

High volume manufacturing of advanced diffractive optical elements by injection molding

B. Bilenberg, T. Nielsen, A. Johansson, V. Miljkovic, N. Hansson and I. Czolkos
NIL Technology, Kongens Lyngby, DK-2800
bb@nilt.com

As the applications for complex optical element constantly increase and get more and more advanced there is a need for production of those in high volumes at low cost and on advanced geometries, free forms. We present a solution for making advanced diffractive optical elements, DOE, by electron beam lithography and dry etching on a silicon wafer and subsequently transfer the structures to an injection molding insert and produce the optical elements by injection molding.

The silicon master, see Figure 1, is made by electron beam lithography and dry etching. The DOE used for the demonstration of the process has four levels with ~450 nm step heights and minimum lateral dimensions of 300 nm, the pixel size of the DOE is down to 500 nm. From the Silicon master a flexible mold copy is made and the flexible mold copy is used to transfer the pattern onto the steel insert for injection molding, see Figure 3, by a nanoimprint process in a specialized imprint tool. As a demonstrator the structured steel insert is used to injection mold DOE parts in COC Topas, see Figure 4 and Figure 5.

Production of DOE structures by injection molding ensures high volume and low cost production of DOEs. Furthermore, injection molding is capable of forming any given shape or free form. With the presented technology we can apply diffractive optical structures to a steel insert with any surface shape enabling simple implement of DOE structures on any given component. Figure 6 shows diffractive structures on a curved steel insert.

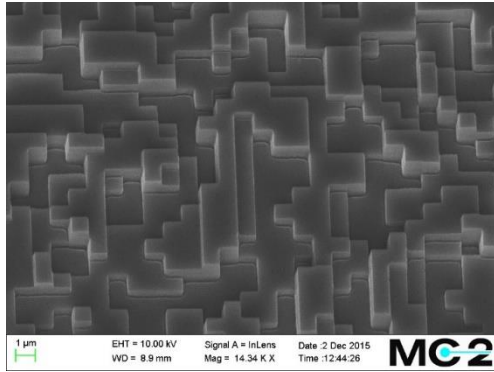


Figure 1: Diffractive optical structures on the silicon master made by electron beam lithography and dry etching. The structures has 4 depth levels with ~450 nm step heights. Minimum lateral dimensions 300 nm.

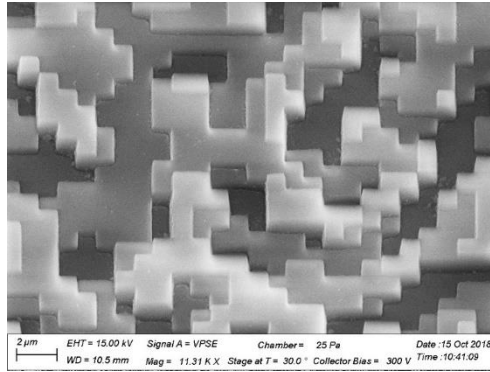


Figure 2: Flexible mold copy from the master shown in Figure 1.

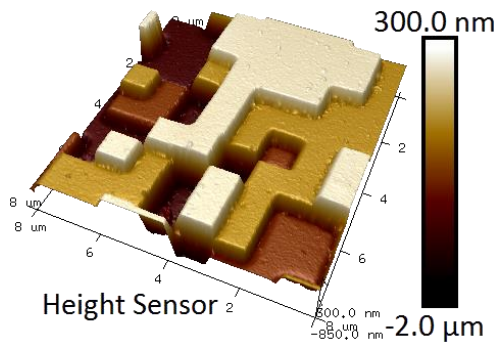


Figure 3: DOE structures transferred to the steel insert by the flexible mold copy shown in Figure 2.

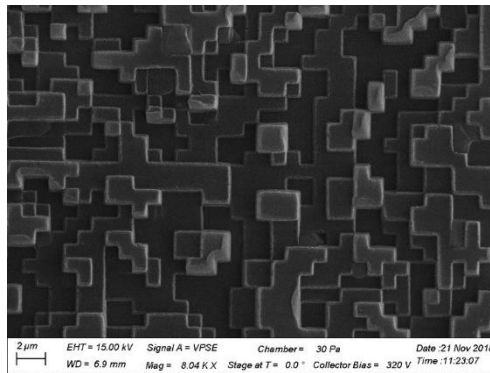


Figure 4: Injection molded DOE structures made by injection molding with the steel insert shown in Figure 3.

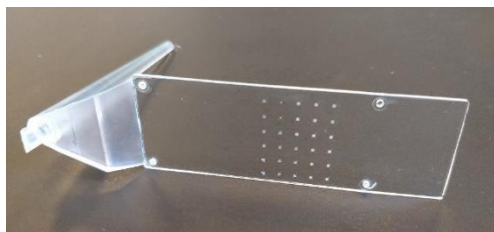


Figure 5: Digital camera image of injection molded DOE structures made by injection molding.



Figure 6: Digital camera image of curved steel insert with diffractive structures.