INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
MATERIALS MANAGEMENT DIVISION
Powai, Mumbai - 400076

Transient Absorption (TA) and Femtosecond Stimulated Raman Spectrometer (FSRS)

Note 1: All components are necessary unless "OPTIONAL" clearly specified against them.
Note 2: Since we will work with short pulses, wherever possible, optics must be reflective and compatible with the spectral requirement. For example, parabolic/concave/flat mirrors or equivalent reflective optical components should replace the lenses.
Note 3: Spectrometer should come with required optics to route the beam from the Amplifier and OPA to the system.
Note 4: For tunability and higher pulse energy of the Raman pump, in the future, we will replace the spectral filtering with ps-NOPA. There should be a provision for optical path compensation and route the Raman pump from ps-NOPA to the sample.
Note 5: Spectrometer must work in reflection and transmission mode for samples.
Note 6: There should be a space for cryostat/furnace in both FSRS and TA configuration.
Note 7: Documentation of components, for example, for optic components, i.e., parabolic mirrors, beam splitter, neutral density filters – (whichever is applicable) measurement range, spectral resolution, spectral range, efficiency, maximum incident energy should be provided, wherever applicable.
Note 8: In the technical bid, point by point list should be furnished to demonstrate requirements have been met.

Other important terms:

1. The system should come with a warranty of 1 years.
2. The authorization letter should be furnished along with the quotation.
3. The compliance statement should be enclosed with the quotation.
4. Indian agent should furnish a letter of authorization from the manufacturer along with the quotation
5. Indian agent should have trained service personnel to provide efficient after-sales service support. Names of those personnel along with their training certificates, should be furnished along with the quotation.
6. At least one similar system must have been installed by Indian agent or the parent company.
7. The installation should be done free of cost for all equipment. Training to operate the instrument must be given to our research scholars at free of charge.
8. Trained Service engineers in India should be available to resolve technical problems.
9. The vendor should take total responsibility for installing the spectrometer with existing amplified laser and demonstrating the performance.
10. In technical bid, technical specifications described below should be substantiated with data measurement on two samples to the user (two of the following samples will be sent -- FSRS: rhodamine 6G/Sapphire/$LiTaO_3$/$LiNbO_3$ in transmission mode, TA: GaN in reflection mode, thin films of halide perovskites in transmission mode). The inability to do so will lead to disqualification from the tender process.

The system **must perform** with our existing 50 fs Coherent fs amplified laser Model Libra (Rep. Rate 1kHz, energy per pulse: 4 mJ @ 1kHz, pulse duration: < 50 fs, Polarization: linear and horizontal, Spatial mode: TEMoo; M2<=1.35, Beam diameter: 9 mm, installed in December 2014), and **must be compatible** with 30-35 fs amplified laser output of energy up to 5 mJ (to be purchased later).

Output from existing amplifier (3 mJ available, rest is used with other optics) should be split into three parts – (1) 1.5 mJ to be fed to OPA, (2) 1 to 1.3 mJ for spectrally filtering the fundamental pulse to less than 10-15 cm-1, and (3) 0.2 to 0.5 mJ for white light generation.

Performance with the existing system and compatibility with the new laser system is a must.

Specifications for the spectrometer:

1. Spectrometer should have hands-off alignment, except when switching between TA transmission, TA reflection, and FSRS mode. Switching between TA transmission, TA reflection, and FSRS mode should have provision for magnetic bases to avoid alignment from scratch. OPTIONAL: Automated beam steering to the fundamental and OPA beam paths.
2. Optics should support the following spectral range for data acquisition and should come with a long pass, short pass, and/or reject filter to avoid contamination with pump beam during detection.
    a. TA: 350-1100 nm
    b. FSRS: 350-1100 nm
3. White light (WL) continuum spectral bandwidth: 350-1100 nm
    a. Preferably should be done with sapphire and CaF2 on automated crystal translation stage to avoid damage. A spare CaF2 crystal must be included.
    b. Beam splitter for probe reference is typically lossy, so should be replaceable by a mirror using magnetic bases.
    c. Probe light spectra should be analyzed for stability over a user specified wavelength range. The probe light spectra with deviation over a threshold should be notified/retaken to maintain statistical weight of the averaged spectrum.
    d. OPTIONAL: WL continuum pulse width should be less than 35-40 fs and preserve the laser pulse parameters and power
        i. preferably using WL prism/chirped mirror compressor.
4. Delay lines for probe and Raman pulse with respect to actinic pulse
    a. TA
        i. Delay line: 4 to 12 ns
        ii. Minimum step size: < 1 fs
        iii. Bidirectional repeatability: < 4 fs
        iv. Retroreflectors – Metallic (with no chirp) or chirp corrected dielectric mirrors to preserve the laser pulse parameters and power
        v. Fully automated and hands-off alignment

vi. Before measurement but after delay line alignment, beam path should not be actively adjusted or changed during the measurement process to avoid any temporal measurement error

b. Additional external delay and routing optics in FSRS configuration (in addition to 4a)
    i. Delay line: 4 to 8 ns
    ii. Minimum step size: < 1 fs
    iii. Bidirectional repeatability: < 4 fs
    iv. Before measurement but after delay line alignment, beam path should not be actively adjusted or changed during the measurement process to avoid any temporal measurement error
c. Note: if other configuration for delay lines, for example, external delay line, is used, then the proposed configuration should meet minimum requirement outlined in 4-a and 4-b.

5. Spectrograph
    a. TA (Transient Absorption)
        i. Spectrally resolved reference channel for correction of probe fluctuation for stable measurements
        ii. Minimum of one grating spectrograph with automated computer-controlled switching with ***resolution < 2.5 nm (@ 500 nm and 10 micron slit)*** with efficiency greater than 50% in spectral range from 450 to 750 nm
            1. Preferable 122 or 300 gr/mm grating with suitable blaze angle to maximize the efficiency
        iii. Multi-channel detector covering spectral range from 300 to 1100 nm
            1. Pixel size <= 500x(24-26) micron
            2. Sensor size >= 1024 pixels
            3. Scanning rate > 2000 spectra/second
        iv. Single/Dual input and dual exit ports, automatic optimization when changing between gratings or cameras, fiber coupling to deliver output light/signal to another part of experiment, wavelength repeatability better than 75 pm, wavelength accuracy center better than 0.15 nm.
    b. FSRS (Femtosecond Stimulated Raman Spectrometer)
        i. Spectrally resolved reference channel for correction of probe fluctuation for stable measurements
        ii. Minimum of two grating spectrograph with automated computer-controlled switching ***with resolution <0.75 nm @ 1000 nm, < 0.5 nm @ 800 nm, <0.4 nm @ 700 nm, 0.3 nm @ 600 nm, 0.25 nm @ 500 nm, 0.2 nm @ 400 nm with 100 micron slit***, along with efficiency greater than 50% in spectral range from 450 to 750 nm
            1. Preferable 600 gr/mm and 900 or 1200 gr/mm grating with suitable blaze angle to maximize the efficiency
        iii. Multi-channel detector covering spectral range from 300 to 1100 nm
            1. Pixel size <= 500x(24-26) micron

2. Sensor size >= 1024 pixels
3. Scanning rate > 2000 spectra/second

c. Note: If CCD is offered instead of CMOS/NMOS detector, CCD should meet requirements outlined in 5-b, with addition requirements
    i. Multi-channel detector covering spectral range from 200 to 1100 nm
        1. Pixel size <= (24-26)x(24-26) micron
        2. Pixel fill factor: 100%
        3. Sensor size >= 1024x(256-512) pixels
        4. Scanning rate > 250 spectra/second
        5. QE > 85% over 400 to 800 nm range
        6. Readout noise: 16 e- (at 1000 kHz) and 4 e- (20 kHz), rms
        7. Dark current: 0.0005 e/pix/sec
        8. Thermoelectrically cooled

6. Spectrometer must work in reflection and transmission mode for samples.
7. Two computer controlled optical chopper should accommodate actinic and Raman pump beams without sacrificing the contrast of pump-on and pump-off measurements and signal amplitude of both TA and FSRS.
8. Spectrometer should support precise monitoring of Raman pump wavelength whenever required without any need of major alignment.
9. Motorized stage for sample mounting with X and Y, and motorized/manual with Z and phi positioning along with liquid sample holder with magnetic stirring and stir bar. There should be a provision for flexible sample holder that can be used to hold transmissive thin-film samples mounted on rigid transmissive substrates. Specifications are below:
    a. X and Y direction to be motorized, Z and phi (rotation axis is Z) stages can be manual but meet requirements in points below
    b. Bidirectional repeatability: 1-5 micron
    c. Backlash: 1-5 micron
    d. Minimum achievable incremental movement: 0.1-0.5 micron
    e. Minimum achievable repeatable movement: 0.2-1.0 micron
    f. Minimum achievable incremental movement in rotation: 5-10 minutes
    g. Minimum achievable repeatable movement in rotation: 8-15 minutes
10. Polarization analysis
    a. Manual Berek polarization rotator (compensator plate) for actinic pump beam.
    b. Manual Berek polarization rotator (compensator plate) for Raman pump beam.
    c. Manual Berek polarization rotator (compensator plate) or half waveplate for probe beam.
11. Motorized/Manual neutral density filters for actinic and Raman pump.
12. External beam routing optics for optical path compensation.
13. Data acquisition hardware and software
    a. PC with 24 inch or larger LCD/OLED monitor (plus keyboard and mouse) with pre-installed software (for both TAS and FSRS) to perform all relevant functions for measurements including which are described in 14-b to 14-f.
    b. Software should include lifetime access to future software upgrades at no cost

c. Computer controlled switching between UV, VIS, and NIR modes
d. Random delay line stepping
e. Selection of time window for delay lines
f. Motorized/Manual control for pump intensity control
g. Automated pump beam shutter

14. Data analysis software for kinetic and spectral analysis should include the following:
    a. Advanced visualization and data export tools
    b. Averaging for multiple surfaces
    c. Advanced data manipulation including slicing, cropping, shifting, smoothing, fitting, subtracting, stitching, normalization etc.
    d. Time zero adjustment and temporal chirp correction for TA measurements
    e. Advanced global analysis including fitting to user-defined models, deconvolution with instrument resolution functions, weighting
    f. Export 3-dimensional datasets to ASCII or other user-friendly output.
15. OPTIONAL: Spectrometer should be upgradable to 240-2400 nm detection range and 500 microsecond time window with sub-ns resolution.
16. Laboratory requirement for installation and smooth functioning of equipment (working temperature range, humidity level, power back-up requirements).