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

PR NO.1000050435 **RFx No. 6100002466**

Item Description: Photon correlation setup with cryostat

NOTE

1. This procurement consists of two technically interdependent subsystems — **Part A (Photon-correlation Microscope System)** and **Part B (Closed-cycle Cryostat System)**. The two subsystems are required to function as a single integrated setup, and hence **must be compatible with each other** in terms of optical alignment geometry, sample positioning, and mechanical interfacing.
2. The two parts are being tendered **together under a single tender** to ensure technical compatibility. The **compatibility between the two subsystems will form a key parameter in the evaluation** of offers.
3. Please note that bidders must quote separately for Part A and Part B.
4. The technical and financial bids for both parts will be received simultaneously.
5. The tender evaluation will be item wise. During evaluation, Part A will be evaluated first and technically compliant vendor will be identified.
6. The technical and financial bids of Part B will then be opened. In the commercial evaluation of Part B, only those bids that are compatible with the technically compliant vendor of Part A will be considered for comparison.
7. Part A and Part B should be mutually compatible and tested prior to delivery and installation at the manufacturer location. Data to be provided for integrated operations of parts A and B
8. A declaration on company letter head regarding compatible components from the bidders for part A as well as B will be mandatory at the time of bid submission. Please provide a declaration with technical details of the compatibility with the appropriate part A or part B.
9. Kindly ensure that the prices for Part A and Part B are clearly stated and specified separately in the quotation.

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Technical:
An integrated Confocal Photoluminescence, TCSPC, Antibunching(g2), Hong Ou Mandel integrated with a closed cycle cryo system, while also allowing all such ambient measurements

Ambient as well as cryogenic 2D and 3D -- Photoluminescence Imaging capability including a confocal microscope, transfer and filtering optics, a spectrograph equipped with gratings, High QE multichannel detector, lasers, computer controlled XYZ stage etc and the relevant software and computer platforms is to be supplied. Company should have at least three antibunching and three TRPL systems in India.

Part A: Photon correlation setup

Sr. No	Item description	Technical compliance (YES/NO)	Additional information (if any)
1	***General requirements***		
a	Fluorescence Lifetime Imaging (FLIM)		
b	Fluorescence spectra spatial mapping for opaque samples (eg. 2D materials on silicon wafer)		
c	Antibunching Experiments - Hanbury Brown Twiss (HBT)		
d	Hong Ou Mandel (HOM) interference experiments		
e	Spatial resolution: diffraction limited spatial resolution 250nm or better with a 532nm laser		
f	White field illumination and optics for locating the region of interest (typically ~100 micron) over a silicon chip size >= 7mmx7mm		
2	**Excitation system:**		
a	**532nm excitation laser**		
	532nm picosecond pulsed laser CW output: 20 mW or higher Pulse operation at 80 MHz or higher Continuously variable repetition rate from CW to atleast 80 MHz Beam quality: TEM00 Pulse FWHM < 80ps Slots for including two polarization optics and a filter before the laser light hits the sample: - rotatable waveplate - rotatable polarizer - filter (bandpass or variable NDF)		
b	**One Laser Driver Module:**		
	freely adjustable, continuously variable repetition rates (from single shot to 80 MHz)		
	pulsed, burst and continuous wave operation of up to 8 laser heads		
	External trigger input		
	Synchronisation output		
c	**Housing of the Lasers:**		
	lasers housed in a compact housing, with up to 5 excitation lasers from polarization-maintaining optical fiber		

d	**Additional ports** An additional laser combining unit fibre entry port must be available to connect a laser (pulsed super continuum laser) provided by the customer via FC/APC fibre coupling. This port will be compatible with an external tunable laser. In future, an additional pulsed excitation laser at 940nm wavelength is planned to be coupled. The system should be ready for this integration on site by the user without shipping the unit back to the factory.		
e	**Filters and mirrors:**		
	Each excitation laser accompanied by a suitable fluorescence detection filter and main dichroic mirror, together with slots for linear polarizer and rotatable waveplate for excitation polarization control and variable neutral density filter for excitation power dependent measurements		

f	Fiber coupled secondary excitation entry port, allowing for modified excitation as below:
	- one pulse per cycle for standard applications such as g2, FLIM via the laser coupling unit to the entry port towards the sample
	- two pulses with the following four fixed time delays (as follows) available via the laser coupling unit to the entry port towards the sample (*basically for two fold excitation of the quantum emitter within the laser repetition period): eg. splitter and a fiber coupled delay line for the specific excitation wavelength of 532nm
	    - 6 ns
	    - 10 ns
	    - 15 ns
	    - 20 ns		

3.	**Microscope System and Objectives:**		
a	**Research grade microscope:**		
	The system should allow confocal microscopy for opaque samples (silicon chips)		
	One should be able to perform excitation and collection from same side (we only have opaque samples, eg. silicon wafer)		
	The setup should be able to perform imaging, illumination, fluorescence collection, etc) for completely opaque samples such as emitters on silicon wafers.		
	The microscope should allow the user to locate a region of interest (~20micron) over a silicon chip of >= 7mm x 7mm dimensions through whitelight imaging.		
	Color video camera for this purpose must be included		
	Compatible white light source for illumination for opaque samples (i.e. silicon chips)		
	Manual movement of XYZ stage for locating region of interest inside on the surface of our silicon chip. In addition to motorized scanning (see below in part c)		
	Sample holders should be able to mount our silicon chips with sizes ranging from 7mm x 7mm to 20mm x 20mm without using any coverslips, etc covering the top of the sample from where the PL emission will be collected		

	Optical Power Meter with capability to put in path of Microscope for measuring power on sample.		
	The system should allow switching between different laser excitation wavelengths		
b	**Objectives:**		
	VIS-NIR Objectives with >80% transmission from 570 -- 800nm: -10x with NA 0.25, WD 9.3 mm or more ; - 50x with NA 0.8, WD 0.58 mm or more; -100x with NA 0.95, Apochromat -100x with NA 0.9, WD 1 mm or more - these should preferably be mounted on a turret for ease of locating our small region of interest (~20 micron) over a large silicon chip area of 7mmx7mm		
c	**Large Area Mapping stage (XY and Z)**		
	Coarse scanning in XY on the surface of silicon chip over an area of 20mmx20mm or more		
	Fine 3D scanning; scan range 80 X 80 X 20 µm or more in xyz with a resolution <=10nm		
<u>4</u>	**<u>Detection System:</u>**		
a	- Open, modular system with various add-on and upgrade options, allowing a large degree of customization. Main Optical Unit with free access to optics and space for inserting custom optics - Atleast three simultaneously usable slots for each of filters, rotatable polarizers and rotatable waveplates for each SPAD arm		
b	Fiber coupled secondary excitation entry port, allowing for modified excitation (ie with custom defined delay mandatory for HOM). Refer to point 2f above.		
c	Tools allowing to optimize for best point measurement performance (=optimized PSF): beam diagnostic tools ▪ calibrated photo diode allowing to calculate the laser power at the objective position ▪ Camera-based monitoring of backscattered excitation light ◦ for determination and adjustment of laser focus position relative to opaque sample (silicon wafer) surface ◦ for detection of laser focus aberrations, allowing high precision alignment for optimal PSF		
d	Easily exchangeable and freely configurable standard sized optical filters ▪ for maximum performance ▪ for best possible match to individual experimental parameters ▪ Slot for 25mm filters in the emission arm before the pinhole		
e	Detection path optimized for maximum sensitivity, enabling best performance for quantum emitter sample (~ spread over a 20 micron area on an opaque silicon chip of dimensions >=7mm x 7mm)		
f	It should be possible to perform PL spectrum spatial mapping on opaque silicon wafer samples (with region of interest of about		

	20um or more) and coupling optics needs to be provided for free space/fiber input ports of a spectrometer (see Sec 4.3)		
4.1	**Single Photon Counting Modules (SPAD):**		
	Two pairs: one for antibunching and one for Hong Ou Mandel (see Section 5 below)		
	Spectral detection range between 400 nm and 1000 nm		
	Detection efficiency of a. >=70% at 650 nm b. >=50% at 550nm c. >=50% at 830nm		
	Dark count <=100 cps		
	Output pulse width <=10ns		
	Suitable coupling optics for these SPCMs for the antibunching and HOM experiment		
	Atleast three slots before each SPAD must be provided for mounting a. filter, b. rotatable polarizer and c. rotatable waveplate		
	4 sets of 750nm shortpass filter before the 4 SPADs to avoid spurious counts due to breakdown light from the SPADs		
4.2	**Electronics and System Software:**		
a	Integrated with the confocal path and synchronized with the time tagger module.		
b	Support for lifetime measurements in the range of 250 ps to 100 nanoseconds or higher.		
c	Electronics for both high precision and high throughput Time-Correlated Single Photon Counting (TCSPC):		
d	Capable of counting 4 independent detector channels simultaneously with < 1 ns dead time per TCSPC channel		
e	Sustained count rates up to 80 M events/s in a single TCSPC channel		
f	Time resolution of < 5 ps		
	Appropriate trigger modules and signal attenuators need to be included		
4.3	**Spectrometer**		
	Spectrometer with a focal length of atleast 300mm		
	Suitable filter for cutting the excitation laser (532nm, please refer to point 2a), with a PL emission spectrum in the range 570 -- 900nm.		
	PL spectral resolution < 0.1nm		
	Three gratings blazed near 550nm to match the spectral resolution and the wavelength range as given above. : - 150 gr/mm		

	- 600 gr/mm - 1800 gr/mm		
	System should be able to take Confocal Photoluminescence spectra spatial mapping with points 100 x 100 or more over a 50 micron x 50 micron (or less) sample area. During this imaging system should maintain focus stabilization.		
4.4	**Integrated data acquisition and analysis software**		
i	Data acquisition and analyses ● Time-resolved point measurements, ● Confocal FLIM, ● Antibunching measurements, ● Software should be able to process antibunching data and provide g^2 versus delay times. ● Should be able to perform spatial mapping of photoluminescence spectra by talking to a spectrometer ● Software should be able to fit lifetimes (exponential models, deconvolution support, etc) and g2 vs delay fitting via various models ● Allow saving the results to standard files formats ● The software license should have lifetime validity		
5.	**HOM interferometer customization**		
	◦ Detection system, consisting of: ▪ Beam splitter 1 (50/50 beam splitter) to split the light into two arms of the interferometer, specified for 570-900nm ▪ Two fiber launch systems (one for each arm) into SM PM fibers ▪ One arm equipped with a translation stage for time delay ▪ Following 4 pairs of SM PM optical fibers (with appropriate connectors) of different lengths for fixed timing compensation of - 0 ns -12.5 ns - 25 ns - 50 ns (the company may provide more than 4 pairs if required to cover the emission wavelength range of 570nm -- 900nm) ▪ 2×2 fiber or free space coupler (Beam splitter 2 for overlapping; 50/50 beam splitter) for a wavelength range of 570-900nm (the company may provide more than one if required to cover the emission wavelength range of 570nm -- 900nm). Should be able to connect to the above fibers using appropriate connectors. ▪ HOM measurement system using 2 SPADs having specs as given in Section 4.1 ▪ Coupling optics needs to be provided for PL spectral spatial mapping via a fiber entrance port of an existing spectrometer ▪ 2x holders for polarizing optics in emission (3 slots for waveplate, polarizer, filter in front of HOM fiber couplers) ◦ Excitation System (optimized for 532nm excitation): ▪ one pulse per cycle for standard applications, ie FLIM, G(2), via Laser Coupling Unit output 1 into the system entry port ▪ two pulses with a fixed time delays of		

	- - 6 ns - - 10 ns - - 15 ns - - 20 ns available via laser coupling unit output 2 into the system entry port, via a fiber-coupled delay line ▪ If providing different output ports for the above two in the laser coupling unit, movable mirrors must be provided to switch output between the two output ports ◦ - Compatibility with coupling to a Cryostat ◦ optical interface to Cryostat ▪ Collimated excitation beam output to external cryostat ▪ Bypass with either using a movable mirror or by by physically rotating the microscope between main optical unit and microscope body to switch between ambient microscope applications and cryostat ▪ Ambient microscope should be able to perform ambient PL mapping, TCSPC measurements, g2, HOM in reflection configuration (i.e. for opaque samples) ▪ Cryostat arm microscope should be able to perform (4.5 K -- 320 K) PL mapping, TCSPC measurements, g2, HOM in reflection configuration (i.e. for opaque samples) ▪ Electronic compatibility of the signals from the controller should be ensured ▪ Photoluminescence spectra spatial mapping, imaging, HBT and HOM should be possible for samples inside the cryostat (4.5 K -- 320 K), which a high spatial resolution < 500nm, with wavelength coverage from 570nm - 900nm - - External cryostat ◦ both systems, ie cryostat and system for HOM and G(2) have to demonstrate mutual compatibilty by combined integration and testing. Vendors have to prove that this is technically feasible (please refer to cryostat specifications below in part B). Please provide a declaration with technical details of the compatibility with the appropriate cryostat		
7.	**Acceptance criteria** - standard FLIM and G(2) ◦ standard acceptance tests based on suitable standard opaque (preferably on silicon wafer) samples provided by the manufacturer, consisting detector dark counts, detector IRF ◦ antibunching performance will be demonstrated with a suitable standard opaque (preferably on silicon wafer) sample provided by the manufacturer - HOM ◦ Beam-Splitter 1: will be better than 42/58 (in a wavelength range of 570 - 700nm)		

	◦ Beam Splitter 2: will be better than 42/58 (in a wavelength range of 570 - 700nm) ◦ Fringe visibility must exceed 78% tested at the factory using a standard interference protocol: a laser beam is split, recombined and detected at one port while the delay line is adjusted to maximize overlap, defined by FV = (Imax - Imin) / (Imax + Imin)		

PART B. CRYOSTAT and Nanopositioner

Sr.No	Item description	Technical compliance (YES/NO)	Additional information (if any)
	General Specifications ● There should not be any need for liquid Helium or any other consumable to run the system. ● Cryostat should have integrated temperature Controller and for the Fully automated and optimized ● Temperature control operations. At least 2 temperature control channels to be included in the system. ● The system should include the user and system calibration thermometers. ● Vacuum pumping system including vacuum pump, gauges, plumbing lines and chiller should be included and integrated with the system. ● Power requirement: Single Phase 50Hz, 220-240VAC		
	● Temperature ranges should be available from ≤ 3.8 K to ≥ 320 K. ● Peak-to-peak sample platform vibration (xy) allowed: 15 nm or lower. Provide sufficient supporting information. ● Temperature stability at the Sample mount of ≤ ±50 mK over 15 minutes. Provide sufficient supporting information. ● Vendors must provide the supporting data for temperature Stability, Vibrations and other critical parameters. ● Sample space of atleast 7.5cm in diameter ● The vacuum shroud and radiation shield should allow optical measurement for opaque samples (eg. silicon wafer chips)		

	Optical specifications: ● Optical windows should be made of fused silica or similar non-birefringent material. ● Type of window: Transmission should be more than 90% for wavelength range 0.4 to 1.0 microns. Appropriate AR coating for this range needs to be supplied. ● In the future, we plan to excite at 940nm and collect luminescence from 1100nm to 1600nm. Please provide windows compatible with these wavelength ranges as well. ● Window diameter should be 25 mm or more. ● The cryostat should have a cryo-objective, i.e. an objective mounted inside the cryostat, with numerical aperture >= 0.75, compatible with wavelength range from 500nm -- 900nm, necessary radiation shields and mounting hardware. The objective should have a minimum temperature drift with the sample. ● Aphromatic wavelength range 500nm -- 900nm with high transparency ● Should be possible to interchangeably use low working distance plate configuration versus above when using the cryostat for external objective scanning		
	Sample mounting: ● Necessary mounting hardware (adapters,spacer plates) for three-axis (XYZ) closed loop (nanopositioner) stage with a range of motion of 5mm (or more) in all three directions, as well as the possibility of scanning in over an area of atleast 30 micron x 30 micron in XY, and a suitable temperature sensor should be included. The Z-positioner closed loop with <=100nm accuracy. ● Base temperature at sample less than 4.5 K for more than 80 hours. ● Necessary hardware for extended temperature controls up-to atleast 320 K. ● Cool down time to less than 5K < 4.5 hours for operation. ● Temperature stability should be better than 20mK/hour at sample. ● Appropriate temperature controller with at least one PID channel (and through integrated software), or through external temperature controller. Appropriate heater is mounted on sample stage for temperature control.		

	● Calibrated temperature sensors at cold head and sample stage positions. ● Vibration levels in all directions < 20 nm peak to peak. (bandwidth required) If performance cannot be shown at the time of installation, the vendor should provide factory test reports for the supplied system. Test data for the system should be provided before shipment of the system. ● Drift stability < 50 nm/hour peak to peak continuously for several days. Drift should be less than 500nm within a day. ● The system should have at least 25 DC electrical pins and 4 RF pins (rated at ~ 15 GHz) for user experiments. These pins should have (resistive) wires which are thermally lagged at platform stage (1st stage/30K stage). ● A suitable Electrical Sample mount with 16 low-frequency DC connectors is to be provided. It should allow sample sizes up to 10mm square. ● Sample mounts must offer convenient platforms for wire bonding or soldering electrical connections to the user’s device. It is preferred to have separable mounting platform and electrical connections via the Wire harness to keep the wiring organized. ● PCB portion of electrical sample mounts should be reusable and replaceable with additional PCBs. Atleast three PCBs must be included. ● Electrical feed through with at least 25 DC pins and 4 RF should be available inside the sample chamber. ● Cryostat should be supplied with three axis stage (see above for specs). The suitable flexible thermal links must be provided for the integration of these stages. ● Cryostat should be supplied with a low temperature compatible XY scanner with specs as mentioned above ● Appropriate sample mounting accessory and cryo compatible grease should be supplied with the system so that on site testing can be done during installation ● Sample positioning within the cryostat to be better than 10 nm accuracy.		
	● Appropriate manifold dry vacuum pumping system (no oil-based pumps). ● Appropriate amount of Helium-4 gas for the system. Appropriate air- or water-cooled helium compressor with full charge of high purity Helium gas, with appropriate flexible lines/hoses. ● The hose lines should be equal to or longer than		

	20 meters. Electrical and cooling water requirements for the compressor must be specified, and the air/water chiller should be included in the quote. ● Maintenance interval for the compressor must be at-least 30,000 hours and for the cold head must be at-least 20,000 hours ● The system should be compatible with an optical table 1500 mm x 3000 mm (including part A). Both parts A and parts B should be able to be mounted on the same optical table of this size. All necessary accessories should be provided. ● Appropriate computer software for controlling the cryostat. Related accessories such as connectors, adapters, cables etc. are necessary for independent operation of the system at 220V, 50 Hz, single phase. ● One year warranty ● Base sample temperature should be demonstrated at the time of installation. ● The vendor should have a track record of having previously supplied similar equipment in India (please furnish the details).		