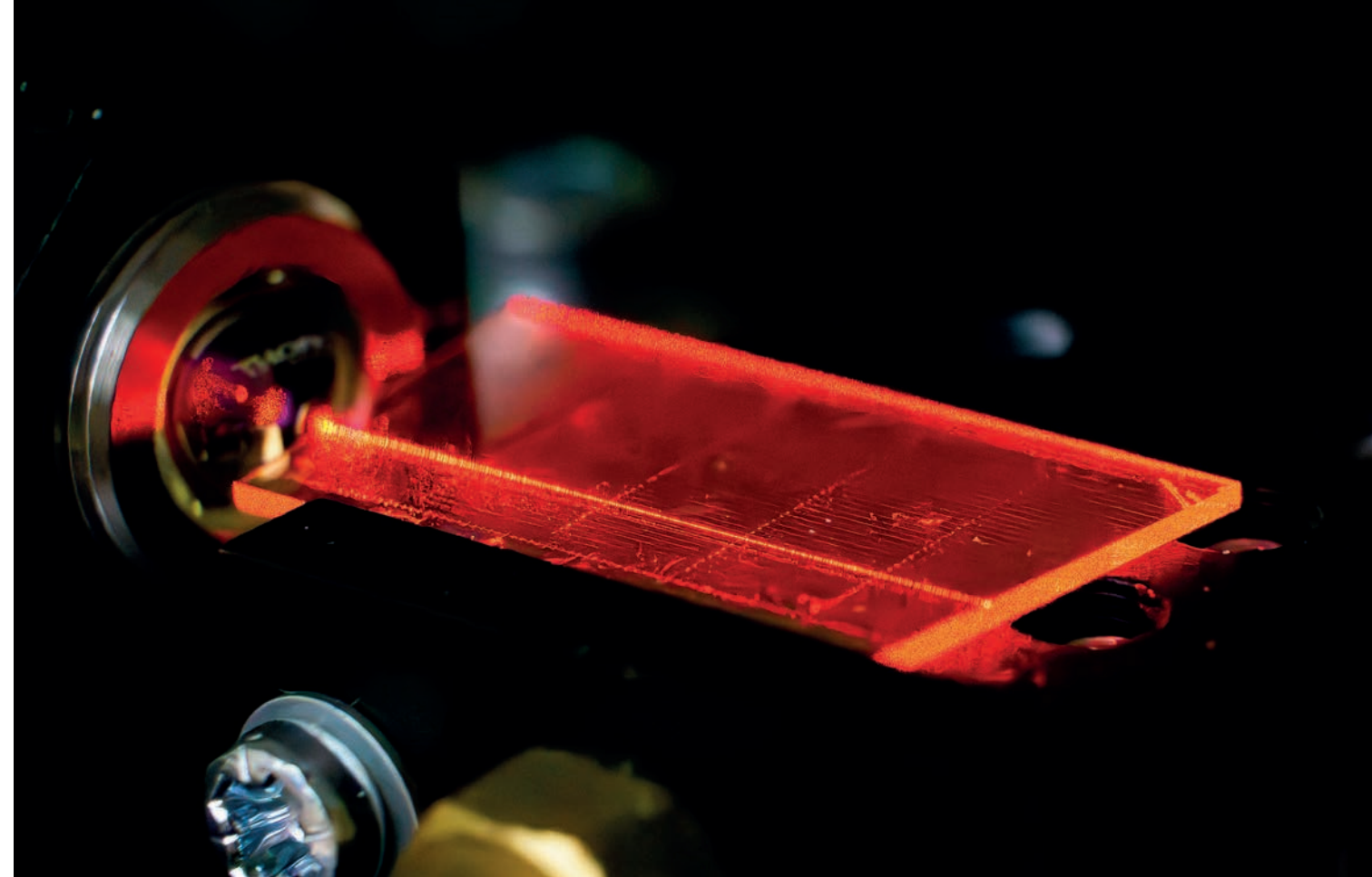


Focus on customized laser light

Customized light sources generated through nonlinear frequency conversion pave the way toward new wavelength ranges for use in science and industry.



Laser light is an integral part of modern applications in areas ranging from telecommunications and medical engineering to manufacturing and quantum sensor technology. However, many of these applications are thwarted by a seemingly simple problem, namely a lack of laser sources in the “right color.” The wavelength of laser light is determined by the laser material, but unfortunately the exact materials needed for many wavelengths are not available.

Instead of waiting for new laser materials, the solution is to convert existing

laser light into the desired wavelength. We do this through nonlinear optical frequency conversion – a physical principle that involves light being passed through special crystals that generate new frequencies. This process is used to create customized light sources tailored precisely to the specific area of application.

From crystal to light source

The technology is based upon periodically poled lithium niobate (PPLN) crystals. The targeted microstructuring of the

crystal facilitates processes like second harmonic generation (SHG) or sum frequency generation (SFG). Fraunhofer IPM has developed a fast, flexible and cost-effective method for maskless structuring without the need for clean-room conditions.

Waveguide technology makes this method even more efficient. The light-matter interaction is maximized by directing the light into microscopic channels in the crystal. This results in a high level of conversion efficiency while allowing for compact designs.

New colors for new areas of application

The new light sources have the potential to be used in a wide variety of areas. In quantum technology, for example, specific wavelengths are needed to cool individual ions or manipulate quantum mechanical states. The development of thorium-based nuclear clocks requires coherent laser light with a wavelength of 148.3 nm, which is a challenge that cannot be met by conventional lasers. Fraunhofer IPM is working on a continuous wave VUV light source based on the

crystal BaMgF₄, which has an exceptionally broad transparency range spanning wavelengths of 130 nm to 13 μm.

The demand for customized light is also growing in the industry. Areas of application span from the highly sensitive inspection of wafers in semiconductor manufacturing to a laser-based system for the drive-by measurement of the vitality of urban trees. Fraunhofer IPM provides the appropriate light source in all of these cases – tailored to requirements, robustly set up and ready for use.

We develop sub-micrometer ridge waveguides made from lithium niobate in which light can be generated and manipulated as required.



A BaMgF₄ crystal grown at the Leibniz-Institut für Kristallzüchtung (IKZ) with exceptionally broad transparency in the wavelength range of 130 nm to 13 µm is ideal for continuous wave VUV light sources.

From prototype to series production

From simulations and material processing to system integration, Fraunhofer IPM has all the in-house expertise needed to develop and implement components for frequency conversion and waveguiding. This allows for short development cycles and customized solutions. Fraunhofer IPM uses its broad technology platform to tap into new markets. The first pilot

projects with industrial partners are already underway. The aim is to put the technology into practice through spin-offs or license models and, in doing so, make laser light available in any color desired.



With our customized light sources,
we bring color into the mix –
exactly where it is needed.”

PD Dr. Frank Kühnemann