



AMOLF

Changing the Properties of Light

AMOLF pushes the boundaries of nanophotonics using the FEI Helios NanoLab platform for rapid nanoprototyping.

The FOM Institute for Atomic and Molecular Physics' (AMOLF) Center for Nanophotonics conducts nanophotonics research by manipulating light with engineered nanostructures. Researchers create nanostructures, typically from metal combined with glass or silicon, and use them to change the properties of light. By making light behave unexpectedly—steering it around corners, slowing it down, or concentrating it—AMOLF builds scientific knowledge with far-reaching applications for communication, information, and medical technology. Using FEI's Helios NanoLab™ DualBeam™ system for the nanocharacterization and nanoprototyping of light-manipulating materials, AMOLF can:

- **Rapidly prototype nanostructures in a day, rather than a week to a month**
- **Make smoother, smaller nanostructures**
- **Test and iterate ideas for changing light properties faster**

The Challenge

Researchers at AMOLF want to see how much they can push the boundaries of light. “We try to do things once thought impossible,” explains Dr. L. Kobus Kuipers, head of the Center for Nanophotonics at AMOLF. “We want to bend light around corners, get it into holes smaller than the wavelength of light, and slow it down, even to the point of standing still.”

The potential real-world applications of such research are varied. “If you can steer light around an optical chip, you can reduce the scale of the chip and add more functionality,” says Dr. Kuipers. “Or, if you slow down light, you can make more energy-efficient optical devices. Concentrating light also is very useful. You can use sunlight more efficiently in solar cells. Or detect lower concentrations of molecules to identify disease at an earlier stage.”

Traditionally, researchers use electronic beam lithography or chlorine etching to make photonic crystals, which are the nanostructures needed to test ideas for controlling light. However, these processes take anywhere from a week to a month, and can cost upwards

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— Dr. L. Kobus Kuipers
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Located in the Amsterdam Science Park, the FOM Institute for Atomic and Molecular Physics is a research laboratory of the Foundation for Fundamental Research on Matter (FOM) division of the Netherlands Organization for Scientific Research. The approximately 100 scientists at AMOLF conduct research in the fields of nanophotonics and the physics of biomolecular systems.

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of \$50,000 per nanostructure. The AMOLF team wanted a faster way to create, characterize, and iterate nanostructures. And the smaller and smoother the structures, the better. "Light is very sensitive to the structures you make, particularly to imperfections," says Dr. Kuipers. "We needed an efficient and precise system for our research."

Why FEI

By choosing FEI, AMOLF got not only the state-of-the-art platform it needed to image, analyze, and control nanostructures; it also gained a partner in pushing the boundaries of science.

Dr. Kuipers explains: "We have direct access to the research and development team at FEI. AMOLF and FEI teams work together on new technology, developing innovative tools that give us an edge in our research. This partnership allows us to observe optical phenomenon before anyone else does—and then share what we've done with the rest of the world. Together, we'll contribute new knowledge to the field of nanophotonics."

The Solution

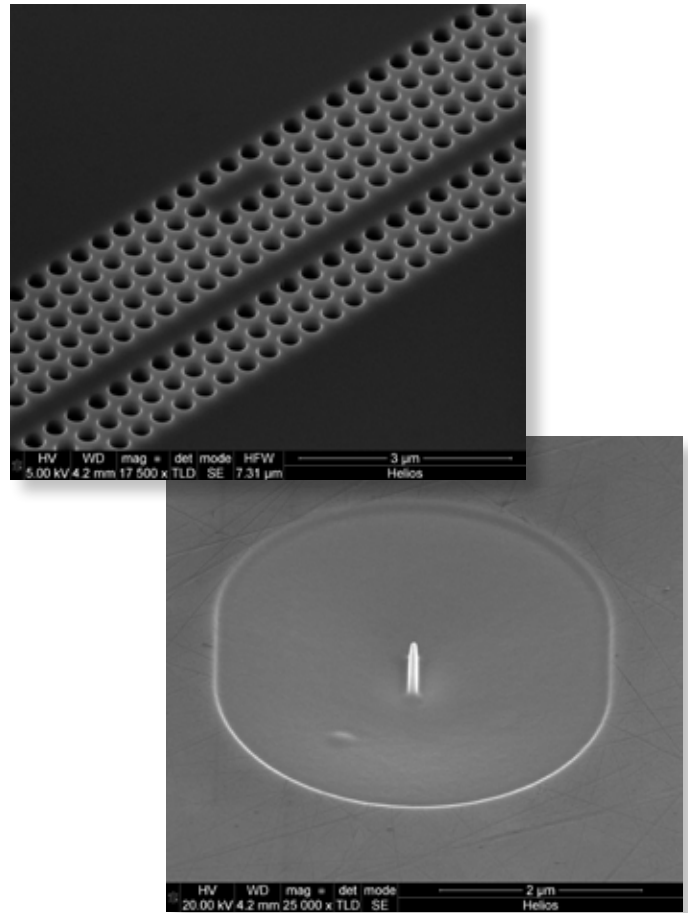
AMOLF uses the Helios NanoLab, a DualBeam from FEI that combines advanced scanning electron microscope (SEM) and focused ion beam (FIB) technologies with gas chemistries, detectors, and manipulators. The platform achieves sub-nanometer resolution at 15kV and better than 1.5nm at 1kV, facilitating nanocharacterization for AMOLF. Just as crucially, the system enables AMOLF to prototype nanostructures very quickly and efficiently.

"The Helios FIB is very good at sculpting metals—we have much more control over what we can make," says Dr. Kuipers. "We can also add materials with the gas injection system, allowing us to tailor structures in the third dimension on the smallest possible scale."

Once the team creates a nanostructure, the Helios helps with characterization. "With the Helios' robust imaging system, we can easily evaluate whether we're actually making the structure we set out to make by assessing its geometry. And together with FEI, we are implementing the first optical characterization in the Helios itself."

The Result

Using the Helios NanoLab platform, AMOLF's researchers do not need to spend up to a month creating a nanostructure to test an idea—they can do it in a day. "Nanoprototyping with



the Helios provides a very rapid cycle for testing and iterating an idea," says Dr. Kuipers. "We don't need to rely on expensive processes and complicated calculations. In fact, in many cases, prototyping a structure with the Helios is faster than crunching numbers on a computer."

AMOLF has etched a line in 200nm polycrystalline Au on glass that was 17 nm wide, and continues to push for smaller nanostructures with the Helios. The system is also helping AMOLF with another goal: creating smoother surfaces on its nanostructures. "We're doing work on metal nanostructures carved from a single crystal of gold," says Dr. Kuipers. "Because light is highly sensitive to imperfections in surfaces, it's critically important that our structures are as smooth as possible. Helios helps us meet this challenge."

Dr. Kuipers sums up the benefit of working with FEI in this way: "Our collaboration with FEI is not only critical to our research, it's helping us push the boundaries of our field."

FEI Company

World Headquarters
5350 NE Dawson Creek Drive
Hillsboro, OR 97124-5793
USA

PH: +1.503.726.7500

fei.com

FEI Europe

PH: +31.40.23.56000

FEI Japan

PH: +81.3.3740.0970

FEI Asia Pacific

PH: +86.21.6122.5988