CLAIMS

1. A system comprising:

a tunable laser to emit a tunable excitation beam with a wavelength tuning range of 50 nm or less;

a wavelength sensor, in optical communication with the tunable laser, to measure ~~an absolute~~a wavelength of the tunable excitation beam;

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, wherein a passband of the band-edge filter overlaps with the wavelength tuning range of the tunable laser;

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,~~1, wherein the wavelength tuning range is at ~~least one~~ most 35 nm, and a center wavelength of the tunable ~~laser, the wavemeter, or the spectrally selective detector is integrated in a photonic integrated circuit~~excitation beam is an ultraviolet (UV) wavelength.

~~1.~~ 3. The system of claim ~~1,~~ 2, wherein the processor is further ~~comprising:~~

~~a band-edge filter, in optical communication~~ configured to determine the Raman spectrum with ~~the tunable laser, to reject at least a portion~~a Raman shift of ~~amplified spontaneous emission from the tunable laser~~up to 4000 cm^{-1}.

4. The system of claim ~~1,~~1, wherein a center wavelength of the ~~spectrally selective detector has an active area larger than 50 μm by 50 μm~~tunable excitation beam is a visible light wavelength.

5. The system of claim ~~1,~~1, wherein the ~~spectrally selective detector comprises a filter to transmit a first portion of~~processor is further configured to determine 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 signalspectrum with a resolution finer than 1 nm.

2. 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.

3. The system of claim 6,1, wherein the first lenstunable laser is arrangedconfigured to fill an acceptance cone-angle oftune the spectrally selective filter withtunable excitation beam across the Raman signal.

The system of claim 6, wherein a distance between the first lens and the second less iswavelength tuning range in less than or equal to about 150 mm. one second.

7. A method of detecting a target substance with a known Raman spectral response in a sample, the method comprising:

exciting emitting a tunable excitation beam with a wavelength tuning range of 50 nm or less, the wavelength tuning range selected based on the known Raman spectral response;

applying the tunable excitation beam to the sample withwhile measuring a wavelength-swept of the tunable excitation beam;

detecting a Raman signal emitted by the sample in response to excitation with the wavelength-swept the tunable 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 tunable excitation beam; and

determining a presence or an absence of the target substance in the sample based on the Raman spectrum.

8. The method of claim 7, wherein the emitting includes emitting the tunable excitation beam with a center wavelength selected from an ultraviolet (UV) wavelength and a visible light wavelength.

9. The method of claim 8, wherein the wavelength tuning range is at most 35 nm, and wherein the determining the Raman spectrum includes determining the Raman spectrum with a Raman shift of ~~the wavelength-swept excitation beam~~up to 4000 cm^{-1}.

~~4.~~ 10. The method of claim ~~9, further comprising:~~

~~filtering light at a wavelength of the wavelength-swept excitation beam from the Raman signal.~~

~~5. 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~~7, wherein the determining 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~~spectrum includes determining the Raman spectrum with a resolution finer than ~~an etendue of the first lens, to focus the Raman light;~~1 nm.

~~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.~~

~~6. 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.~~

~~7. The swept-source Raman spectroscopy system of claim 11, wherein the nonlinearly swept laser beam sweeps non-continuously in wavelength.~~

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

9. 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.

10. 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.

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

11. 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 towards 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.

12. The method of claim 18, wherein emitting the nonlinearly swept laser beam comprises making at least one mode hop with the tunable laser.

~~13. The method of claim 18, wherein emitting the nonlinearly swept laser beam comprises sweeping the nonlinearly swept laser beam non-continuously in wavelength.~~

~~14. 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 an incidence angle~~;~~ of the Raman light on the filter;

detecting ~~the Raman light comprises detecting~~ , with a detector, a spatial distribution of the Raman light~~, the spatial distribution mapping to the transmission of the filter~~; and

estimating the Raman spectrum ~~is~~of the sample based on the spatial distribution of the Raman light.

12. The method of claim ~~18,~~11, wherein ~~measuring the absolute wavelength of the~~ a passband of the filter shifts to shorter wavelengths at larger values of the incidence angle.

13. The method of claim 11, wherein the transmission of the filter varies nonlinearly ~~swept laser beam as a function of time comprises:~~with the incidence angle.

~~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~~

14. The method of claim 11, wherein the filter is a photonic crystal filter.

15. The method of claim 11, wherein the emitting includes sweeping the laser beam over a set of excitation wavelengths,

wherein the detecting includes, for each excitation wavelength of the set of excitation wavelengths, detecting the spatial distribution of the Raman light emitted by the sample in response to that excitation wavelength to detect a set of spatial distributions of the Raman light, and

wherein estimating the ~~wavelength~~ Raman spectrum includes reconstructing the Raman spectrum based ~~at least in part~~ on the ~~plurality of Talbot images~~set of spatial distributions of the Raman light.

16. The method of claim 11, wherein the incidence angle is a first incidence angle of a set of incidence angles defined by the Raman light on the filter,

wherein the transmission of the filter is different for each incidence angle of the set of incidence angles, and

wherein the spatial distribution of the Raman light is a wavelength distribution that maps to the transmission of the filter.

17. A system, comprising:

a tunable laser to emit a swept laser beam towards a sample along a first axis;

a filter having a transmission that varies in wavelength as a function of an incidence angle of the Raman light on the filter, to receive and filter the Raman light;

a detector to receive the Raman light from the filter and to detect a spatial distribution of the Raman light; and

a processor, operably coupled to the detector, to estimate a Raman spectrum of the sample based on the spatial distribution of the Raman light.

18. The system of claim 17, wherein the transmission of the filter varies nonlinearly with the incidence angle.

19. The system of claim 17, wherein the tunable laser is further configured to emit the laser beam by sweeping the laser beam over a set of excitation wavelengths,

wherein the detector is further configured to detect the spatial distribution by detecting, for each excitation wavelength of the set of excitation wavelengths, the spatial distribution of the Raman light emitted by the sample in response to that excitation wavelength to detect a set of spatial distributions of the Raman light, and

wherein the processor is further configured to estimate the Raman spectrum by reconstructing the Raman spectrum based on the set of spatial distributions of the Raman light.

20. The method of claim 17, wherein the incidence angle is a first incidence angle of a set of incidence angles defined by the Raman light on the filter,

wherein the transmission of the filter is different for each incidence angle of the set of incidence angles, and

wherein the spatial distribution of the Raman light is a wavelength distribution that maps to the transmission of the filter.