Tunable subpicosecond synchronously pumped fiber-optics stimulated-Raman laser

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A tunable subpicosecond stimulated-Raman-scattering laser has been developed. In this laser the stimulated-Raman-active medium, with a broad gain line, is a single-mode glass optical fiber. During synchronous pumping of the laser by a cw Nd:YAG laser with active mode locking ($\tau_p = 60$ ps), pulses 400–500 fs long have been obtained over the tuning spectral interval 1.076–1.12 μm. In addition, lasing at higher Stokes components and a spectral tuning of the laser have been achieved.

The problem of producing light pulses of tunable frequency, which have lengths in the femtosecond range, has recently attracted considerable interest. The greatest progress toward reducing the pulse length of laser light sources has been achieved by making use of nonlinear processes in glass optical fibers (Refs. 1–4, for example). Methods of this sort for producing femtosecond light pulses are based on a nonlinear conversion of comparatively long initial laser pulses in the fibers. In particular, Grudinin *et al.*[4] have proposed a simple way to produce femtosecond pulses which involves extracting at a higher-order Stokes component of the stimulated Raman scattering individual noisy surges of the spontaneous emission, from which the stimulated Raman scattering develops. However, because of the statistical nature of the spontaneous emission, the extraction of isolated pulses is of a random nature in that approach. In the present letter we report a new approach to the solution of this problem, in which

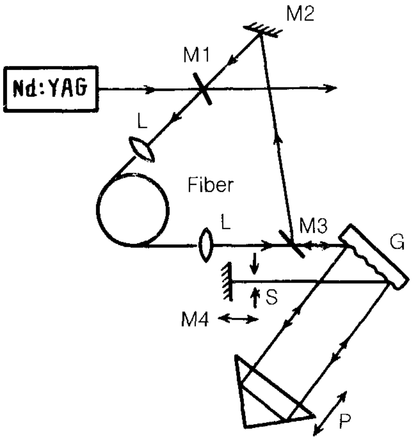

FIG. 1.

the fiber serves as a stimulated-Raman-scattering laser active medium. The cw lasing which is arranged makes it possible to produce stable, tunable, femtosecond pulses.

The stimulated-Raman-scattering gain line in quartz glass stretches from essentially zero to more than 1000 cm^{-1}. Nevertheless, in the conventional arrangements of synchronously pumped stimulated-Raman-scattering fiber lasers, the pulses which are generated in the spectral region of a positive dispersion of the group velocities of the fibers have a length comparable in magnitude to that of the pump pulses (usually, 100 ps).[5] Pulses 0.8 ps long were recently achieved by Kafka *et al.*[6] through compensation for the dispersion of the fiber in the resonator of a stimulated-Raman-scattering laser. In the present letter we report a development of a tunable, synchronously pumped, ring, stimulated-Raman-scattering laser with a pulse length of 0.4 ps.

A dispersive delay line using a diffraction grating G, a rectangular prism P, and a mirror M4 (Fig. 1) is positioned in the laser resonator in order to achieve a regime of in-resonator contraction of the Stokes pulses. An adjustable slit S is placed in front of mirror M4 in order to arrange in-resonator spectral selection. Synchronous pumping of the laser is provided by a cw Nd:YAG laser with active mode locking (the length of the pump pulses is 60 ps, and their repetition frequency is 125 MHz). After the light from this laser is reflected from dichroic mirror M1, it is coupled into the fiber.

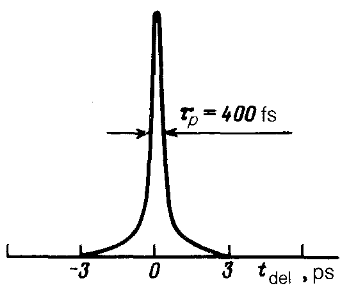

FIG. 2.

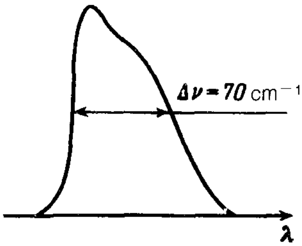

FIG. 3.

A single-mode fiber 110 m long, which preserves the polarization of the light, is used in order to eliminate polarization instabilities from the laser. The length of the resonator is adjusted by moving mirror M4; the dispersion of the resonator is adjusted by moving prism P.

At an average pump power of 0.8 W, the energy efficiency of the conversion of the pump light into the light of stimulated Raman scattering is $\sim 40\%$. A smooth tuning of the laser output wavelength over the interval 1.076–1.12 μm is achieved by moving mirror M4 and by adjusting slit S. The minimum length of the pulses from the stimulated-Raman laser is 400 fs, according to measurements based on a background-free autocorrelation technique of noncollinear second-harmonic generation in a nonlinear crystal (Fig. 2). The length of the pulses remains below 500 fs as the laser output wavelength is tuned over the entire spectral interval. The output spectrum of the laser is shown in Fig. 3.

In a modified version of the resonator of this laser, we have achieved lasing and a wavelength tuning at the second-order and third-order Stokes components of the stimulated Raman scattering.

Depending on the choice of the pump wavelength, this stimulated-Raman-scattering laser can be operated in both the visible and near-IR parts of the spectrum, i.e., over the entire range of transparency of quartz glass.

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Translated by Dave Parsons