1.06µm-1.35µm Coherent Pulse Generation by a Synchronously-Pumped Phosphosilicate Raman Fiber Laser

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Rare-earth-doped fiber lasers are attractive for microscopy and imaging applications and have developed over the past decades rapidly. They are unable to cover near-infra-red region entirely and therefore Raman and parametric process are promising for producing new wavelengths which are out of emission band of the current fiber lasers.

Here, we demonstrate a synchronously-pumped Raman laser system for producing coherent signals spanning from 1.06 µm to 1.35 µm. The laser system comprises a passively-mode-locked oscillator, two stages of amplifier and a phosphosilicate Raman oscillator. The schematic of experimental setup is shown in Fig. 1(a). A mode locked oscillator operating at 37 MHz is using as a seed source. The output pulse duration and central wavelength are 6 ps and 1065 nm, respectively. 6 mW output from oscillator is launched to pre amplifier comprises 85-cm long Yb 401-PM pumped by a single mode diode through a PM wavelength division multiplexer (WDM). The power amplifier consists of a 3.5-m long Yb 1200-DC-PM with 6 µm core diameter and 125 µm cladding diameter pumped by a temperature stabilized, high power multimode diode laser via a multimode pump-signal combiner (MPC). A 30/70 coupler is employed for delivering pump signal at 1060 nm to the Raman oscillator comprises 4.2-m long ph-doped fiber. To synchronize pump and Raman and achieve coherent pulses, we adjust the length of cavity by a precise translation stage. By using proper filter inside the Raman cavity, different wavelengths are achieved.

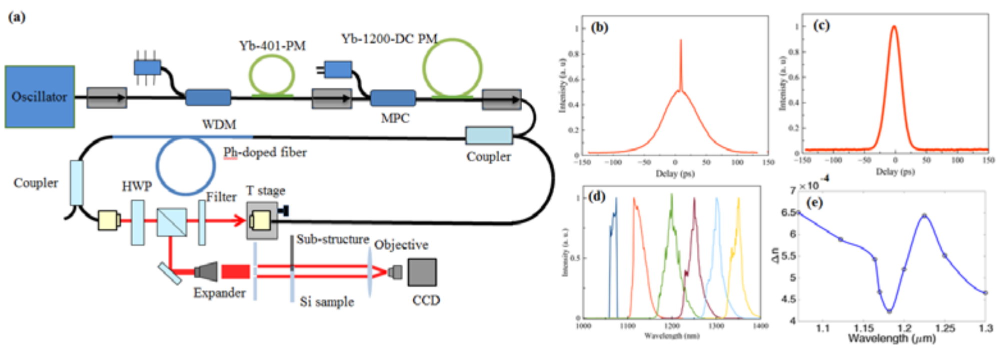

Fig. 1 (a) The schematic of experimental setup. WDM, wavelength division multiplexer; HWP, half wave plate; MPC, multimode pump-signal combiner; T stage, translation stage Measured intensity autocorrelation (b) before and (c) after synchronization. (d) Measured different wavelengths. (e) Measured refractive index difference between silicon and modified silicon for different wavelengths.

As an application of the proposed system, we quantify the phase delay and refractive index of Si subsurface structures as functions of wavelength. Si subsurface structures are a product of new fabrication technology that we proposed previously [1]. We measure the refractive index of the subsurface Si structures through interferometric method, and we track its spectral dependency by utilizing the large tunable range of the proposed laser. The interferometric method works as follow: the laser beam is divided to two identical parallel beams, with empty space in between (2 mm). First, both beams go through the Si sample along the thickness of the sample (1 mm). Both beams should pass though unprocessed area of Si at this point. After passing the sample, the beams are overlapped together by a lens, and the result interference pattern is captured by InGaAs camera after being magnified by 20x objective. After capturing the interference pattern, we slide the sample transversely so one of the beams is passing through the subsurface structures, while the second stays passing unprocessed area. Due to the phase difference between both beams, the interference pattern shifts. The pattern's shift to period ratio can be directly used to calculate phase delay

In conclusion, we have demonstrated a synchronously-pumped Raman laser based on ph-doped fiber to generate coherent signals from 1.06 µm to 1.35 µm. As an application, we measured change of refractive index due to modification.

[1] O. Tokel, A. Turnali, I. Pavlov, S. Tozburun, I. Akca, and F. Ö. Ilday, "Laser-writing in silicon for 3D information processing," arXiv:1409.2827v1 (2014).

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