WAVELENGTH OPTO-ELECTRONIC

Micro-Lens Array (MLA)

— *Efficient use of light using sub-micron lenses*

Introduction

Micro-lenses are sub-micrometre lenses (often up to 10 microns), typically made with fused silica due to its excellent transmission characteristics of UV to IR rays. MLAs are one or two-dimensional arrays of these micro-lenses (lenslets), patterned in a squared packing order on a wafer. MLAs are commonly manufactured using standard semiconductor processes like photolithography and reactive ion-etching (RIE).

Theory

The packing of the lenses in an array determines the *fill factor*. Circular lenslets on a square wafer will cover π/4 = 78.5% of the wafer. A higher fill factor is desirable, and achievable by hexagonal packing of lenslets as seen in Figure 1 – but these arrays are usually not applicable. The fill factor determines the light throughput of the material, apart from the transmittivity of the MLA.

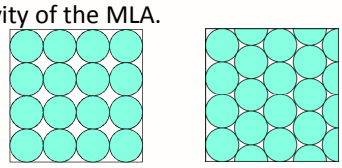

Figure 1. Square/hexagonal arrangement pattern

MLAs are implemented in devices that require an increase in optical fill factor due to metallic shielding and non-photosensitive areas, without the use of additional optical components. For example, MLAs are used in charge coupled devices (CCD) to concentrate the light onto its photodiode rather than metallic exposure gates and shield, where the imaging information is lost.

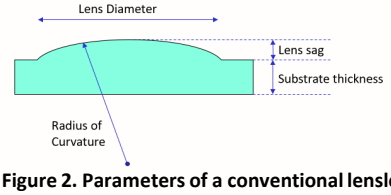

Figure 2. Parameters of a conventional lenslet

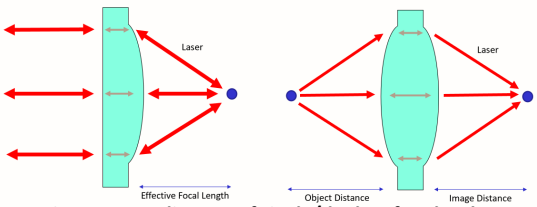

Figure 3. Ray diagram of single/dual surface lenslet

Important Parameters

- Lens Diameter
- Effective Focal Length (EFL)
- Radius of Curvature (ROC)
- Array Size
- Refractive Index, n
- Lens Sag

Applications

MLAs can homogenize, collimate and image light from various emitters, from excimer lasers to high power LED. They are useful for applications that require high frequency and non-Gaussian uniformity. Depending on use case, specific types of micro-lenses are used; e.g.

a) Gradient-Index (GRIN) lenses

GRIN lenses are made of two flat and parallel surfaces, where only plane optical surfaces are used instead of conventional curved surfaces. The lens feature a varied refractive index through the lens, which causes light rays to bend inside the lens (Figure 4). GRIN lenses are also commonly found in photocopiers and scanners.

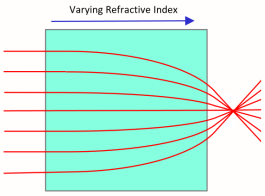

Figure 4. GRIN lens causing rays of light to bend within

b) Micro-Fresnel Lenses (MFL)

Fresnel lenses are made up of a series of concentric grooves engraved into plastic or glass. Acting as individual refracting surfaces, the contours bend parallel light rays to a common focal length (Figure 5), or collimates the beam, depending on the direction. The direction of propagation of light does not change within a medium but is only deviated at the surface. This lens provides a better focusing performance compared to conventional lenses. MFL is commonly utilized in TLR/SLR camera screens.

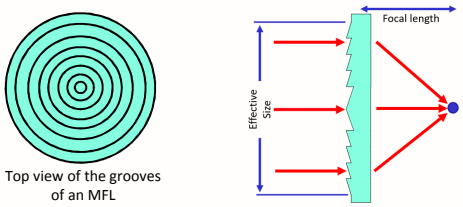

Figure 5. MFL lens causing rays to focus

MLA systems are used in, but not limited to the following application scenarios:

- Shack-Hartmann Wavefront Sensor
- Medical/aesthetic Laser Treatments
- Laser Material Processing
- CCD & CMOS Image Sensors

Conclusion

As a global enterprise, leading photonics innovation since 2002, WOE has built up customization engineering capability for thermal imaging, inspection and measurement systems.

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