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SLAC takes delivery of world's largest optical lens

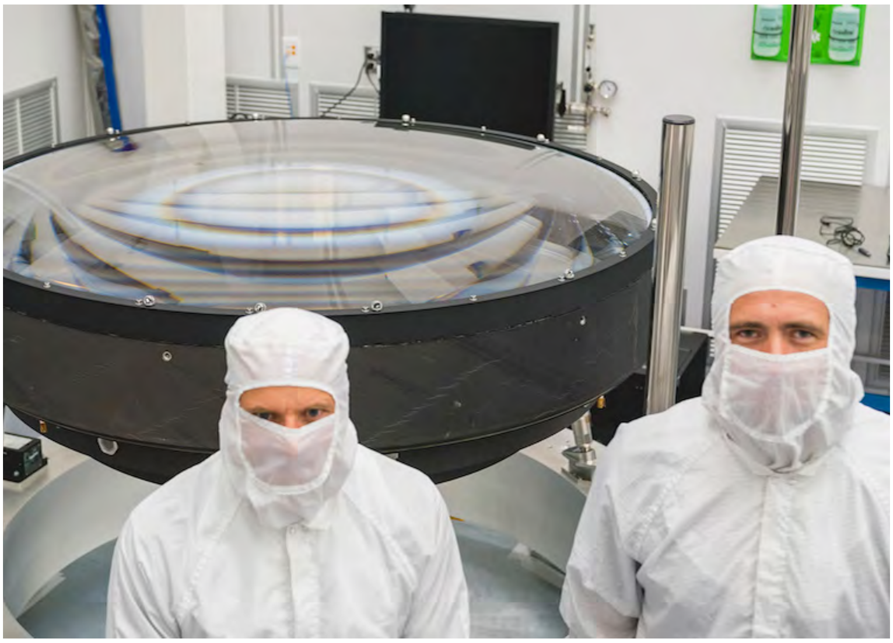
Digital camera optics for Large Synoptic Survey Telescope leave LLNL ready for integration.

A lens measuring 1.57 meters across and thought to be the largest high-performance optical lens ever fabricated has arrived at SLAC National Accelerator Laboratory, a major step towards its eventual destination in a digital camera used by the Large Synoptic Survey Telescope (LSST).

The full camera lens assembly, including the large L1 lens along with a smaller companion L2 lens measuring 1.2 meters in diameter, was designed by Lawrence Livermore National Laboratory (LLNL) and built over five years by Ball Aerospace and subcontractor Arizona Optical Systems. A third lens, L3, 72 centimeters in diameter, will also be delivered to SLAC within a month.

SLAC is managing the overall design, fabrication and final assembly of LSST's $168 million, 3,200-megapixel digital camera, which is said to be now 90 percent complete and due to be finished by early 2021.

"The success of the fabrication of this unique optical assembly is a testament to LLNL's world-leading expertise in large optics, built on decades of experience in the construction of the world's largest and most powerful laser systems," said Scot Olivier, who has been involved in Lawrence Livermore's LSST project for more than a decade.



Credit: Farrin Abbott/SLAC National

LLNL engineer Vincent Riot and optical engineer Justin Wolfe in front of the LSST main lens assembly.

According to the LSST Corporation, the digital camera in the LSST is the largest digital camera ever constructed. The final structure will measure 1.65 x 3 meters and weigh 2,800 kg. It is a large-aperture, wide-field optical imager capable of viewing light from the near ultraviolet to near infrared.

When assembled, the L1 and L2 lenses will sit in an optics structure at the front of the camera body; L3 will form the entrance window to the camera's cryostat, containing its focal plane and associated electronics.

Precise focusing requirements

The CCD digital camera will record images seen by the telescope's main optical system, itself a novel three-mirror design combining 8.4-meter primary, 3.4-meter secondary and 5-meter tertiary mirrors. First light at LSST is anticipated in 2020, with full operations commencing in 2022.

Designing a digital camera capable of meeting the LSST's ambitious imaging goals has led LLNL to tackle a number of challenges, according to the project team. The final detector format employs a mosaic of 189 16-megapixel silicon detectors arranged on 21 "rafts" to provide the total 3.2 gigapixels resolution.

The camera will take a 15-second exposure every 20 seconds, with the telescope being repointed and settling within five seconds, requiring an exceptionally short and stiff structure. This in turn implies a very small f-number, along with very precise focusing of the camera.

LSST documentation indicates that the 15-second exposures are a compromise to allow spotting both faint and moving sources. Longer exposures would reduce the overhead of camera readout and telescope repositioning, allowing deeper imaging, but fast-moving and near-Earth objects would move significantly during an exposure. Each spot on the sky is to be imaged with two consecutive 15 second exposures, to reject cosmic ray hits on the CCDs.

"Any time you undertake an activity for the first time, there are bound to be challenges, and production of the LSST L1 lens proved to be no different," commented Justin Wolfe of LLNL. "You are working with a piece of glass more than five feet in diameter and only four inches thick. Any mishandling, shock or accident can result in damage to the lens. The lens is a work of craftsmanship and we are all rightly proud of it."

https://optics.org/news/10/9/29

Schott and EV Group team up on mixed-reality wafers

Glass giant partners with lithography equipment firm to mass produce high-refractive-index material.

Austria's EV Group (EVG), which specializes in wafer bonding and lithography equipment, has teamed up with the optical glass giant Schott to help scale production of large glass wafer material intended for new applications in augmented and virtual reality (AR/VR).

The two firms say that they will demonstrate the readiness of 300 mm (12 inch) nanoimprint lithography (NIL) for high-volume patterning of the high-refractive index (HRI) material at next week's China International Optoelectronic Exposition (CIOE) event in Shenzhen.

The approach has been developed for manufacturing precision waveguides in up to 1.9 index material that will be used as light guides in the forthcoming generation AR, VR, and "mixed reality" (MR) headsets.

Economies of scale

EVG says that the partnership combines its proprietary "SmartNIL" process with Schott's "RealView" HRI glass wafer technology, the latest version of which was launched earlier this year at the Display Week exhibition in San Jose, California.

Schott is set to showcase one of the patterned wafers at the Shenzhen event, with its head of AR Rüdiger Sprengard saying in a company release:

"Scaling up to 300-mm manufacturing of high-refractive index glass wafers is critical to achieving the production volumes at the economies of scale that our customers need to meet growing market demand for today's and tomorrow's leading AR/MR devices.

"Through this joint effort, EVG and Schott are demonstrating the equipment and supply-chain readiness for 300-mm HRI glass manufacturing today."

EVG explains that, until now, use of the NIL technique to pattern glass substrates with structures for photonics applications has been limited to 200 mm-diameter glass. The migration to the larger format - the same size of material used to make most silicon semiconductor chips - is seen as a key step for bringing new AR/VR/MR headsets into mass consumer and industrial markets at an affordable cost.

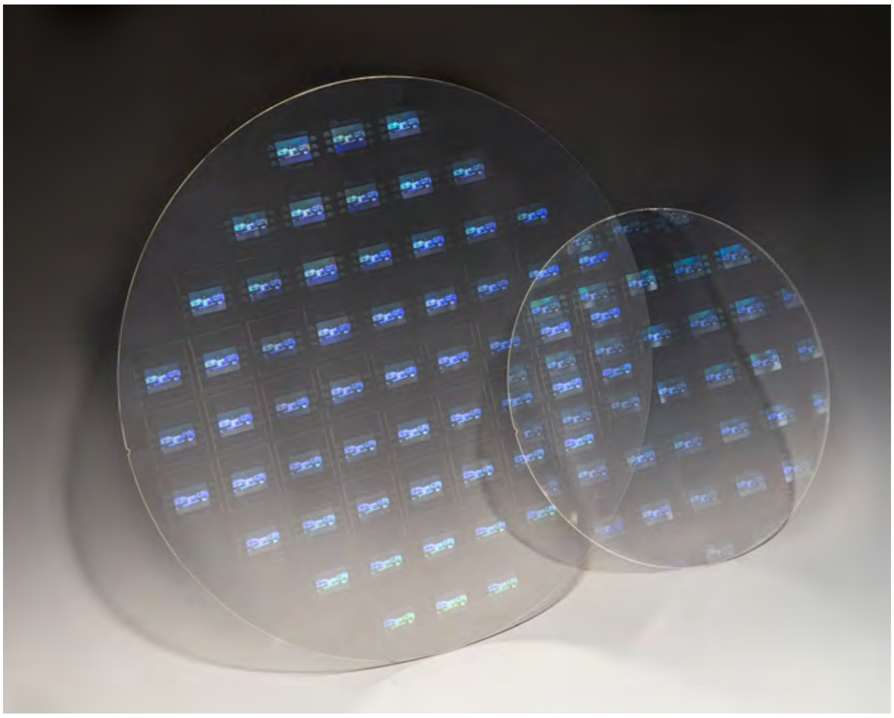


Photo: EV Group.

Schott's high-index glass wafers, shown here as a pair measuring 300mm and 200mm in diameter, are being patterned using a nanoimprint lithography method developed by the Austrian equipment firm EV Group. The companies say that the technology is now ready to be scaled up for the next generation of AR/VR/MR headsets.

The Austrian equipment firm adds that a key challenge with that migration was maintaining high substrate quality and process uniformity on the larger substrates, which demands advanced automation and process control capabilities.

Its SmartNIL approach is said to address the nanopatterning requirements, with its new "HERCULES NIL 300 mm" machine bringing the technology to the larger wafer format.

Innovation incubator

Markus Wimplinger, director of corporate technology development at EVG, said in a separate release that the partnership with Schott was an example of progress made at its open access innovation incubator.

The incubator has been set up to allow a diverse set of partners and companies across the NIL supply chain to collaborate with EVG, with the aim of shortening development cycles and time-to-market for innovative photonic devices and applications.

"We are excited to partner with companies like Schott to demonstrate the value of EVG's NIL solutions in not only enabling the development of new technologies and processes, but also accelerating their introduction to mass markets," Wimplinger said.

"This current work proves the maturity of NIL equipment and processes, and is laying the groundwork for 300 mm manufacturing for a variety of exciting new photonics-based products and applications."

The high refractive index of the latest Schott wafers is said to enable "deeply immersive" AR/VR/MR applications thanks to a wide diagonal field of view of up to 65 degrees – said to be far superior than any competing material currently on sale.

Having introduced the first generation of the material at last year's Display Week event, Schott adds that it is already providing samples of the 300 mm-diameter glass to customers, and is ready to ramp up production as and when it is required.

https://optics.org/news/10/8/42

Laser coating process better protects car brake discs

Fraunhofer ILT-developed EHLA technique is reliable, efficient, and greener. To be presented at Frankfurt Motor Show.

More than many other car components, brake discs are subject to repeated mechanical loads. As a result of this continual abrasion, they produce fine particulate matter, which poses a substantial environmental threat. Now, however, a new coating process developed by the Fraunhofer Institute for Laser Technology (ILT) and RWTH Aachen University can significantly reduce this impact.

By using Extreme High-speed Laser Material Deposition, known by its German acronym EHLA, brake discs with an effective protection against wear and corrosion can be constructed in a procedure that is both fast and economical.

To date, say the partners, it has proved difficult to provide adequate protection for brake discs by means of conventional coating processes such as electroplating or thermal spraying. The problem with such processes is that they do not produce a metallurgical bond between the cast iron disc and the protective coating; moreover, they are expensive and use a lot of materials.

"The EHLA process is ideal for use in the automotive industry, especially for coating brake discs," said Thomas Schopphoven, research fellow and team leader of Productivity and System Technology within the Laser Material Deposition group at the ILT.

"Conventionally, it's very difficult to coat brake discs, because they have to withstand high loads, and there are cost and environmental considerations. But with EHLA, it's now possible to apply coatings that from a metallurgical bond with the base material of the disc and therefore adhere very strongly. Unlike conventional coatings, these do not flake and chip."

Advance on conventional processes

Coatings produced with conventional processes have pores and cracks. But with the EHLA process, the coating remains intact and therefore provides longer and more effective protection for the component. This process is suitable for a wide range of materials so it is possible to select an environmentally-friendly coating for each application.

The EHLA process is a new process variant on the established laser material deposition techniques, which have proved successful in areas such as the repair of turbine blades. EHLA does, however, have a number of decisive advantages.

With the EHLA process, the powder particles of the coating material are melted directly in the laser beam, rather than in a melt pool on the surface of the component. Since the melt pool now is fed by liquid drops of material rather than solid particles of powder, the coating process is much faster, rising from the 0.5–2 m/min with conventional laser material deposition to as much as 500 m/min.

This also substantially reduces the exposure to heat of the material being coated. Unlike conventional laser material deposition, where the heat affected zone can have a depth of one or more millimeters, thermal exposure with the EHLA process remains in the micrometer range. This enables the use of entirely new material combinations such as coatings for aluminum or – as with the brake discs – cast-iron alloys.

Coating a brake disc with the EHLA process.

Firmly-bonded

The low heat input prevents the carbon to dissolve from the brake disc into the melt, otherwise resulting in brittle phases, pores, joining defects and cracks in the coating and bonding zone. In other words, it is now possible for the first time ever to provide brake discs made of gray cast iron with an effective coating that is firmly bonded with the base material.

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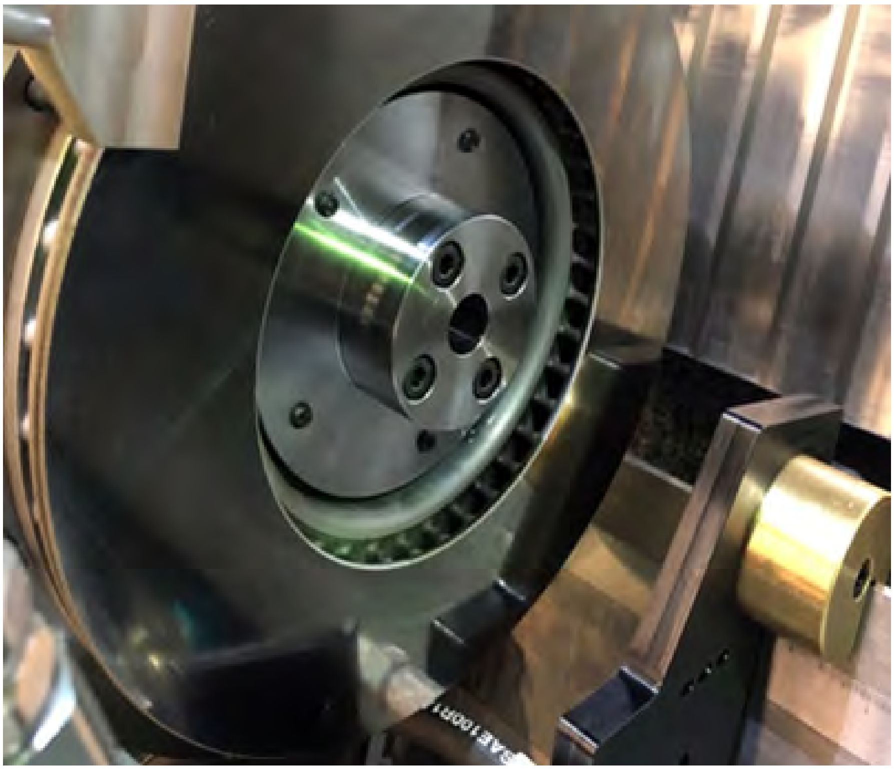
Laser coating process better protects car brake discs

With laser material deposition, the coating produced is usually at least half a millimeter in thickness. This consumes a lot of material and also makes finishing substantially more complicated. By contrast, the EHLA process produces very thin layers of between 25 and 250 micrometers. As a result, the coating is both purer and smoother, with roughness reduced to around one-tenth of its previous value.

Moreover, the EHLA process uses as much as 90 percent of the fed powder material. It is therefore extremely resource-efficient and more economic. The basic requirements for the use in an industrial, mass-production setting are at reach.

Industrial application could soon be a reality. Initial investigations have demonstrated that the EHLA process is



Brake even: finished brake disc coated with the EHLA process.

© Buderus Schleiftechnik, Aßlar, Germany | HPL Technologies, Aachen,

capable of reliably producing coatings – with different material combinations – for conventional brake discs made of gray cast iron. A system that is ready for use in mass production, including a modified grinding process for finishing the components, is currently under construction at the Aachen-based company HPL Technologies.

https://optics.org/news/10/9/7

Cheap microlens fabrication method uses single laser pulse

Simple technique developed at Italian Institute of Technology, Genoa, is "poised to expand microlens applications", say developers.

A growing number of applications, including smartphone cameras, depend on microlenses to boost performance. A newly-developed technology, called laser catapulting, could make it easier and less expensive to fabricate these miniature lenses with customized properties, such as shape or focusing power.

Researchers from Istituto Italiano di Tecnologia (Italian Institute of Technology), Genoa, describe their new laser-additive method for creating microlenses using a single laser pulse in a paper in Optical Materials Express. The technology can even allow microlenses and microlens arrays to be fabricated directly on cameras or solar cells.

Microlenses improve the performance of cameras and solar cells by concentrating light into the most sensitive areas of the devices. For example, they are widely used in the newest smartphone cameras to increase sensitivity and imaging speed in low-light conditions.

"Our fabrication approach simplifies the production of lenses while allowing more variety in the design and more flexibility in the environments where microlenses can be used," said research team leader Martí Duocastella. "In addition to completely new applications, this method could lead to new cameras that acquire video under low light conditions, solar cells with improved efficiency and microscopes that are better at capturing fast processes."

Catapulting with light

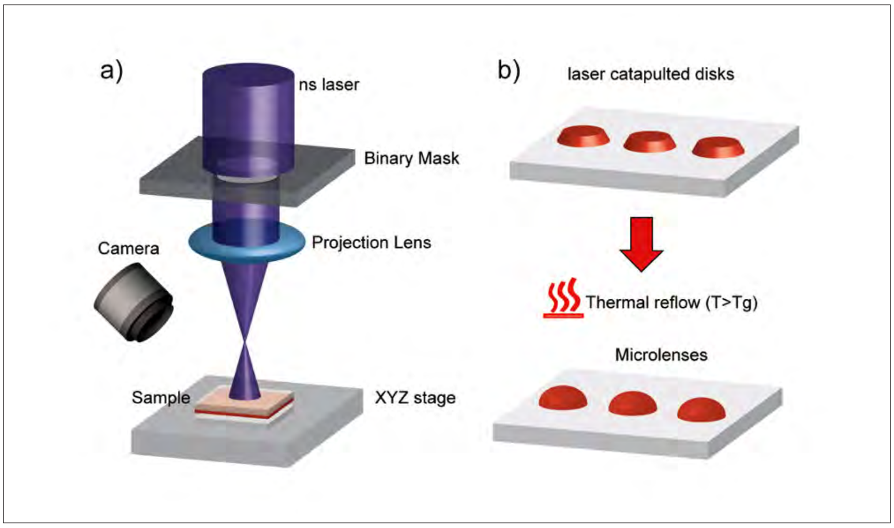
Although micro-optics are commercially available, they can be prohibitively expensive and hard to add to existing devices. Even with traditional microlens fabrication methods such as photolithography, it is difficult to integrate lenses or to make very densely packed microlens arrays.

The researchers developed catapulting to overcome these limitations. The method uses a laser pulse to remove and catapult a micro disk from a thin polymeric film and drop it onto a defined region of interest. The polymer in the microdisk is then heated so it can thermally reflow, allowing capillary forces to shape the microdisk into a round lens. Changing the shape of the laser beam allows fabrication of microlenses with different focusing properties or shapes, such as rectangular, triangular or circular.

"Laser catapulting connects the dots between existing laser-based fabrication methods to solve problems with current microlens fabrication strategies," said Duocastella. "It fills the gap between the growing number of applications that require microlenses and the technologies capable of generating on-demand customized micro-optics."

After studying the relationship between the laser beam shape and the resulting microdisks, the researchers explored the reproducibility, precision and accuracy of their technique. Their analysis showed that the method could be used to reproducibly produce microlenses with radiuses between 50 and 250µm and high smoothness. Measuring the optical properties of the microlenses and the light collection capabilities of microlens arrays made with the technique showed that these micro-optics exhibited diffraction-limited performance.

The researchers say that laser catapulting could be combined with fast laser beam shaping methods for on-the-fly control of optical performance and shape of individual microlenses within an array.



Practical implementation and operational principle of laser catapulting. a) Scheme of the experimental setup used for catapulting polymeric disks with a UV pulsed nanosecond laser. b) Working principle of the LCP process. First, polymeric disks are transferred onto a receiver substrate and second, microlenses are formed by thermal reflow, namely the heating of the polymer above its glass transition temperature (Tg).

Source: IIT / Optical Materials Express.

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Cheap microlens fabrication method uses single laser pulse

Capturing fast biological processes

The researchers are planning to use laser catapulting to fabricate microlenses on top of photodetector arrays so they can develop a high-speed 3-D microscopy system to characterize rapid biological processes, such as neuronal communications or virus trafficking. The microlenses will increase the light-collecting efficiency of the photodetectors and thus decrease imaging time.

"These novel photodetector arrays offer important advantages compared to confocal microscopy but can't collect as much light as traditional single point detectors," said Duocastella. "We believe that microlenses, and laser catapulting in particular, will help improve the performance of these photodetector arrays and expand their use among the microscopy community."

Conclusions

The Optical Materials Express paper states: "Laser catapulting is a single-shot laser-additive manufacturing method that enables the rapid fabrication of microlenses with various geometries including circular, triangular, and rectangular by simply adjusting the beam shape. As experimentally demonstrated, LCP is a highly reproducible process capable of individually controlling the microlens optical power, curvature, and geometry.

"The deposition of solid microdisks enables, in a single laser shot, the preparation of 100% fill-factor uniform or multifocal MLAs. By combining LCP with fast beam shaping methods such as spatial light modulators or acusto-optofluidics, we anticipate the on-the-fly control of the individual geometries and optical performance of the microlenses within an entire MLAs.

"Various applications require micro-optics to increase photon collection efficiency, but they come with particular demands that current fabrication methods cannot accommodate. The ease of implementation, in-situ fabrication, and high level of control offered by LCP, including the geometry of the microlenses, will help to fill this void and expand the usage of micro-optics to novel and fascinating industrial and scientific areas."

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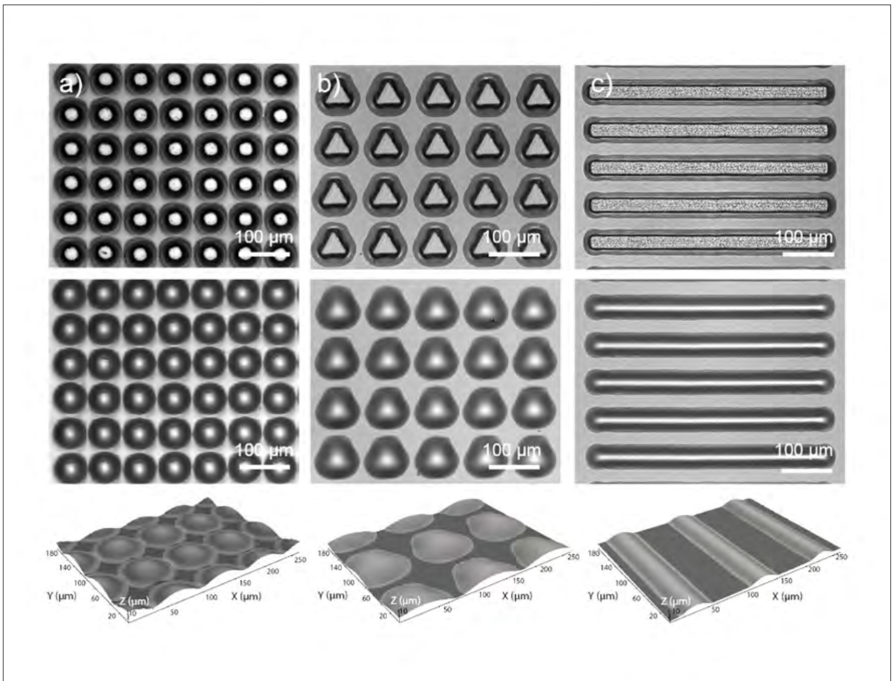

Source: IIT / Optical Materials Express.

Microlenses preparation with laser catapulting. Optical images showing circular (a), triangular (b), and rectangular (c) polymeric microdisks (top row) and corresponding microlenses (middle raw) obtained with laser catapulting and subsequent thermal reflow. The bottom row shows 3D maps of some representative circular, triangular, and cylindrical microlenses.

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