APPLICATION NOTE

APPLICATIONS OF DIRECT WRITE GRAYSCALE LITHOGRAPHY

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Hydrophobicity, anti-reflectivity, special decoration effects, and other characteristics can be achieved by certain periodic shapes or 3-dimensional structures on the microscale. For most applications and products in today’s markets, special functions or properties as mentioned above are highly demanded by industries due to the added value that they provide. The DWL 66+ Laser Lithography System from Heidelberg Instruments offers high accuracy at a fast writing speed when creating high-resolution 2D patterns or complex 3D structures.

The basic process for fabricating grayscale structures using the DWL 66+ is as follows:

Prepare the substrate in a clean room environment by cleaning it from chemical impurities and particles;

1. Apply a thick layer (typically > 5 µm) of a low-viscosity positive photoresist, for example AZ4562, by spin coating it on the substrate surface. After coating, the resist is baked to drive off any solvents;

2. Create designs using a CAD software (e.g. AutoCAD). Prepare the desired structures as design file. For grayscale exposures, possible file formats include DXF, STL, GDSII, XYZ and Bitmap;

3. Convert the designed files, expose them directly onto the resist coated substrate and then develop the exposed image;

4. Transfer the desired patterned features into the substrate using an etch process or by creating a mold via an electroplating process.
In our production process, the formed structures are massively reproduced by nano-imprinting technology so that the products with functional structures can be commercialized.

2D Applications: Metal Mesh
Metal mesh is an electrically conductive and transparent surface, which can be used to replace ITO (Indium Tin Oxide) glass in display applications. The surface is covered with criss-crossing grooves that form a diamond pattern. A conducting material such as silver paste is used to fill these grooves so that the whole surface becomes electrically conductive while maintaining good transparency.

(a)                   (b)                        (c)

Fig. 1: Illustrations of metal mesh: (a) (b) overview of metal mesh at different angles; (c) microstructure of metal mesh with a groove width of 5 µm

MLA and Naked-Eye 3D Display Application
Microlens arrays (MLA) are passive optical devices with many special properties and functions. An MLA is a matrix of (sub-)micron lenses arrayed in specific periods. One of its functions is that it enables human eyes to perceive patterns in 3D fashion without the aid of extra accessories. The following shows microlens arrays with hexagonal arrangement with different periods.

(a)                                 (b)

Fig. 2: Hexagonal MLAs with period of (a) 30 µm and (b) 60 µm

The following shows a micropatterned array fabricated on the DWL 66+ that is coupled with a microlens array.
3D Applications: Compound and Solar Cell Application

Compound structures are complex structures combined with micro and nanostructures. As an example, the insect eye, especially the moth or fly eye, consists of a similar series of compound structures. Combined with our nanoimprinting technology, nanosize structures can be integrated onto the microstructure, thus forming compound structures.

Fig. 3: Single object naked-eye 3D display effects

Fig. 4: Compound structure of (a) butterfly wing structure, (b) moth eye structure and (c) fly eye structure
When such structures are applied onto thin films, the films exhibit properties of anti-reflection and light trapping. The film is then applied to the solar cell. The performance of the modified solar cell compared to conventional solar cell is summarized below:

![Solar cell real-time opto-electrical conversion performance comparison. The solar cell with the moth eye film has an average performance increase of around 5% over the conventional solar cell. The testing was carried out in Xi’Ning City, Qinghai Province, China.](image)

**Fig. 5:** Solar cell real-time opto-electrical conversion performance comparison. The solar cell with the moth eye film has an average performance increase of around 5% over the conventional solar cell. The testing was carried out in Xi’Ning City, Qinghai Province, China.

### 3D Applications: Saw/Triangular Pattern and Phone Decoration Application

Other 3D shapes can reflect different effects which can then be used in decoration applications, for example in the back covers of smartphones.

![Microstructure of triangular curved gratings and its application in phone decoration patterns, (d) mold of the pattern](image)

**Fig. 6:** (a), (b) Microstructure of triangular curved gratings and (c) its application in phone decoration patterns, (d) mold of the pattern