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Nano-particles help US Naval Research Lab build powerful lasers

Safer sources, at 85 per cent efficiency, achieved using laser-pumped silica fiber doped with holmium.

Scientists at the U.S. Naval Research Laboratory (US NRL), Washington, DC., have devised a new process for using nano-particles to build powerful lasers that are more efficient and safer for human eyes.

They have achieved this using rare-earth-ion-doped optical fiber. Essentially, it is a process using laser light pumping a silica fiber infused with holmium ions. According to Jas S. Sanghera, who heads the NRL's Optical Materials and Devices Branch, the team has achieved an 85 percent efficiency with the new process.

"Doping just means we're putting rare earth ions into the core of the fiber, which is where all the action happens," Sanghera explained. "That's how we've produced this world record efficiency, and it's what we need for a high-energy, eye-safer laser."

According to Colin Baker, research chemist with the Optical Materials and Devices Branch, the lasing process relies on a pump source--most often another laser—which excites the rare earth ions, which then emit photons to produce a high quality light for lasing at the desired wavelength.

"But this process has a penalty," Baker said. "It's never 100 percent efficient. What you're putting in is pump energy, not the high quality light at the wavelength you want. What's coming out is a much higher quality of light at the specific wavelength that you want, but the remaining energy that isn't converted into laser light is wasted and converted into heat."

U.S. Navy photos by Jonathan Steffen.

Left: Colin Baker, U.S. Naval Research Laboratory, holds a silica glass rod that will be pulled into an optical fiber suitable for production of an eye safer laser. Right: Jas Sanghera, U.S. Naval Research Laboratory branch head for Optical Materials and Devices, holds up holmium-doped optical fiber for eye safer lasers.

'More eye safe'

That loss of energy ultimately limits power scaling and the quality of the laser light, which makes efficiency particularly important. With the aid of a nano-particle dopant, the team has achieved an efficiency level of 85 percent with a laser that operates at a 2µm wavelength, considered a more "eye-safe" wavelength, compared with the traditional 1µm.

The danger arises from the potential of scattered light to be reflected into the eye during a laser's operation. Scattered light from the path of a 100kW laser operating at 1µm, such as arises from using a ytterbium dopant, can cause significant damage to the retina, leading to blindness. With an eye-safer laser, operated at wavelengths longer than 1.4µm, the danger from scattered light is considerably lessened.

Baker says that the nano-particle doping also solves several other problems, such as that it shields the rare earth ions from the silica. At 2µm, the silica's glassy structure can reduce the light output from the rare earth ions. The nanoparticle doping also separates the rare earth ions from each other, which is helpful since packing them closely together can also reduce the light output.

'Clever chemistry'

"The solution was some very clever chemistry that dissolved holmium in a nano-powder of lutetia or lanthanum oxide or lanthanum fluoride to create a suitable crystal environment for the rare earth ions," said Sanghera. "Using bucket chemistry to synthesize this nano-powder was key in keeping the cost down."

The particles of the nano-particle powder, which Sanghera's team had originally synthesized for a previous project, are typically less than 20nm. "Additionally, we had to be able to successfully dope these nano-powders into the silica fiber in quantities that would be suitable to achieve lasing," Sanghera added.

At the Optical Materials & Devices Branch, Sanghera's team are working with a room-sized, glass-working lathe, where the glass that will eventually become the fiber is cleaned with fluorine gases, molded with a blow torch and infused with the nano-particle mixture – what the scientists call a nanoparticle slurry. The result is a rare-earth-ion-doped, one-inch diameter, glass rod, or optical preform.

Next door, scientists use a fiber pulling system to soften the preform with a furnace and elongate it, in a process akin to pulling taffy, into an optical fiber. Sanghera's team has already submitted a patent application for the process. Among the potential applications they envision for the new specialty fiber laser are high powered lasers and amplifiers for defense, telecommunications and even welding and laser-cutting.

"From a fundamental perspective, the whole process is commercially viable," said Sanghera said. "It's a low-cost process to make the powder and incorporate it into the fiber. The process is very similar to making telecom fiber."

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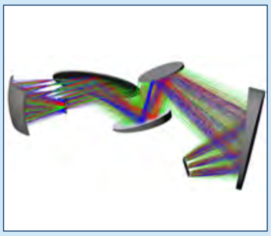

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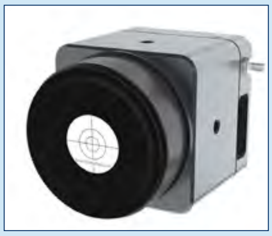

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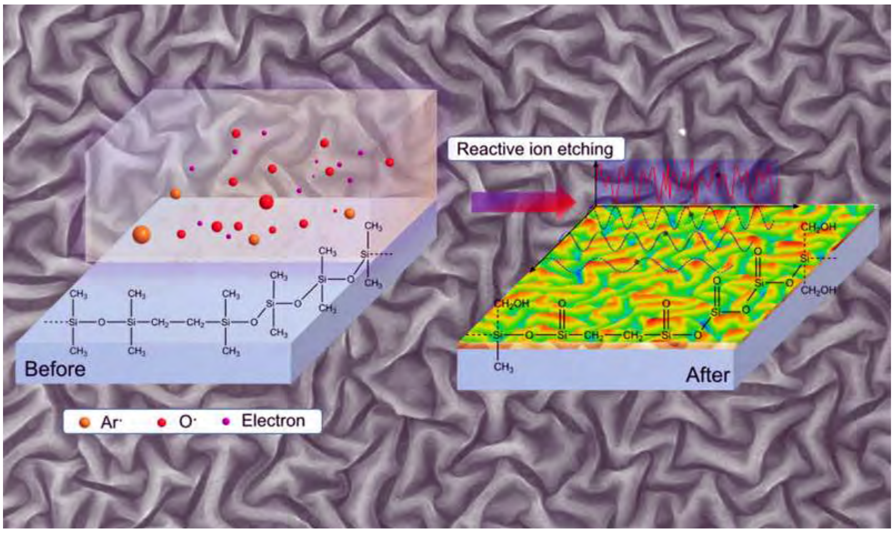
Nanostructures free photons to boost white OLED efficiency

Researchers at TU Dresden achieve external quantum efficiency of 76.3% with scalable, lithography-free method.

Since the first development of white OLEDs in the 1990s, numerous efforts have been made to achieve a balanced white spectrum and high luminous efficacy at a practical luminance level. However, the external quantum efficiency (EQE) for white OLEDs without additional outcoupling techniques typically only reaches 20 to 40 percent today.

About 20 percent of the photons generated in conventional OLEDs remain trapped in the glass layer of these devices. The reason for this is the total internal reflection of the particles at the interface between glass and air. Further photons are waveguided in the organic layers, while others get ultimately lost at the interface to the top metal electrode.



Credit: Sebastian Reineke et al., Nature

Principle of reactive ion etching for the generation of quasi-periodic nanostructures.

Numerous approaches have been investigated to extract the trapped photons from OLEDs. Now, an international research team led by Dr. Simone Lenk and Prof. Sebastian Reineke from the TU Dresden, Germany, have developed a new method for freeing the photons. Their work is described in Nature Communications.

The physicists have introduced a “straightforward, scalable and notably lithography-free method for the generation of controllable nanostructures with directional randomness and dimensional order, significantly boosting the efficiency of white OLEDs.” The nanostructures are instead produced by reactive ion etching. This, say the team, has the advantage that the topography of the nanostructures can be specifically controlled by adjusting the process parameters.

In order to understand the results obtained, the scientists have developed an optical model that can be used to explain the increased efficiency of OLEDs. By integrating these nanostructures into white OLEDs, an external quantum efficiency of up to 76.3% can be achieved.

‘Further applications’

For Dr. Simone Lenk, the new method opens up numerous new avenues; she commented, “We had been looking for a way to specifically manipulate nanostructures for a long time. With reactive ion etching, we have found a cost-effective process that can be used for large surfaces and is also suitable for industrial use.”

Over the past three decades, organic light-emitting diodes have been steadily conquering the electronics market, say the Dresden scientists: “from OLED mobile phone displays to roll-out television screens, the range of applications is growing”.

Since light-emitting diodes only produce monochrome light, manufacturers typically employ various additive color-mixing processes to produce white light.

A key focus of OLED research is on improving the performance of white OLEDs for lighting elements such as ceiling or car interior lighting; such components are subject to much stricter requirements in terms of stability, angular emission and power efficiency.

optics.org interviewed Dr Lenk about her group’s work and its potential for commercialization.

What are the factors limiting the efficiency of conventional white OLEDs?

“The factors limiting the efficiency of white OLEDs are electrical efficiency (ratio of generated excitons to the number of injected electrons); the radiative efficiency of the emitters (ratio of generated photons to the number of generated excitons); and the outcoupling efficiency (ratio of outcoupled photons to generated photons). Typical efficiencies for white OLEDs are in the range between 10 and 25%.”

How does your approach improve this; and by what factor?

“Our approach is the implementation of a quasi-periodic nanostructure working as an internal scattering layer to outcouple trapped photons. The nanostructures are produced by reactive ion etching. The advantage lies in the fact that the periodicity and height of

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Nanostructures free photons to boost white OLED efficiency

the nanostructures can be completely adjusted via the process parameters and that thus an optimal outcoupling structure for white OLEDs can be achieved. Using this nanostructure as internal outcoupling structure and additionally a glass half sphere for external light outcoupling, we can enhance the efficiency by a factor of 3.4."

Could commercially-produced OLEDs could be significantly more efficient in mass production by using your approach?

"I assume yes – reactive ion etching is comparitively cheap and the nanostructures could be easily adopted for mass production."

http://optics.org/news/10/7/24

Image courtesy Osram Opto Semiconductors.

OLEDs are "steadily conquering the electronics market," says the Dresden team.

First images from Mars will be seen through Jenoptik lenses

When NASA launches the Mars 2020 mission the first images back to Earth in February of 2021 will be seen through lenses designed and engineered by Jenoptik.

The Jenoptik Light & Optics team in Jupiter, FL have been developing three types of mission critical lenses for use with the Mars Rover's engineering cameras. Navigation lenses will capture the first live video footage from the mission as the rover explores the surface of Mars, crucially important when the rover drives autonomously. Hazard avoidance lenses will provide images that will help the rover identify obstacles and allow NASA engineers to see the movement of the robotic arm during sample collection. Finally, a cache lens will verify that a complete collection of the rock and soil samples have been achieved. Due to the cache lens' proximity to the samples collected, to avoid contamination, the cleanliness requirements are extremely challenging.

All three lens types were built in a Jenoptik class 5 clean room with state-of-the-art filtration technology for high-precision optical assemblies. Custom test equipment was developed at Jenoptik to measure the optical performance during the demanding temperature extremes to withstand the conditions on Mars. Jenoptik performed several environmental tests in vacuum and over a wide temperature range with the lowest temperature being -135°C.

© NASA

Artist's concept of Rover on Mars.

"Jenoptik is accustomed to demanding applications requiring expertise in the design, manufacture, and testing of complex optical assemblies in the fields of semiconductor, medical devices and defense industries", said Jay Kumler, President of Jenoptik Optical Systems in North America. "We are very proud of the technical challenges and rigorous testing we have overcome which has really benefited the entire company, and we are honored to be a part of the monumental mission to Mars."

NASA invests $45M in US firms for space technology

Development funds allocated to many photonics-related developments and companies across America.

US space agency NASA has selected 363 proposals from small businesses and research institutions across 41 states to help advance the types of technological capabilities needed for future space missions, and to support the agency in other areas. Many of the target projects are in photonics-related technologies (see list, below).

American businesses are expected to help NASA land astronauts on the Moon (again) in five years and establish a sustainable presence there, as part of the agency's larger Moon to Mars exploration project.

These selections have an estimated value of more than $45 million and are part of NASA's Small Business Innovation Research and Small Business Technology Transfer programs.

"We are excited about the entrepreneurial, innovative ideas that these small businesses are bringing to the table," said Jim Reuter, associate administrator for NASA's Space Technology Mission Directorate. "The technologies show great promise in helping NASA achieve its objectives across all mission areas, including our efforts to send American astronauts to the Moon, and then on to Mars, while also providing a long-term boost to the American economy."

Nearly one hundred of the selected companies will be first-time recipients of a NASA SBIR or STTR contract. More than 20% of the businesses are from underrepresented communities, including minority and women-owned businesses.

The selected proposals will support aeronautics, human space exploration and operations, science, and space technology. The selections cover research and development for a variety of applications, such as:

An intelligent rover wheel with integrated sensing and perception subsystems to improve mobility on the Moon and planetary bodies. The technology could also be used on Earth for autonomous tractors and other off-road vehicles.

A laser-based mass spectrometer that could be used to search for life on other planets. The technology could also be used for habitat air monitoring and terrain mapping.

A lightweight, deployable solar panel that leverages recent advancements in thin film solar cell technology. It rolls into a compact cylinder for storage, as opposed to conventional rigid solar panels that require mechanical hinges.

Technology that enables autonomous and safe operations of unmanned aircraft systems over long periods of time in cluttered, complex environments.

A technique to generate crater maps faster and at higher resolutions than the best manual identification efforts. This could help NASA efficiently map surface features of the Moon and Mars.

A simulation to screen, test and validate commercial off-the-shelf hardware that could be used for high-performance computing systems. The technology could help mission managers more efficiently select onboard electronics.

Image: NASA.

NASA is investing in technologies to enable Moon-to-Mars developments.

Proposals were selected according to their technical merit and feasibility, as well as the experience, qualifications and facilities of the submitting organization. Additional criteria included effectiveness of the work plan and commercial potential.

NASA's SBIR and STTR programs encourage small businesses and research institutions to develop innovative ideas that meet the specific research and development needs of the federal government. The programs are intended to stimulate technological innovation in the private sector, increase the commercial application of research results, and encourage participation of socially and economically disadvantaged persons and women-owned small businesses.

Three phases

The NASA SBIR and STTR programs are conducted in three phases:

- Phase I is the opportunity to establish the scientific, technical, and commercial merit and feasibility of the proposed innovation. SBIR Phase I contracts last for six months and STTR Phase I contracts last for 13 months, both with maximum funding of $125,000. The 363 selected proposals announced in this release are all in Phase I.

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NASA invests $45M in US firms for space technology

- Phase II is focused on the development, demonstration and delivery of the innovation. Phase II contracts last for 24 months with maximum funding of $750,000. Only small businesses awarded a Phase I contract are eligible to submit a proposal for a Phase II funding agreement. The latest SBIR program Phase II selections were announced in mid-May.
- Phase III is the commercialization of innovative technologies, products, and services resulting from either a Phase I or Phase II contract. Phase III contracts are funded from sources other than the SBIR and STTR programs.

To the Moon… and beyond

Charged with returning astronauts to the Moon within five years, NASA's Artemis lunar exploration plans are based on a two-phase approach: the first is focused on speed – landing astronauts on the Moon by 2024 – while the second will establish a sustained human presence on and around the Moon by 2028. NASA is expected to use knowledge, technologies and capabilities learnt on the Moon mission in the preparations for sending astronauts to Mars on subsequent missions.

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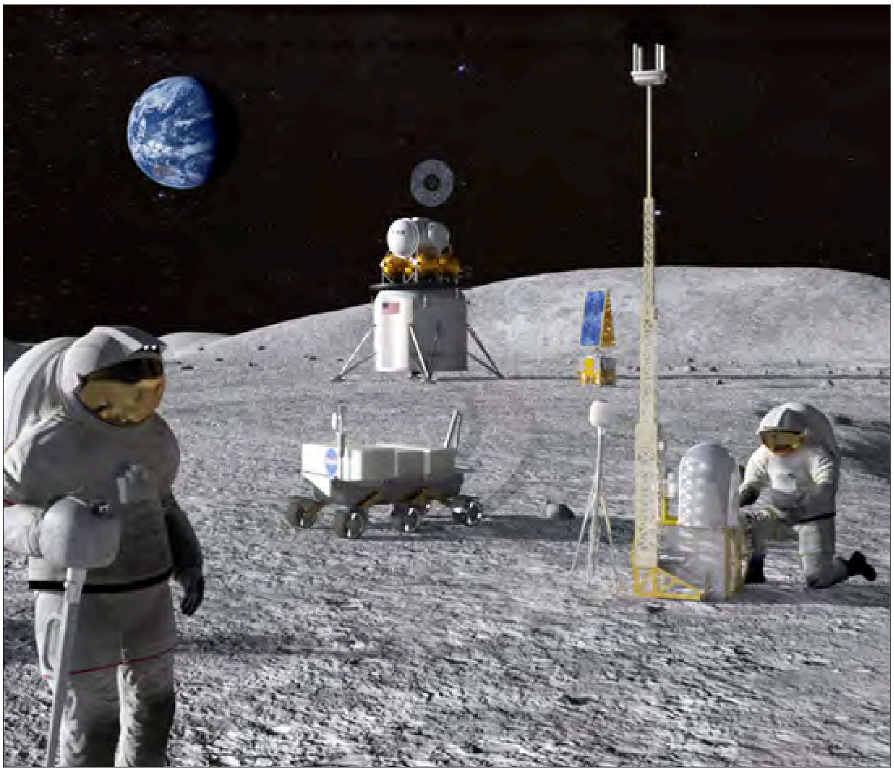
Image: NASA.

NASA is planning to land astronauts back on the Moon by 2024.

Image: courtesy of NASA / Zeiss.

Man in the Moon: Neil Armstrong's classic photograph of Buzz Aldrin.

One small camera click by a man, one giant photo album for mankind

Zeiss recalls developing its bespoke camera lenses that recorded first visit to the Moon, 50 years ago.

Fifty years may have passed since the first Moon landing, on 20 July 1969, but the unmistakable images, which have this week been widely republished around the world, have lost none of their power to fascinate. In fact, the main reason this event become so firmly entrenched in our collective memory is that it gave us the iconic images captured during the Apollo missions.

These were not only the first photographs ever taken of the Moon's surface, the image of the Earth as seen from the Moon also continues to inspire people of all generations to this day. And all the images from these missions originated in cameras using lenses developed by optics pioneer Zeiss.

The first Moon landing was also the first global media event. Audience ratings typically amounted to 50 per cent of populations, across the world, which means that an estimated 500 million people followed the event live on television. Many observers still remember exactly where they were when the Moon landing took place.

The history of photography in space took off with the Mercury (1962) and Gemini (1964) programs, which preceded the Apollo missions. Increasingly, camera lenses were bring used in the Earth's orbit. During these years, explained the company in a release published this week, "Zeiss laboratories further refined the technology and designed camera lenses ready to meet the challenges posed by space."

Custom lens, made for the Moon

In October 1968, Zeiss received the order for a camera lens to be used during the Moon landing, which was scheduled to take place a mere nine months later as part of the Apollo 11 mission.

"The time for this development was extremely brief," commented Dr. Vladan Blahnik, who works in research and development at the company. The optical data for the preceding model, the Biogon 4.5 / 38 (f 4.5 / 38mm focal length) still needed to be calculated manually, which was an extremely time-consuming process.

However, a mainframe computer helped to determine the mathematical parameters for the subsequent Zeiss Biogon 5.6 / 60, the camera lens designed for the Moon landing, in just a couple of weeks. Dr. Erhard Glatzel (1925-2002), a leading mathematician from the optical design department at Zeiss, ultimately received the Apollo Achievement Award for this and the development of other special lenses for space photography.

Bespoke 'Moon lens'

The customized Zeiss Biogon 5.6 / 60 "Moon lens" had to meet a number of requirements. While it was supposed to work within an easy-to-use camera, it also had to precisely map the lunar surface around the landing site.

Blahnik explained, "They decided on a camera fitted with a Reseau plate, which created a grid of cross-marks on the

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One small camera click by a man, one giant photo album for mankind

images. These made it possible to calculate the distances between individual objects on the Moon."

Image: courtesy NASA / Zeiss.

One small step for a man...

"The special symmetric design of the camera lens provided an excellent correction for distortions and all other image errors." A straight line remains a straight line. Furthermore, the images have great definition and edge-to-edge contrast.

Research inspires the present

Apart from the Zeiss Biogon used on the surface of the Moon, the company designed a number of other special camera lenses for space photography in the 1960s, among them lenses that could transmit UV-waves or extremely fast lenses such as the Zeiss Planar 0.7 / 50.

The company added that it continues to benefit from this research into the present day. Some examples are in the development of faster lenses for professional movie cameras, lenses for aerial photography used in surveying the Earth's surface, and lithographic lenses employed in the production of microchips.

Image: Zeiss.

The customized Zeiss Biogon 5.6/60 "Moon lens".

The camera lens made a significant contribution to the Apollo 11 lunar mission. But, interestingly, the cameras with the Zeiss lenses are still up there on the Moon, because to make the return journey, the astronauts needed to save every gram in order to take back as many samples of Moon rocks as possible; so only the valuable exposed film made it back to Earth.

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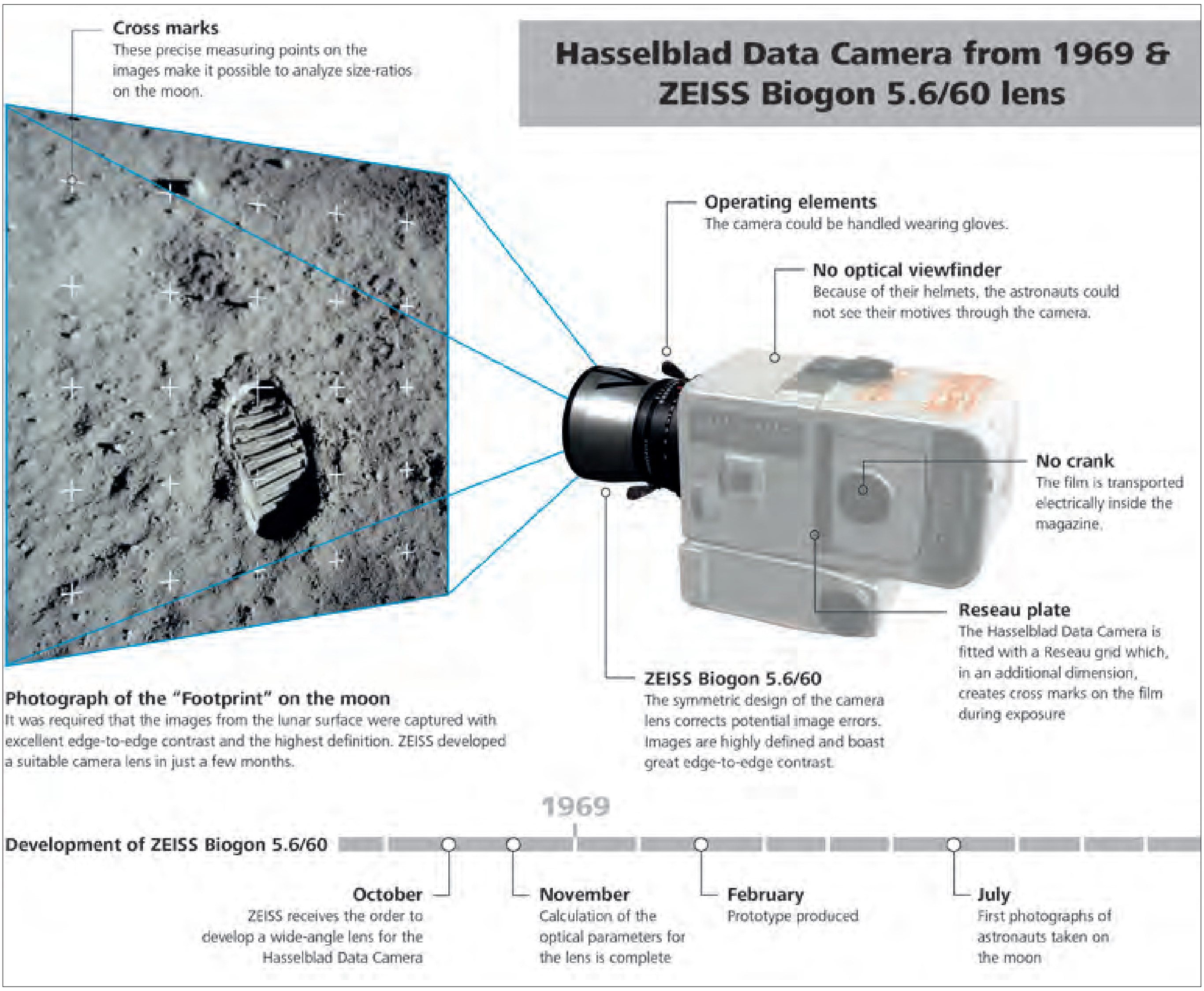

Image: Zeiss.

How Zeiss did it: the specification, operation and development timeline of the special Moon lens.

NASA Jet Propulsion Lab installs SuperCam on Mars 2020 rover

Camera, laser, spectrometer combination specified to identify "pencil point" targets from 6m away.

Engineers at NASA's Jet Propulsion Laboratory in Pasadena, California, have installed the SuperCam Mast Unit onto the Mars 2020 rover. The instrument's camera, laser and spectrometers are specified to identify the chemical and mineral makeup of targets as small as a pencil point from a distance of more than 6 meters (20 feet).

Credits: NASA/JPL-Caltech.

In this image taken June 25, 2019, engineers install the SuperCam instrument on Mars 2020's rover. This image was taken in the Spacecraft Assembly Facility at NASA's Jet Propulsion Laboratory, Pasadena, California.

SuperCam is a next-generation version of the ChemCam instrument operating on NASA's Curiosity Mars rover. It has been developed jointly in the U.S., France and Spain. Once France delivered the last piece of flight hardware, the instrument was fully integrated on the Mars 2020 rover at the end of June, 2019, in the Spacecraft Assembly Facility's High Bay 1 clean room at JPL.

"SuperCam has come a long way from being a bold and ambitious idea to an actual instrument," commented Sylvestre Maurice, the SuperCam deputy principal investigator at the Institut de Recherche en Astrophysique et Planétologie in Toulouse, France. "While it still has a long way to go — all the way to Mars — this is a great day for not only SuperCam but the amazing consortium that put it together."

Mars 2020 scientists will use SuperCam to examine Martian rocks and soil, seeking organic compounds that could be related to past life on Mars.

"SuperCam's rock-zapping laser allows scientists to analyze the chemical composition of its targets," said Soren Madsen, the payload development manager at JPL. "It lets the Mars 2020 rover conduct its cutting-edge science from a distance."

Also to be installed in the next few weeks is Mars 2020's Sample Caching System, which includes 17 separate motors and will collect samples of Martian rock and soil that will be left on the surface of Mars for return to Earth by a future mission.

Detail of the SuperCam instrument.

Mars 2020 will launch from Cape Canaveral Air Force Station in Florida in July of 2020. It will land at Jezero Crater on Feb. 18, 2021.

Human exploration

NASA will use Mars 2020 and other missions, including to the Moon, to prepare for human exploration of the Red Planet. The agency plans to establish a sustained human presence on and around the Moon by 2028 through NASA's Artemis lunar exploration plans.

SuperCam is led by Los Alamos National Laboratory in New Mexico, where the instrument's Body Unit was developed. That part of the instrument was installed in the body of the rover in May and includes several spectrometers, control electronics and software.

The Mast Unit was built with contributions from numerous academic laboratories in France, led by the French space agency Centre National d'Études Spatiales, and includes the high-powered laser, a telescope, a camera, an infrared spectrometer and a microphone. Calibration targets on the rover deck are provided by Spain's University of Valladolid.

Send your name to Mars

JPL is building and will manage operations of the Mars 2020 rover for the NASA Science Mission Directorate at the agency's headquarters in Washington. If you wish to send your name to Mars, you can do so until Sept. 30, 2019. Add your name to the list and obtain a souvenir boarding pass to Mars here.

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