Pursuit of new potential applications of glass materials from three-dimensional laser diffraction grating machining using a femtosecond laser

User: Ohara Inc.
New Material Development Sec.,
New Field Product Business Development Unit.

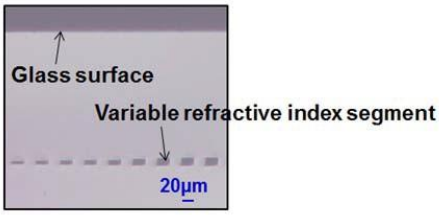
Main Research Development Details

Since its foundation in 1935, Ohara Inc. (hereafter Ohara) has contributed to the development of the optical industry in Japan by developing and providing optical materials for meeting the latest needs as a dedicated manufacturer of optical glasses. Today, it has established the top share in the optical glass industry. By utilizing its experience and long history in this technology, Ohara has been committed to research and development by seeking new potential applications of glasses and by providing advanced materials for use in optical and electronics related industries. In this regard, one of the recent achievements by Ohara is the formation of a permanent refractive-index change segment inside glass using femtosecond laser processing.

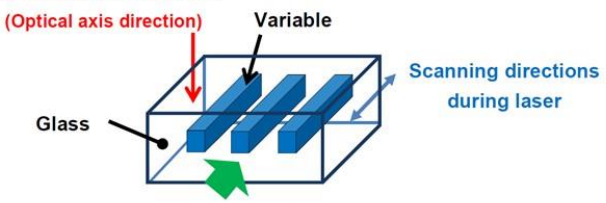
Achieving a new diffraction optical component by forming a refractive-index change segment inside flat glass

Ohara has achieved the processing of the high-precision diffraction optical components inside glass on the basis of special material (proprietary glasses and glass ceramics) composition-development technology and the joint research experiences gained from the "High-efficiency Processing Technology for Three-dimensional Optical Devices project" (commissioned by New Energy and Industrial Technology Development Organization).

Processing example: forming the variable refractive-index segment inside the glass

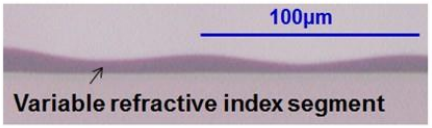


- Viewing the processing segment

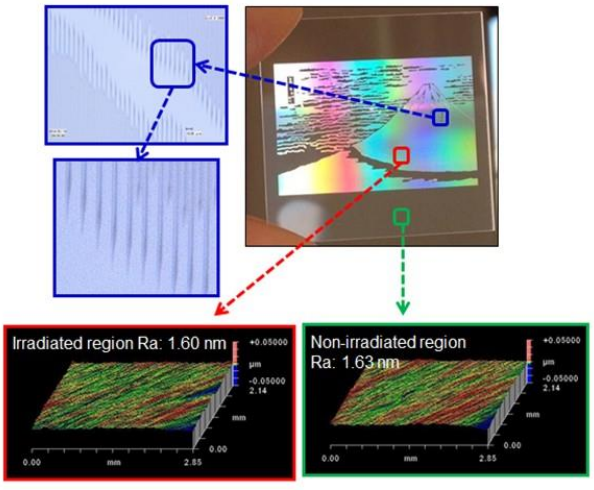


Viewing direction (cross-sectional direction in the variable refractive index segment)

Special shape that is difficult in surface processing is achieved by laser direct rending
(Example) Sinusoidal diffraction grating



Laser processed segment magnified (line and space processing)

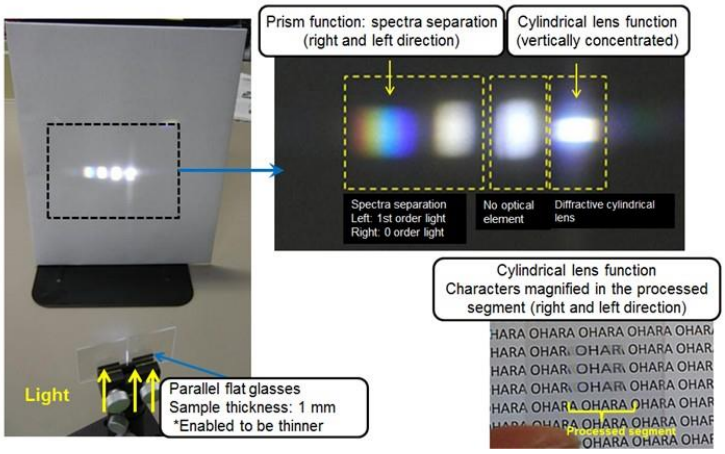


No apparent transformation in the laser irradiated region.

The above figures are examples of the images directly rendered by the femtosecond pulse laser.

Cross-sectional diffraction grating, which is considered to be difficult to achieve for complex geometries such as sinusoidal or blaze geometry with surface treatment, is created inside the glass without affecting the glass surface. As represented in the figures below, this processing done into the thin flat glass plate has achieved the diffraction optical component having the capability of prism and lens with a flat surface. This enables to form a compact device, thereby resulting in the ease of handling, which is required in a manufacturing stage and in ordinary use. The aforementioned processing case is by use of a lens with a single focus and stage scanning as well as the introduction of all-at-once radiation. In the future, using glass holograms would enable more efficient processing.

Creating a diffraction optical component (prism, lens) inside parallel flat glasses

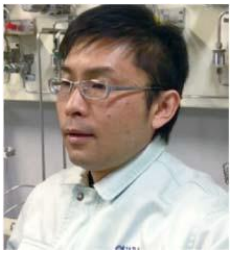


Having expertise in forming special-composition glasses and laser processing, Ohara can develop its own proprietary composition, thereby resulting in the development of three-dimensional laser diffraction grating machining glasses having a larger refractive-index difference (Δn) fabricated with low energy by leveraging its novel materials manufacturing technology. By focusing on extremely short-pulse laser processing as the primary technology for enhancing the added value of glass and glass ceramics materials, Ohara is further committing to the development of processing technology and application materials.

Choosing a laser source

"As a future perspective, we have focused on the all-at-once radiation processing using glass holograms. The higher the pulse energy per pulse, the wider is the processing coverage enabled by a single pulse; therefore, on selecting the laser, the magnitude of the pulse energy was considered to be a major factor for the determination.

In consideration of the stability and workability, an all-solid-state excitation laser is preferable and Coherent's Legend Elite Duo was selected for its high power and stability. Other multiple laser systems were also installed, such as a high repetition frequency system RegA operating at several hundred kHz, for research and development."



Tomohiro Hashimoto
OHARA Inc.
New Material Development Sec.
New Field Product Business Development Unit.
Advanced Material Product Div.
Special Products Division

Lasers Used in the Laboratory

Legend Elite Duo

RegA