Lessons learned from the optical metrology of molded aspheres for cell phone cameras

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Modern miniature cameras common to smart phones and other portable devices are astonishingly complex and sophisticated optical assemblies, comprising multiple advanced aspheres assembled in a cell that is just a few mm in diameter. The lens elements are injection molded in high volume, and include features for mechanically locating centers of curvature as well as maintaining proper separation and orientation of the elements when combined into the final lens. The completed lenses are tested for imaging quality, often revealing deficiencies that are difficult to trace to specific manufacturing errors once the lenses are assembled. Precision metrology for individual lens surfaces, lens geometries, and alignment features is an important part of improving performance and production yield [1].

We have measured injection molds and lens elements prior to assembly using 3D optical metrology using a new instrument based on interference microscopy, and have found this approach to be an effective means of discovering issues that can affect image quality [2, 3]. These issues include problems with the flow and distribution of material during injection molding (FIGURE 1), variations in the location of mechanical features (FIGURE 2), and defects in aspheric form and smoothness only visible with full 3D non-contact metrology (FIGURE 3).

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1. P. J. de Groot, "Challenges and solutions in the optical measurement of aspheres," in *Ultra Precision Manufacturing of Aspheres and Freeforms*, OptoNet Workshop, (2016).
2. X. M. Colonna de Lega, M. F. Fay and P. de Groot "Optical evaluation of lenses and lens molds", US Patent Application 20160047712 (2016).
3. T. Dresel, J. Liesener and P. de Groot "Measuring topography of aspheric and other non-flat surfaces", US Patent Application 20150192769 (2015).

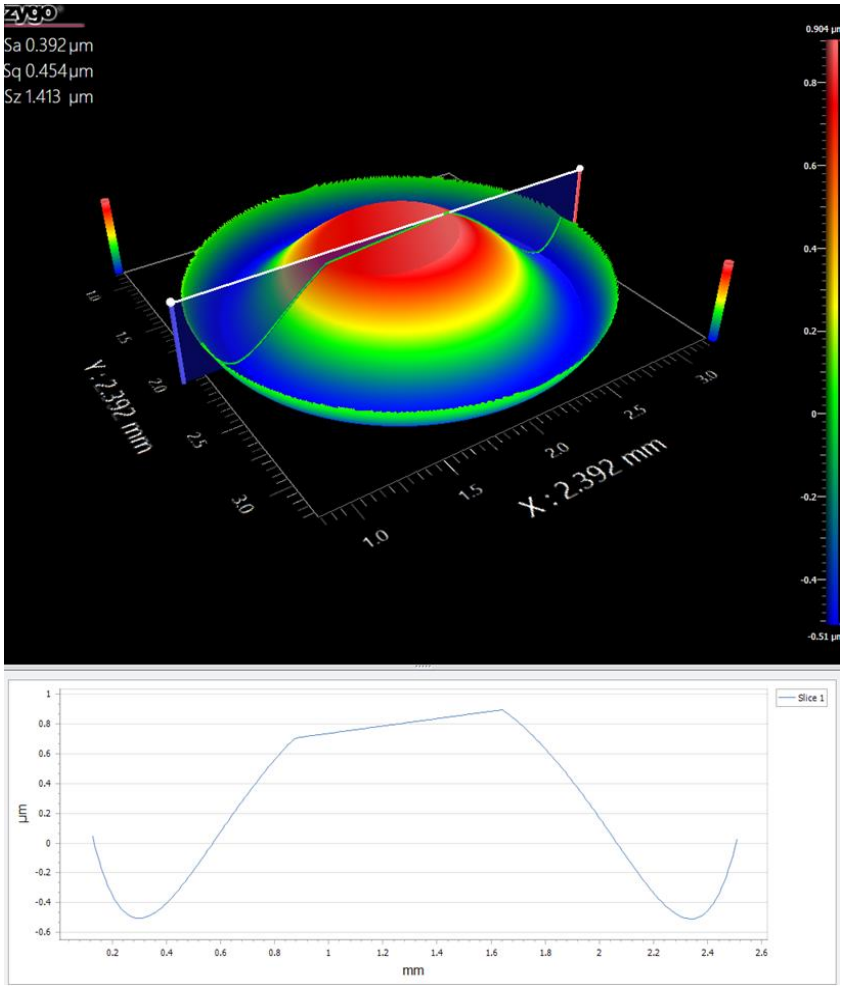

FIGURE 1: Measured aspheric departure of an aspheric smart phone lens element, illustrating a molding defect. Here the glass has failed to completely fill the mold.

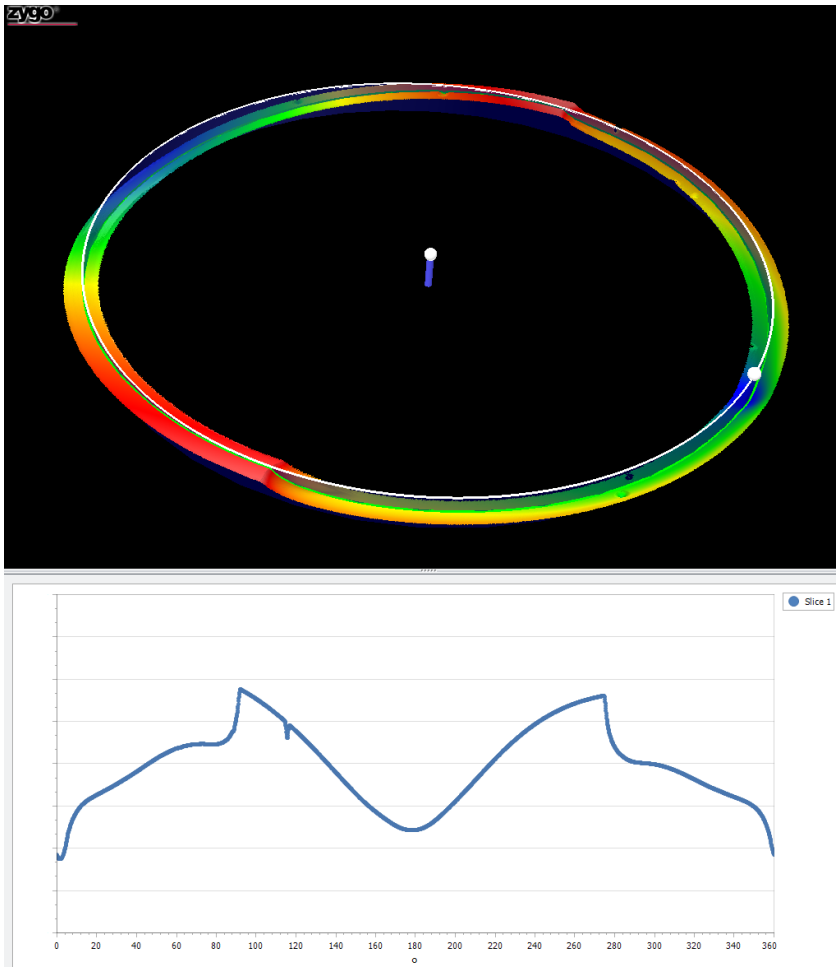

FIGURE 2: Measured shape of the tilt control interlock feature of a microlens element, illustrating a step defect that would impact the proper alignment of the lens assembly.

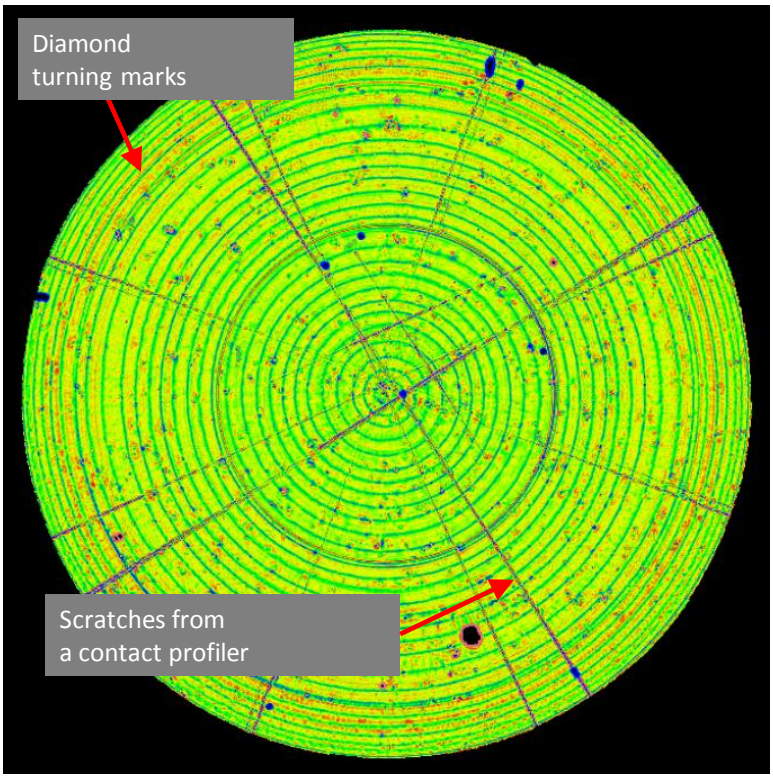

FIGURE 3: High-resolution measurement of departure from the desired aspheric form of a microlens, showing defects related to the diamond turning process for the lens molds and damage from a previous measurement using a stylus-type form profiler.