 110 to provide such a function. In the embodiment, the light sources 124, 126, 128, 130 are provided in equal spatial separation about the ring-shaped attachment 122. Such an arrangement is preferable in order to provide optimal distribution of illumination originating from the light sources, but other arrangements may be possible in other scenarios, for example, overloading on one side when a separate
10 flash attachment is provided on the other side of the camera aperture.

Light source 124 is provided in a D-shaped structure 132 set into the ring-shaped attachment 122. D-shaped structure 132 houses both the actual light source 124, which is electrically coupled through the ring-shaped attachment 122 to the internal electrical circuitry within the camera housing 102, as well as a lens 134 provided over the light source 124. The lens 134
15 provides at least two functions – the designed dispersal of generated illumination from the light source 124, as well as the protection of light source 124 from the elements and other environmental factors.

In the embodiment, the lens 134 includes a Fresnel lens formation 136. Fresnel lens provide a more efficient capture of generated light and directs the illumination accordingly, with
20 respect to a plurality of refractive planes provided in the Fresnel lens formation 136. The Fresnel lens formation 136 also allows use within a short focal length of the light source 124, and the material of the lens as well as the angle incidence of generated illumination provide a resultant direction of the generated illumination by way of refraction of generated illumination through designed angular structures as provided in the Fresnel lens formation
25 136.

FIG. 2a illustrates a magnified cut-out of the light source and corresponding lens of FIG. 1. In the embodiment, light source 124 is housed within the D-shaped structure 132, and a set of lens 134 is placed over the light source 124. Lens 134 includes a Fresnel lens formation 136. In the embodiment, the Fresnel lens formation 136 comprises a plurality of curvilinear elongate raised prisms 138, 140, 142 provided on a base plane 144 of the lens 134. First
30 curvilinear elongate raised prism 138 includes a first end 138a extending distally to a curved apex 138b and then back toward a second end 138c at which the prism terminates. In being

formed as such, the prism 138 is provided as a U-shaped structure. Further, in the U-shaped structure of prism 138, first end 138a and second end 138c are directed towards the camera aperture 110. In other words, the U-shaped structure of the prism has its two ends 138a and 138c provided closest to the aperture 110, while the apex 138b of the prism is provided
5 furthest from the aperture 110.

Second curvilinear elongate raised prism 140 is provided with a U-shaped structure similar to that of first curvilinear elongate raised prism 138, but enlarged and substantially encompassing the first prism 138. The second prism 140 is also provided parallel to the first prism 138. The function of providing a plurality of prisms 138, 140, 142 in parallel with each
10 other and progressively further from the light source 124 provides for more capture of the generated illumination to be redirected for designed lighting of a photographic subject during flash photography.

FIG. 2b illustrates a cross-sectional view of the light source and corresponding lens of FIG. 2a. Line A-A is provided across a mid-line of the Fresnel lens formation 136 of the lens 134, and a cross-sectional view is provided thereafter for reference. Light source 124 is provided
15 in the present embodiment as a U-shaped light source, and mounted upon light receptacle 146. Light receptacle 146 is a provided base for the arranged to receive a light source 124 and to operate the light source 124. The light receptacle 146 includes electrical circuitry as part of the ring-shaped attachment 122 and electrically couples the light source 124 through the ring-
20 shaped attachment 122 to an electrical circuit in the camera body 102, such that the light source 124 can thus be controlled or activated by a central processing system within the camera body 102.

The cross-sectional view FIG. 2b also illustrates clearly the side profile structure of the curvilinear elongate raised prisms 138, 140 and 142. Prism 142 is raised to provide an
25 angular side surface 146, and an elevation side surface 148. Angular side surface 146 is arranged to receive generated illumination, depicted and summarized as a singular ray 150 originating from the light source 124 and contacting the angular side surface 146, and is refracted thereafter through the prism 142, for diffusing the illumination from the light source 124.

Further, it may be noted that the angles of the angular side surfaces of the prisms 138, 140, and 142 increasingly vary based on the distance to the light source 124. The first prism 138
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includes a lower elevation side surface 148 and thus a low angle of the angular side surface 146. The second prism 140 includes a higher elevation side surface 148, as compared with the first prism 138, and thus an increased angle in the angular side surface 146 of the second prism. In the third prism 142 in parallel with the first and second prisms, 138, 140, while
5 more distanced from the light source 124, the provided angle of the angular side surface 146 is increased, so as to provide a more pronounced area for receiving generated illumination.

In use, the Fresnel lens formation 136 of the present embodiment provides an outward dispersion of light away from the camera aperture 110, by way of the plurality of angular side surfaces of each curvilinear elongate raised prism 138, 149, 142. An example singular ray
10 150 is shown arriving at angular side surface 146 of third prism 142. The refractive index of the prism 142 is higher than that of air in which the ray 150 travels in from the light source 124 to the prism 142. As such light bends toward the normal to the angular surface 146. A resultant ray 152 can be seen emerging from the lens 134 in an outward direction from the light source 124.

Returning back to FIG. 1, it is noted that the plurality of light sources 124, 126, 128, 130 are similarly formed, each including a D-shaped structure housing the light source and a lens. The lens including a Fresnel lens formation which includes a plurality of U-shaped elongate curvilinear raised prisms provided on a lens base plane, the prisms causing a diffusion of light
15 outwards from the light sources 124, 126, 128 and 130. The D-shaped structures of the light
20 sources 124, 126, 128, 130 are directed towards the camera aperture 110, and the apex of the structure located further from the aperture 110.

In use, the processing system on the camera 100 activates all light sources 124, 126, 128, 130 on the ring-shaped attachment 122 circumscribing the camera aperture 110 in order for the camera 100 to capture an image with flash photography. As mentioned, various illumination
25 characteristics may be varied to provide user configuration in obtaining a user-preferred picture. In an embodiment, a light sensor 112 is provided on the front of the camera, on the camera body 102, which is able to determine the amount of light and automatically generates instruction through the processing system to control the flash photography apparatus 100 in providing illumination for an image to be captured by the camera 100.

FIG. 3a illustrates a front face of a mobile telephone with a built-in camera and a flash
30 photography apparatus according to another embodiment of the present disclosure. Mobile

telephone 200 is classified as a smartphone in which an on-board processor and memory run an operating system on which the phone 200 operates. The operating system of the phone 200 includes a graphical user interface (GUI) 202 generated by the operating system of the phone 200 and output on a display 206 on the front face 204 of the phone 200. A user of the phone
5 200 manipulates the phone through the GUI 202, by which a multitude of available applications may be accessed for use on the phone 200.

One of the most popular applications on the mobile telephone 200 is the use of an on-board camera 210. Present day mobile telephones provide processing power, image capture capability and network connectivity – a well-integrated combination which supports a user's
10 desire for regular social networking updates. For example, it is very desirable to be able capture an image with the on-board camera 210, apply post-processing to the captured image through an application on the phone 200, and post the user's captured and edited picture on the user's social networking account. All which can be done on and through the phone 200.

FIG. 3b illustrates a rear view of the mobile telephone 200 of FIG. 3a. On the rear face 208 of
15 the phone 200, there is provided a camera 210 for capturing an image. No shutter is provided for the mobile phone camera 210, and camera aperture 212 is provided for receiving reflected light rays into a CMOS sensor provided within the phone 200 for the capturing of an image and the storage of that image into memory on the phone 200.

The camera 210 is provided with a flash photography apparatus 220, including a plurality of
20 light sources 222, 224, 226, 228 provided circumferentially about the camera aperture 212. In the present embodiment, the light sources 222, 224, 226, 228 are installed by the manufacturer of the phone 200 during assembly of the phone. No removably mounted ring attachment is provided for receiving the light sources 222, 224, 226, 228, and the flash photography apparatus 220 of the present embodiment is not meant to be removeable or
25 replaced.

In the embodiment, the light sources 222, 224, 226, 228 are provided in equal spatial separation about the circumference of the camera aperture 212. Further, each light source is also provided and installed in a D-shaped structure 230 which houses the light source 224 and which electrically couples the light source 224 to the internal circuitry of the phone 200. Lens
30 232 is provided with the D-shaped structure 230 and overlaid the light source 224.

The flash photography apparatus 220 for the mobile phone 200 according to the present embodiment, in particular the D-shaped structure 230 and elements comprised within, is generally equivalent in terms of design, structure and functionality to the previously described embodiment for which a flash photography apparatus 120 is provided for camera 100. Further, it is noted that flash photography apparatus 220 is not limited by application size, for example, a smaller size might be needed in a mobile phone with small dimensions, while in a tablet computer where abundant rear surface area provides no limitation on size, a larger flash photography apparatus might be provided to improve flash distribution.

FIG. 4a illustrates a close up view of a flash photography apparatus according to an embodiment. Camera 300 includes a camera aperture 302 by which light waves are received to a CMOS sensor in order to capture a photographic image. Camera 300 is provided for use on a mobile telephone, but may also be included in other applications. In this embodiment, flash photography apparatus 308 is provided and two light sources 310, 312, are provided about the circumference of the camera 300 and camera aperture 302. In particular the light sources 310, 312 are provided on opposite ends of the camera 300.

Similarly, each light source 310, 312 is provided and installed in a D-shaped structure 314 which houses the light source 310 and which electrically couples the light source 310 to the internal circuitry of the camera 300. Lens 316 is provided with the D-shaped structure 314 and overlaid the light source 310. Fresnel lens formation 318 is provided, and includes a plurality of curvilinear elongate raised prisms 320, 322, 324, which range in size from a smallest 320 being internal to the Fresnel lens formation 318, and being encompassed by other raised prisms 322, 324, and increasing in size with each following prism. Further, it is noted that the angles of the angular flat surfaces of the plurality of curvilinear elongate raised prisms 320, 322, 324 increasingly vary from the inner-most prism 320 to the outer-most prism 324.

In the present embodiment, the light sources 310, 312 are spot LED sources. Spot LEDs provide general illumination and are designed for providing illumination in all directions, without any specific guidance. The lens 316, in particular, the Fresnel lens formation 318 provided on the lens 316, provides guidance for generated illumination from the light source 310 such that light is directionally diffused and focused, at the same time.

FIG. 4b illustrates a cross-sectional view of the camera and flash apparatus of FIG. 4a. Camera aperture 302 is shown in more detail as providing a pathway for light to be received by a CMOS sensor (not shown). A set of focusing lens 304 provide limited zoom and focus capability for the camera 300. The camera aperture 302 is flanked by light sources 310 and 312. Lens 316, provided with Fresnel lens formation 318, provides a directed diffusion of illumination as provided by the light sources 310, 312.

In particular, in accordance with the cross-sectional cut-out of the flash photography apparatus 308, it may be noted that along this transversal axis, propagation of light is left relatively unaffected in the straight sections of the curvilinear elongate raised prisms 320, 322, 324 of the Fresnel lens formation 318. At the curved portions, rays of light as generated by the light source 310 are incident on the angular side surfaces of the raised prisms which results in light being diverted out and away from the camera aperture 302.

In order to provide an understanding of how the Fresnel lens formation 318 actually functions together with the light sources 310 and 312, a luminance meter is used to provide a measurement in determining the actual illumination established by the flash photography apparatus.

In other embodiments, the plurality of curvilinear elongate prisms in a Fresnel lens formation according to the present disclosure, could be any one of three prisms, four prisms, five prisms, six prisms or any other number of prisms in parallel, and having a varying angle of the side surface of the prism.

In other embodiment, the plurality of light sources with a complementary lens including a Fresnel lens formation could be any one of two light sources, three light sources, four light sources, five light sources, or any other number of light sources, the light sources circumferentially provided about a camera and a camera aperture.

FIG. 5a-f illustrate a plurality of lens arrangements according to various embodiments of the present disclosure. Variations in the number of lens for use with a light source, the number of prisms in a Fresnel lens formation for a lens, and the shape of the lens arrangement are all possible, according to the various embodiments.

FIG. 5a illustrates a lens arrangement 510 according to an embodiment of the disclosure. Lens arrangement 510 includes four lens, each for providing over a light source. Each lens is provided with three curvilinear elongate raised prisms forming a U-shaped structure.

FIG. 5b illustrates a lens arrangement 520 according to an embodiment of the disclosure.

- 5 Lens arrangement 520 includes four lens, each for providing over a light source. Each lens is provided with six curvilinear elongate raised prisms forming a U-shaped structure.

FIG. 5c illustrates a lens arrangement 530 according to an embodiment of the disclosure. Lens arrangement 530 includes two lens, each for providing over a light source. Each lens is provided with four curvilinear elongate raised prisms forming a U-shaped structure.

- 10 FIG. 5d illustrates a lens arrangement 540 according to an embodiment of the disclosure. Lens arrangement 540 includes three lens, each for providing over a light source. Each lens is provided with three curvilinear elongate raised prisms forming a U-shaped structure.

FIG. 5e illustrates a lens arrangement 550 according to an embodiment of the disclosure. Lens arrangement 550 includes five lens, each for providing over a light source. Each lens is provided with three curvilinear elongate raised prisms forming a U-shaped structure. Notably, lens 550 is also provided with an external shape in accordance to that as formed by the Fresnel lens formations of each of the five lens. Accordingly, other shapes of the lens arrangement including a plurality of lens for providing over a plurality of light sources are possible, and could be determined with respect to the number of lens provided.

- 20 FIG. 5f illustrates a lens arrangement 560 according to an embodiment of the disclosure. Lens arrangement 560 includes six lens, each for providing over a light source. Each lens is provided with three curvilinear elongate raised prisms forming a U-shaped structure.

- According to a second aspect of the present disclosure, there is provided a method of manufacturing a lens for use in a flash photography apparatus for an image capture device. In the embodiment, a computer numerical control (CNC) machine tool is provided to machine a blank in obtaining a master. The CNC machining process is fully automated and highly accurate. A structural drawing of a lens including a Fresnel lens formation is created as a computer aided design drawing and verified and optimized for CNC machining. The CNC process utilizes various tools and methods to physically reproduce the structural drawing by way of machining a blank in cutting, grinding, and smoothing to obtain the master. In the
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CNC process, the blank is held in situ while the automated machining tools carry out the CNC based machining. It is of note that the machined master is of the exact physical representation as a desired lens of the present embodiment. In the embodiment, the blank could be any of stainless steel, silver, metallic alloy, plastic, glass, and wood.

- 5 After the forming of the master, the master is utilized as a mandrel in carrying a nickel electroforming process. In this process, nickel is electrodeposited on the master in creating a nickel electroform. Two DC-connected electrodes are provided for submergence in an electrolytic bath containing metallic salts. The master is provided as a negative cathode, and a nickel metal source is provided as a positive anode. In running an electric current to the
- 10 cathode and the anode, the positively charged nickel metal source is broken down and ionized in the electrolyte bath ($\text{Ni}^{2+} + 2\text{e}^-$). The positively charged Ni^{2+} ions are then attracted to the negatively charged master and a build-up of nickel metal is achieved evenly and all over the surface of the master. In the nickel electroforming process, a high degree of accuracy can be obtained in reproducing the shape and surface detail of the master.
- 15 After a predetermined time, in consideration of the nickel deposition rate of the electroform setup, a sufficiently thick layer of nickel is formed over the master. A separation process, comprising a pulling force used to separate the master and the nickel formed insert, is then carried out to remove the nickel electroform from the master. This nickel electroform becomes the desired insert for a molding process in forming a lens according to an
- 20 embodiment. Such a process is well known in the art of nickel electroforming and is not further elaborated in this disclosure.

The insert is then loaded into a mold and the mold injected with a molten solid. The molten solid is then allowed to harden, which causes the hardened molten solid to take the form of the shape of the insert within the mold, forming a lens with a Fresnel lens formation. In the

25 embodiment, the molten solid is any of plastics, being polycarbonate (PC) or polymethylmethacrylate (PMMA), and polymer compound.

In providing a lens arrangement with a plurality of lens each including a Fresnel lens formation, assuming each lens includes the same Fresnel lens formation, the creation of a single master is sufficient for the molding process in forming such a lens arrangement with a

30 plurality of lens. The machined master is put through a number of iterations of the nickel electroforming process, and a number of nickel electroforms are obtained as inserts. The

number of inserts is then loaded onto a mold for forming such a lens arrangement with a plurality of lens.

If different lens having different Fresnel lens formations are desired, multiple masters can be machined with the correct physical specifications of the desired lens with the desired Fresnel lens formation. The multiple number of masters can then undergo a nickel electroform process to obtain the desired inserts for use in injection molding for formation of a lens arrangement.

FIG. 6 provides a block diagram of a method of manufacturing according to an embodiment of the present disclosure. Prior to carrying out the manufacture of the flash lens, a suitable flash lens design and type of LED to provide the flash illumination is selected. Engineers carrying out such selection typically also proof the design by running the selected designs through computer-aided simulations for verification of operating efficiency. Refinements to the design may be carried out and the verification process reiterated in order to arrive at a refined design for production.

Block diagram 600 provides a flow diagram of a method of manufacturing. In block 610, a blank is machined, preferably through a CNC machining process, in order to obtain a master. In block 620, a nickel electroform process is carried out on the master. This creates a layer of nickel to be deposited on the master, as carried out inside an electrolytic bath. In block 630, the deposited nickel is separated from the master in order to obtain an insert. In order to assess the quality and integrity of the inserts, an additional process of a surface finishing inspection may also be carried out. The process should ensure that the insert is manufactured according to the predetermined design in size, shape, and quality.

Concurrently to the present manufacture of the insert, a mold base and corresponding components are also fabricated. Such fabrication of the mold and components may be according to any of the present methods in the state of the art.

In block 640, the insert is loaded into the mold base. In block 650, molten solid is injected into the mold and allowed to harden, to form a lens according to an embodiment of the present disclosure.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with existing flash photography

apparatus for use with image capture devices. While features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects, and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed systems, components, processes, or alternatives thereof, may be desirably combined into other different systems, components, processes, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope and spirit of the present disclosure. Such different systems, components, processes and/or modifications, alterations, and/or improvements are encompassed by the following claims.

Claims

1. A flash photography apparatus for use with an image capture device, comprising:
a plurality of light sources provided circumferentially about a camera aperture of the image capture device;
5 a plurality of lens provided over the plurality of light sources to affect the projection of light generated from the plurality of light sources, each of the plurality of lens comprising a Fresnel lens formation provided over one of the plurality of light sources, the Fresnel lens formation comprising:
a plurality of curvilinear elongate raised prisms provided on a lens base plane,
10 each prism provided with an angular flat surface for the refraction of light generated by the one of the plurality of light sources, each of the plurality of curvilinear elongate raised prisms comprising a first end extending distally to a curved apex and towards a second end at which the prism terminates, the prism forming a U-shaped structure, and where the first ends and the second ends of the plurality of curvilinear elongate raised prisms are directed towards the
15 camera aperture.
2. A flash photography apparatus according to claim 1, wherein the plurality of curvilinear elongate raised prisms comprise a first prism forming a U-shaped structure and a second prism forming a similar U-shaped structure enlarged and substantially encompassing the first
20 prism.
3. A flash photography apparatus according to claim 2, wherein the second prism is parallel to the first prism.
- 25 4. A flash photography apparatus according to any of the preceding claims, wherein the plurality of curvilinear elongate raised prisms comprise angular flat surfaces of varying angles.
5. A flash photography apparatus according to claim 4, wherein the angles of the angular
30 flat surfaces of the plurality of curvilinear elongate raised prisms increasingly vary based on a distance to the one of the plurality of light sources.

6. A flash photography apparatus according to any of the preceding claims, wherein the plurality of curvilinear elongate raised prisms comprise at least three curvilinear elongate raised prisms.
- 5 7. A flash photography apparatus according to any of the preceding claims, wherein the plurality of light sources comprise any from two to eight light sources, each with an overlaid lens.
8. A flash photography apparatus according to any of the preceding claims, wherein the
10 Fresnel lens formations of the plurality of lens comprise the same number of curvilinear elongate raised prisms.
9. A flash photography apparatus according to any of the preceding claims, wherein the light source is any of a spot LED and a U-shaped LED.
- 15 10. A method of manufacturing a lens for use in a flash photography apparatus for an image capture device, comprising:
- machining a blank with a computer numerical control (CNC) machine tool to obtain a master, the master machined to provide a structural reproduction of a Fresnel lens formation,
20 the Fresnel lens formation comprising:
- a plurality of curvilinear elongate raised prisms provided on a lens base plane, each prism provided with an angular flat surface for the refraction of light generated by a light sources, each of the plurality of curvilinear elongate raised prisms comprising a first end extending distally to a curved apex and towards a second end at which the prism terminates,
25 the prism forming a U-shaped structure;
- carrying out a nickel electroforming process in allowing a nickel deposit to build up over the master during the nickel electroforming process;
- separating the deposited nickel from the master after the nickel electroforming process to obtain an insert for a mold;
- 30 loading the insert into the mold; and
- injecting a molten solid into the mold and allowing the molten solid to harden and take the shape of the insert within the mold in forming a lens with a Fresnel lens formation.

11. A method of manufacturing according to claim 10, further comprising carrying out a number of iterations of the nickel electroforming process to obtain a plurality of inserts, wherein the plurality of inserts are loaded into the mold for forming a lens with a plurality of Fresnel lens formations.

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12. A method of manufacturing according to claim 10, comprising carrying out the nickel electroforming process on a plurality of masters, so as to obtain a plurality of different inserts.

10 13. A method of manufacturing according to any of claims 10 to 12, wherein the blank comprises any one of stainless steel, silver, metallic alloy, plastic, glass, and wood.

14. A method of manufacturing according to any of claims 10 to 13, wherein the molten solid is any of plastics, glass, and polymer compound.

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