

CLAIMS

1. A system comprising:
 - a tunable laser to emit a tunable excitation beam;
 - a wavelength sensor, in optical communication with the tunable laser, to measure an absolute wavelength of the tunable excitation beam;
 - a spectrally selective detector to detect a Raman signal emitted by a sample in response to excitation with the tunable excitation beam; and
 - a processor, operably coupled to the wavelength sensor and the spectrally selective detector, to determine a Raman spectrum of the sample based on the Raman signal and the absolute wavelength of the tunable excitation beam.
2. The system of claim 1, wherein at least one of the tunable laser, the wavemeter, or the spectrally selective detector is integrated in a photonic integrated circuit.
3. The system of claim 1, further comprising:
 - a band-edge filter, in optical communication with the tunable laser, to reject at least a portion of amplified spontaneous emission from the tunable laser.
4. The system of claim 1, wherein the spectrally selective detector has an active area larger than 50 μm by 50 μm .
5. The system of claim 1, wherein the spectrally selective detector comprises a filter to transmit a first portion of the Raman signal and to reject at least a second portion of the Raman signal and a photodetector to detect the first portion of the Raman signal.
6. The system of claim 5, further comprising:
 - a first lens, in optical communication with the sample, to collect the Raman signal;
 - a second lens, in optical communication with the first lens and the photodetector, to focus the first portion of the Raman signal on the spectrally selective detector.
7. The system of claim 6, wherein the first lens is arranged to fill an acceptance cone-angle of the spectrally selective filter with the Raman signal.

8. The system of claim 6, wherein a distance between the first lens and the second lens is less than or equal to about 150 mm.
9. A method comprising:
 - exciting a sample with a wavelength-swept excitation beam;
 - detecting a Raman signal emitted by the sample in response to excitation with the wavelength-swept excitation beam;
 - measuring an absolute wavelength of the wavelength-swept excitation beam; and
 - determining a Raman spectrum of the sample based on the Raman signal and the absolute wavelength of the wavelength-swept excitation beam.
10. The method of claim 9, further comprising:
 - filtering light at a wavelength of the wavelength-swept excitation beam from the Raman signal.
11. A swept-source Raman spectroscopy system comprising:
 - a tunable laser to emit a nonlinearly swept laser beam;
 - a first filter, in optical communication with the tunable laser, to reject amplified spontaneous emission (ASE) noise emitted by the tunable laser and to pass the nonlinearly swept laser beam;
 - a first lens, in optical communication with the first filter and having a numerical aperture of at least 0.5, to focus the nonlinearly swept laser beam to a point within a sample and to collect Raman light emitted by the sample in response to the nonlinearly swept laser beam;
 - a second filter, in optical communication with the first lens, to filter the Raman light with an extinction ratio of at least 60 dB;
 - a second lens, in optical communication with the second filter and having an etendue equal to or greater than an etendue of the first lens, to focus the Raman light;
 - a detector, in a focal plane of the second lens, to detect the Raman light;
 - a wavemeter, in optical communication with the tunable laser, to measure an absolute wavelength of the nonlinearly swept laser beam as a function of time; and

a processor, operably coupled to the detector and the wavemeter, to estimate a Raman spectrum of the sample based at least in part on the Raman light and the absolute wavelength of the nonlinearly swept laser beam as a function of time.

12. The swept-source Raman spectroscopy system of claim 11, wherein the tunable laser experiences at least one mode hop while emitting the nonlinearly swept laser beam.

13. The swept-source Raman spectroscopy system of claim 11, wherein the nonlinearly swept laser beam sweeps non-continuously in wavelength.

14. The swept-source Raman spectroscopy system of claim 11, wherein the detector has an active area with a width of at least 50 micrometers.

15. The swept-source Raman spectroscopy system of claim 11, wherein the wavemeter comprises:

- a lens to generate a substantially collimated beam from the incident radiation; and
- a grating to diffract the substantially collimated beam so as to form a plurality of Talbot images at intervals along a direction perpendicular to the grating; and
- a detector array, disposed at an angle with respect to the grating, to detect at least a portion of the plurality of Talbot images.

16. The swept-source Raman spectroscopy system of claim 11, wherein the detector is configured to detect a spatial distribution of the Raman light on the detector.

17. The swept-source Raman spectroscopy system of claim 11, wherein the tunable laser, the first filter, and the wavemeter are integrated on a substrate.

18. A method of measuring a Raman spectrum of a sample, the method comprising:
emitting a nonlinearly swept laser beam from a tunable laser;
filtering amplified spontaneous emission (ASE) noise from the nonlinearly swept laser beam;
focusing the nonlinearly swept laser beam to a point within a sample;
collecting Raman light emitted by the sample in response to the nonlinearly swept laser beam with a first lens having a numerical aperture of at least 0.5;

- filtering the Raman light with an extinction ratio of at least 60 dB;
 - detecting the Raman light with a detector having a lateral dimension of at least 1 millimeter;
 - while focusing the nonlinearly swept laser beam to a point within a sample, measuring an absolute wavelength of the nonlinearly swept laser beam as a function of time; and
 - estimating the Raman spectrum of the sample based at least in part on the Raman light and the absolute wavelength of the nonlinearly swept laser beam as a function of time.
19. The method of claim 18, wherein emitting the nonlinearly swept laser beam comprises making at least one mode hop with the tunable laser.
20. The method of claim 18, wherein emitting the nonlinearly swept laser beam comprises sweeping the nonlinearly swept laser beam non-continuously in wavelength.
21. The method of claim 18, wherein:
- filtering the Raman light comprises transmitting the Raman light through a filter having a transmission that varies in wavelength as a function of incidence angle;
 - detecting the Raman light comprises detecting a spatial distribution of the Raman light, the spatial distribution mapping to the transmission of the filter; and
 - estimating the Raman spectrum is based on the spatial distribution of the Raman light.
22. The method of claim 18, wherein measuring the absolute wavelength of the nonlinearly swept laser beam as a function of time comprises:
- transmitting incident radiation through a grating to generate a plurality of Talbot images;
 - detecting the Talbot images with a detector array tilted with respect to the grating; and
 - estimating the wavelength based at least in part on the plurality of Talbot images.