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MATERIALS MANAGEMENT DIVISION
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PR No. 1000052739 Rfx No. 6100002880:

Specification for QSM - Quantum Scanning Microscope (Qty: 01 No)

Sr. No	Item Description	Detailed Technical Specification	Technical Compliance (Yes / No)	Additional Information (if any)
1	**Quantum Scanning Microscope**	An integrated instrument for scanning magnetic microscopy using NV diamond centers (SNVM), including an atomic force microscope (AFM) coupled to a confocal laser unit and detector, MW source and NV-center diamond AFM probes, with control electronics and all the IT required for acquisition and control data processing (PC + software). The instrument must also be capable to perform MOKE imaging and hysteresis loop measurements.		
1.1	**Hardware Features**	**a. AFM part** 1. AFM necessarily uses a fixed-tip technique (only movements of the sample in X, Y and Z). The AFM tip must be in the fixed local plane of the excitation laser, and the system must be scanned by the sample in X, Y and Z directions, so that the excitation laser and AFM tip always remain perfectly aligned and focused.		

		2. A motorized "coarse" sample positioning system with a range of >5x5x5rnm3 and an accuracy of at least 1 µm		
		3. The AFM part contains an AFM scanning ranges XY> 80x80pun2 and Z>10ąm in mode "closed loop" (i.e. the position of the sample during scanning is determined by X, Y and Z position sensors included in a feedback loop).		
		4. Topographic imaging noise levels are typical: /0.2nm in X and Y (BW 100Hz) and +0.2 nnm in Z (BW lkHz)		
		5. The area receiving the sample should be as large as possible (e.g. to accommodate sample holders for in operando measurements)		
		6. The instrument must be equipped with an imaging system for lateral visualization, the sample and the AFM probe.		
		b. Scanning modes for the AFM section		
		1. Topography mode: Classic AFM topography imaging with feedback on the amplitude or resonance frequency of the Tuning Fork Oscillation		
		2. Constant height" mode: In this mode, the mean plane of the sample surface		

		is determined by at least 3 points on the scan range and SNVM measurement is performed in a plane at a given height above this mean plane.		
		3. 2-pass" mode; In the first measurement, the topography of the sample is determined, then on a second pass, the probe flies over this topography at a constant height		
		c. Confocal optical coupling with NV center AFM probe 1. Lens is at least 50X and 0.7 numerical aperture with highest transmission possible in the NV center emission band (650-800nm)		
		2. The equipment includes a green excitation laser (around 5l5nm) with a maximum power > l 0mW, variable and controlled by the software (typically from 0.01 to l 00%).		
		3. Confocal optics for XY scanning and Z-focusing of the laser on the AFM-NV tip for precise, automatic optimization of the focus the excitation laser on the probe's NV center. Scanning must be based on piezoelectric actuators to ensure the best possible precision (typically of 50nm).		
		4. A single-photon avalanche diode detector with the highest efficiency possible around 670nm (typically >60%).		

		5. Excitation wavelength filtering prior to entry into the photon detector		
		6. The microscope must include an optical wave plate in excitation path to allow polarisation control of the excitation line, controllable via software		
		7. The device's optical system must enable magneto-optical Kerr effect measurements (MOKE).		
		8. The device's optical system must enable hysteresis loop measurements via magneto-optical Kerr effect measurements (MOKE).		
		9. This instrument is designed to be compatible with an inverted optics geometry, for illuminating and reading NV centers from underneath the sample		
		d. Microwave irradiation system (MW) for the single NV center of the AFM probe 1. A variable MW source from 0.5 to 6Ghz and a suitable amplifier for this range frequency. Maximum output power must exceed 30 dBm and be set from 0 to max from the software.		
		2. The MW circuit must be capable of generating a MW pulse with a duration of 4ns or more.		
		3. An XYZ micromanipulator to bring the antenna radiating the MWs as close as possible to the NV		

		4. The AFM head tip holder must be compatible with AFM NV probes with a integrated MW line		
		e. Vector Electromagnet to generate arbitrary bias fields 1. The instrument must include a "magnetic field module" for applying vectorially a magnetic field to the sample and the AFM probe (true 3D vector field). This field must have a maximum value greater than 80mT (typically 100mT) and must be modifiable rapidly in amplitude and orientation. The module must be capable to switch the bias field direction from in-plane to out-of-plane during a scan.		
		2. The instrument must be fitted with a sample holder allowing DC and RF connections to the sample for in operando measurements. This sample holder must be compatible with the "magnetic field module".		
		3. The instrument must be compatible with a heated sample holder (up to at least 100°C) while the sample is being measured, keeping AFM scan drift low		
		4. The instrument must be hosted in a sound- and heat-insulating enclosure with a active temperature		

		control to achieve the lowest possible AFM drift in all the directions (typically <2nm/h along X, Y and Z).		
		5. The instrument must include a vibration damping table to isolate the microscope from the vibrations of the environment.		
		6. The instrument must be supplied with at least 10 AFM probes containing a single NV center showing an ESR contrast of at least 15 % for a photoluminescence of at least 350 Kcts/ s and distance from NV center to surface <50nm		
		7. At least 4 equivalent equipment must already have been installed worldwide.		
		8. The control computer should include a raid 1 backup system.		
		9. The control computer must include a storage system of at least 2TB.		
1.2	**Measurement Modes**	**a. Basic Modes** The instrument must support at least the following magnetic imaging modes following: 1. “Quenching” mode: measurement of the photoluminescence of the NV center without applying MW		
		2. Iso-B mode: measurement of the PL of the NV centre under MW irradiation at a single frequency		
		3. Dual mode Iso-B: measurement of the PL difference of the NV centre under MW		

		irradiation at 2 different frequencies		
		4. CW-ODMR mode: measurement of ESR (Electron Spin Resonance) position on the MW frequency band required to account for variations in the magnetic field at the sample surface		
		5. FAST CW-ODMR mode: CW-ODMR with ESR resonance tracking measured on a reduced-frequency window. This window needs to be moved dynamically in order to track the shift of the ESR resonance as a function of the magnetic fields radiated at sample surface. This mode should allow to measure using pixel rates of up to 200 Hz.		
		6. Spin-wave imaging: spatially image surface spin waves and allow scanning with height control		
		7. Gradiometry (magnetic gradient maps using spin echo synchronized to the AFM tuning fork oscillation)		
		b. Advanced measurement modes The instrument must be able to apply arbitrary sequences of laser and MW pulses (of a duration of the order of 10ns)		

		1. Pulsed ODMR 2. Rabi oscillations 3. Relaxation time (T1) 4. XY sequences 5. Spin Echo (T2) 6. Ramsey (T2*) The system must enable the corresponding imaging linked to these "measurement in the field temporal” (for example, produce an image with T1 measurement at each pixel) The control software features a dedicated interface to allow writing custom pulsing sequences for the laser and MW which can also be used for scanning		
1.3	**Warranty**:	1 year from the date of installation		