[005] It will be desirable to provide a headlamp with increased LESD unit carrying capacity, with an efficient thermal management design as well as increased functionality, such as selective LESD illumination, within a single lighting device.

Summary of Invention

[006] In one aspect, there is provided a lighting device for a vehicle headlamp, comprising: a single, continuous strip of flexible circuit comprising a plurality of light emitting semiconductor devices (LESDs), a frame supporting the flexible circuit, the frame comprising a plurality of mounting surfaces for mounting the LESDs onto the frame, the flexible circuit having a shape configured to extend over each mounting surface, and the LESDs having a layout on the flexible circuit configured to position one or more LESDs over each mounting surface. The frame comprises a complex structure comprising any of a circular member, an elongated support member connected to and extending from a base, a semi-circular member connected to a central member and rear sleeves connecting the central member to the base, that provides the plurality of mounting surfaces on which to mount the LESDs, as well as heat sink fins formed on the frame to assist with cooling, the mounting surfaces comprising a top, front facing, bottom or lateral side mounting surfaces. The layout of the LESDs is configured to position any of a first, second, third or fourth groups of LESDs on, respectively, the top, front facing, bottom or lateral side mounting surfaces, the LESDs capable of providing a high beam, low beam, or day time running light source. Each LESD group is electrically connected to a separate circuit trace in the flexible circuit so that each LESD group is independently operable from other LESD groups for selective LESD illumination, to enable switching on and off of the high beam, low beam or daytime running light sources, or combinations thereof, within a single lighting device.

[007] In another aspect, a vehicle headlamp is provided, comprising a light reflector, a lens fitted over the light reflector, and a lighting device arranged between the light reflector and the lens via an aperture in the light reflector, the lighting device comprising: a single, continuous strip of flexible circuit comprising a plurality of light emitting semiconductor devices (LESDs), a frame supporting the flexible circuit, the frame comprising a plurality of mounting surfaces for mounting the LESDs onto the frame, the flexible circuit having a shape configured to extend over each mounting surface, and the LESDs having a layout on the flexible circuit configured to position one or more LESDs over each mounting surface.

[008] In a further aspect, a lighting element for a vehicle headlamp lighting device is provided, comprising a single, continuous strip of flexible circuit comprising a plurality of light emitting semiconductor devices (LESDs), the flexible circuit having a shape configured to extend over a plurality of mounting surfaces of a frame comprising a complex structure comprising any of a circular member, an elongated support member connected to and extending from a base, a semi-circular member connected to a central member and rear sleeves connecting the central member to the base, and the LESDs having a layout on the flexible circuit configured to position one or more LESDs over each mounting surface of the frame. The mounting surfaces comprise a top, front facing, bottom or lateral side mounting surfaces. The layout of the LESDs is configured to position any of a first, second, third or fourth groups of LESDs on, respectively, the top, front facing, bottom and lateral side mounting surfaces, the LESDs capable of providing a high beam, low beam, or day time running light source. Each LESD group is electrically connected to a separate circuit trace in the flexible circuit so that each LESD group is independently operable from other LESD groups for selective LESD illumination, to enable switching on and off of the high beam, low beam and daytime running light sources, or combinations thereof, within a single lighting device.

[009] These and other aspects of the invention are described in the detailed description below. In no event should the above summary be construed as a limitation on the claimed subject matter which is defined solely by the claims as set forth herein.

CLAIMS

1. A lighting device for a vehicle headlamp, comprising:

a single, continuous strip of flexible circuit comprising a plurality of light emitting semiconductor devices (LESDs),

a frame supporting the flexible circuit, the frame comprising a plurality of mounting surfaces for mounting the LESDs onto the frame,

the flexible circuit having a shape configured to extend over each mounting surface, and the LESDs having a layout on the flexible circuit configured to position one or more LESDs over each mounting surface,

wherein the frame comprises a complex structure comprising any of a circular member, an elongated support member connected to and extending from a base, a semi-circular member connected to a central member and rear sleeves connecting the central member to the base, that provides the plurality of mounting surfaces on which to mount the LESDs, as well as heat sink fins formed on the frame to assist with cooling, the mounting surfaces comprising a top, front facing, bottom or lateral side mounting surfaces,

the layout of the LESDs is configured to position any of a first, second, third or fourth groups of LESDs on, respectively, the top, front facing, bottom or lateral side mounting surfaces, the LESDs capable of providing a high beam, low beam, or day time running light source,

and

each LESD group is electrically connected to a separate circuit trace in the flexible circuit so that each LESD group is independently operable from other LESD groups for selective LESD illumination, to enable switching on and off of the high beam, low beam or daytime running light sources, or combinations thereof, within a single lighting device.

2. The lighting device of Claim 1, wherein the frame comprises a top mounting surface and a bottom mounting surface relative to a mounted position, the flexible circuit extending over the top mounting surface and the bottom mounting surface, the flexible circuit comprising a first LESD group positioned on the top mounting surface for providing a high beam light source, and a second LESD group is arranged on the bottom mounting surface for providing a low beam light source.

3. The lighting device of Claim 1 or 2, wherein the frame comprises a front facing mounting surface relative to a mounted position, the flexible circuit extending over the front facing mounting surface, and the flexible circuit comprising a LESD group positioned on the front facing mounting surface for providing a day time running light (DRL) source.

4. The lighting device of any of Claims 1 to 3, wherein the frame comprises a lateral side mounting surface relative to a mounted position, the flexible circuit extending over the lateral side mounting surface, the flexible circuit comprising a LESD group positioned on the lateral side mounting surface.

5. The lighting device of any of Claims 1 to 4, wherein the plurality of mounting surfaces are located on different planes.

6. The lighting device of any of Claims 1 to 5, wherein at least one of the top, bottom or lateral side mounting surfaces has a slope profile.

7. The lighting device of any of Claims 1 to 6, wherein the flexible circuit is creased at each location where the flexible circuit is folded over an edge of the frame.

8. The lighting device of any of Claims 1 to 7, further comprising a base attached to the frame, the base comprising mating features for mounting onto a light bulb socket of a vehicle headlamp assembly.

9. The lighting device of any of Claims 1 to 8, wherein a vibration damping tape is provided on the portions of the base contacting the light bulb socket of the vehicle headlamp.

10. The lighting device of any of Claims 1 to 9, wherein the frame comprises a material having thermal conductivity of above 15 W/mK.

11. The lighting device of Claim 10, wherein the frame comprises heat dissipating features selected from the group consisting of cooling fins, an electric fan and a liquid coolant.

12. The lighting device of any of Claims 1 to 11, wherein a thermally conductive interface tape is provided between the flexible circuit and the mounting surfaces of the frame.

13. A vehicle headlamp, comprising a light reflector, a lens fitted over the light reflector, and a lighting device of any of Claims 1 to 12 arranged between the light reflector and the lens via an aperture in the light reflector.

14. A lighting element for a vehicle headlamp lighting device, comprising:

a single, continuous strip of flexible circuit comprising a plurality of light emitting semiconductor devices (LESDs), the flexible circuit having a shape configured to extend over a plurality of mounting surfaces of a frame comprising a complex structure comprising any of a circular member, an elongated support member connected to and extending from a base, a semi-circular member connected to a central member and rear sleeves connecting the central member to the base, and the LESDs having a layout on the flexible circuit configured to position one or more LESDs over each mounting surface of the frame,

wherein the mounting surfaces comprising a top, front facing, bottom or lateral side mounting surfaces,

the layout of the LESDs is configured to position any of a first, second, third or fourth groups of LESDs on, respectively, the top, front facing, bottom and lateral side mounting surfaces, the LESDs capable of providing a high beam, low beam, or day time running light source,

and

each LESD group is electrically connected to a separate circuit trace in the flexible circuit so that each LESD group is independently operable from other LESD groups for selective LESD illumination, to enable switching on and off of the high beam, low beam and daytime running light sources, or combinations thereof, within a single lighting device.

15. The lighting element of Claim 14, wherein

a first section of the flexible circuit comprises a first LESD group formed at a position on the flexible circuit corresponding to the upper mounting surface on the frame, and

a second section of the flexible circuit comprises a second LESD formed at a position on the flexible circuit corresponding to the lower mounting surface on the frame.

16. The lighting element of Claim 14 or 15, wherein a section of the layout comprises a LESD group formed at a position on the flexible circuit corresponding to the location of a front-facing mounting surface on the frame.

17. The lighting element of Claim 14 or 15, wherein a section of the layout comprises a LESD group formed at a position on the flexible circuit corresponding to the location of a lateral side surface on the frame.

18. The lighting element of any of Claims 14 to 17, further comprising a thermally conductive interface tape is provided on a surface of the flexible circuit opposite the surface on which the LESDs are formed.