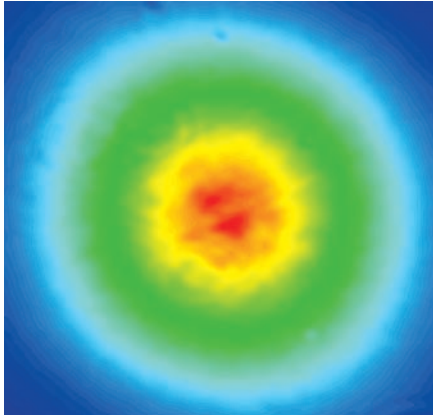


LASER MATERIALS

Crystal quality



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Opt. Lett. Doc. ID 98893 (2008)

There is a continuing search for gain media for compact laser systems that produce ultrashort pulses and ultrahigh peak power. Now, a collaboration between several research groups in Germany unveils a terawatt-level diode-pumped laser using single-crystalline Yb:CaF₂ as the amplifying medium.

Mathias Siebold and colleagues used a chirped pulse amplification process: femtosecond seed pulses stretched to 85 ns were amplified and then recompressed. Cylindrical Yb:CaF₂ crystals with a diameter of 28 mm and a length of 20 mm were pumped by two stacks of diode lasers. The team obtain a pulse energy of 197 mJ and a duration of 192 fs after recompression, corresponding to a peak power of 1 TW.

By using longer seed pulses the scheme can also produce nanosecond pulses that have an energy of up to 905 mJ without optical damage. This shows the potential of Yb:CaF₂ as a new laser material for high-energy nanosecond lasers.

Despite the low efficiency obtained, which can potentially be overcome by further optimization and scaling-up of the system, the researchers are confident that Yb:CaF₂ will be a promising gain medium for future ultrahigh-peak-power diode-pumped lasers.

NONLINEAR OPTICS

Down to size

Opt. Express **16**, 18050–18056 (2008)

Optical parametric oscillators (OPOs) convert laser light into two beams of lower-frequency photons. Harnessing this idea in optical fibres enables compact devices suitable for many diagnostic applications, and OPOs are now a very popular tool in optics laboratories all over the world.

Researchers in the USA have now shown that fibre optical parametric oscillators (FOPOs) can be used to generate sub-100-fs pulses.

Key to this achievement was a reduction in the length of the FOPO. The system used by Jay Sharping and co-workers incorporates a fibre just 4.2 cm long. This was made from a commercially available microstructured optical fibre that was modified by reducing the diameter of the core from 5 μm to 4 μm . This shifted the zero-dispersion wavelength. The fibre was placed in a 3-m-long optical cavity and pumped by 370-fs light pulses (wavelength of 1,032 nm) from a fibre laser.

The system's output was a series of pulses just 70 fs long with a centre wavelength of 880 nm. The team see a future investigation of the effects of different set-up parameters — core size and fibre length, for example — as crucial for a better understanding of this potentially very useful device.

FILAMENT PROPAGATION

Polarized apart

Opt. Lett. Doc. ID: 99060 (2008)

Filament propagation describes a beam that passes through a medium without diffraction. The properties of a laser filament — a small diameter and high intensity — are governed by laser-induced optical Kerr self-focusing and plasma defocusing. Now Yanping Chen and colleagues in Quebec, Canada, show how the polarization components of a femtosecond pulse can be separated by a co-propagating filament.

The researchers use 1-kHz, 800-nm, 75-fs (slightly negatively chirped) Ti:sapphire laser pulses: the first generates the filament, and the second is frequency doubled to 400 nm using beta barium borate crystal, for use as a probe. The polarization of the probe beam is analysed with a cube polarizer.

The pump was found to modify the polarization distribution of the probe. The polarization was parallel to the pump at the centre of the probe beam and orthogonally polarized at the periphery. The results were verified using different initial probe polarizations, all resulting in the same polarization distribution.

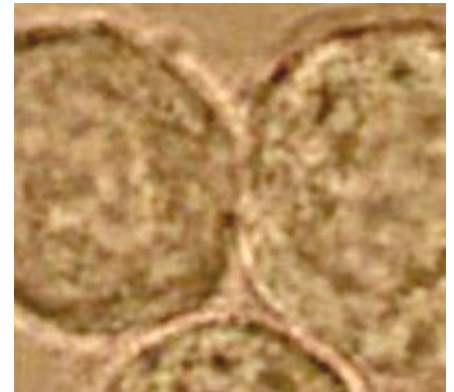
The mechanism of the polarization separator is explained by the difference in pump-induced nonlinear contributions to the refractive indices along the two orthogonal directions. For the components of the probe polarized parallel to the pump, the pump-induced Kerr self-focusing and plasma defocusing balance.

For the orthogonal components they do not balance, so these components are diffracted outwards.

The technique provides a novel broadband femtosecond polarization separator, useful for ultrafast information processing and telecommunications.

BIOPHOTONICS

Femtosecond fusion



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Appl. Phys. Lett. **93**, 163901 (2008)

Researchers in Hong Kong have come up with a way of efficiently fusing human cells together using femtosecond light pulses from a fibre laser.

Cell fusion happens naturally, but the ability to do it artificially provides cell biologists with a better understanding of the process. This in turn could lead to developments in genetic techniques and cancer treatments. Previous optics-based fusion techniques, such as the use of nanosecond-long pulses of UV light, have suffered from poor fusion success rates, about 10%, and surrounding cells were damaged by scattered light. Polyethylene glycol was found to improve the efficiency for fusing yeast cells, but it is toxic. The challenge is to improve the efficiency, but at the same time keep the cells alive.

Hao He and co-workers from the Chinese University of Hong Kong take an all-optical approach that does not require any chemicals. Optical tweezers moved two human hepatocellular carcinoma cells (HepG2) into contact. Pulses of light 200 fs long, at a wavelength of 1,550 nm were focused onto the contact area for about 10 s. The cells were then incubated for 90 minutes at 37 °C. The fusion was successful in 37.5% of the tests. Thermal effects were limited to the focal volume, reducing disruption to surrounding cells.

The technique was also used to join two different types of cell, HepG2 and human cervical cancer cells, although this was achieved at a much lower efficiency of 10%.