Full Wafer Double Sided Monolithic Lens Fabrication Using UV-Imprint Lithography

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Monolithic Lens Array (MLA) fabrication has emerged over the past decade as a constantly growing market, as it eliminates the requirement of using glass substrates and thereby increasing the scalability and material compatibility of optical devices. In this paper, we discuss the capability of imprint lithography to manufacture double-sided monolithic wafer-level-optics, which enables low cost of ownership and high throughput. MLAs are nowadays a key component in next generation flashlights for mobile phones, high pixel wafer-level-cameras and integration with LED arrays. However, the main challenges in manufacturing MLAs are: (1) obtaining arrays with low Total Thickness Variation (TTV) over large areas, (2) low aberration and distortion of the lens geometry, (3) critical ultra-precision lens-to-lens alignment, and (4) interconnected MLAs. Traditionally, injection moulding and diamond micro-milling techniques have been used in the production of MLAs [1, 2]. Whereas injection moulding is a rather low cost manufacturing method when addressing low and medium volume productions, it poses major disadvantages in term of production scalability. The moulds allow for lens arrays of only few centimetres square at a time and, moreover, the thermal cycling of the materials drastically limits the overall throughput. The different approach of micro-milling also has a strong limitation in terms of scalability: these high-quality lens arrays would simply be too costly for medium to large volume productions. Finally, both these traditional methods are limited in fabricating interconnected and double sided MLAs in a single step, i.e. where high alignment accuracy is required.

As it will be demonstrated in the presentation, the highly sophisticated SUSS UV- imprint lithography equipment addresses and solves the challenges of high-volume MLAs manufacturing: it allows for a very low TTV, for the accurate definition of the final thickness of the monolithic layer and for precisely aligned and interconnected MLAs. The SUSS imprint technique is based the use of UV-curable optical polymer material in combination with two hybrid stamps. The stamps are made of a polymer layer on a glass carrier that providing the necessary in-plane stiffness of the system leads to imprints without distortions in the lens geometries. In the initial steps of the imprint procedure, the two stamps are set parallel to respect of each other and the UV-curable polymer material is dispensed on one of the stamps and afterwards spread between the two stamps. The final thickness of the polymer's monolithic layer is obtained via the SUSS Active Wedge Error Compensation technology, that allows a constant real-time control over the relative position of the two stamps.. Furthermore, the imprint process takes full advantage of the SUSS mask aligner hardware on which it is based, by leading to high-quality alignment results. In the final step, the imprint material is cured using a high uniformity UV-LED exposure unit. Hence, by using SUSS imprint technology, fabrication of full wafer double sided MLAs are achievable in a single and thereby enabling

low cost of ownership and high throughput. Fig 1. Shows a schematic of an imprint process. Fig 2. Shows a picture of a full wafer-level MLA sheet as obtained with the SUSS imprint lithography equipment.

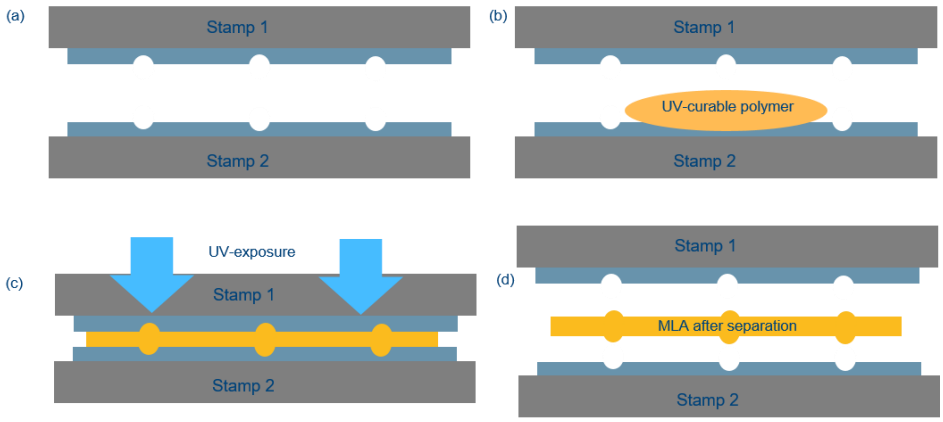

Figure 1. (a)- (d): Process flow-monolithic lens imprinting

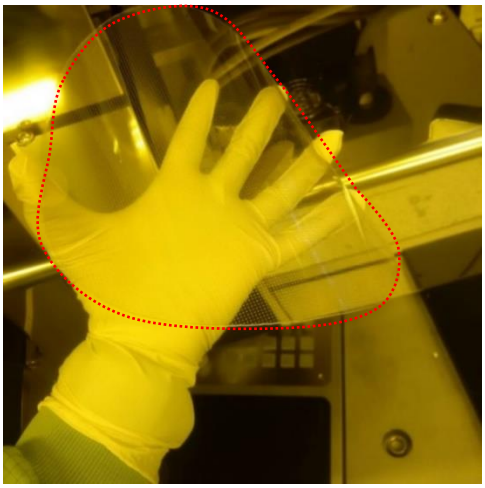

Figure 2. Picture of monolithic lens wafer

Reference:

[1] Gih-Keong Lau and Milan Shrestha; "Ink-Jet Printing of Micro-Electro-Mechanical Systems (MEMS)" Micromachines, doi: 10.3390/mi8060194 (2017).

[2] Scheiding, Sebastian, Yi, Allen, Loose, Roman, Gebhardt A, Li, Lei , Risse, Stefan, Eberhardt, Ramona and Tünnermann, Andreas; "Diamond milling or turning for the fabrication of micro lens arrays: comparing different diamond machining technologies" Proceedings of the SPIE, Volume 7927, id. 79270N (2011).