**Annexure I**

## Technical Specifications for 'Cryostat'

| 1 | **Bidder Eligibility Criteria-** | **Compliance (Yes/No)** | **Reference Page No.** |
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| 1.1 | The bidder/OEM should have supplied at least 3 similar items to IITs, NITs, IISERs, CSIR Labs or other Govt. R&D organizations in the last 5 years, PO copies or installation certificates along with contact details of end user need to be submitted as the proof of supply. IIT Madras reserves its right to verify the claims submitted by the bidder and the feedback from the previous customers will be part of technical evaluation. | | |
| 1.2 | The Bidder/OEM's service center should be in India to attend service related issues. Proof of facility location & contact details to be provided along with technical bid. | | |

## 2. Technical Requirements for Cryostat

**Important features and other details**
**Main Equipment: Cryostat**

Cryogen-free cryomagnetic system for measuring the electrical and magneto-electrical transport properties of quantum solids.

## General Specifications

**Key Features**
A cryogen-free cryo-magnetic system for the measurement of electrical and magneto-electrical transport properties of quantum solids in the temperature range of 300 mK to 300 K and under a continuously variable magnetic field of 0 to ±14T. In addition, the chip-carrier mounted sample holders (operating under low pressure < $10^{-5}$ mbar) should be rotatable about a horizontal axis in the angular range of 0 to 180$^{o}$ such that the sample is always under the uniform magnetic field.

| S.NO | | Technical Specifications | Complied / Not Complied | Reference Page No |
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| **2.1** | | The cryogen-free cryomagnetic system should be based on Pulse-Tube refrigeration. The detailed specifications of the Pulse-Tube refrigerator along with the compressor should be provided separately. | | |
| **2.2** | | **Top loading variable temperature insert (VTI)** | | |
| | i | Temperature attainable at the sample position should be 1.6 to 300 K, with a possibility to maintain the sample at a given temperature for at least about 72 hours or higher. In addition, there should be no abrupt change in sample temperature, as the temperature is swept from1.6 to 300 K. | | |
| | ii | The VTI sample space should be at least 50 mm or higher in diameter and it should be isolated from the cooling fluid circulation loop. | | |
| | iii | The VTI should be fitted with 40-pin or higher chip carrier sample holder with ESD protection. Additionally a smaller 20-pin or higher chip carrier sample should also be provided with easy option of fixing either 40 pin or 20-pin chip carrier sample holders. Further, it should have the option for holding the sample at two fixed planes: Parallel and perpendicular to the axial magnetic field. | | |

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| | iv | Two 24 pin Fischer connectors should be provided to couple the electrical leads outside the VTI. Additionally a separate suitable Fischer connector(s) should be provided for taking the electrical leads for heater and temperature sensor. All Fischer connectors must be hermetically sealed type. | | |
| | v | A minimum of 22 twisted pairs of resistive wiring should be provided with one end wired to the chip carrier sample holder and the other end soldered at the two 24-pin Fisher connectors. | | |
| | vi | The electrical resistance between the twisted pairs and that between each wire and the ground must be not less than 50 G Ohms. | | |
| | vii | The sample should be maintained at low pressure ($10^{-5}$ mbar or better) all through the measurements. | | |
| | viii | The cool down time of the VTI from 300 to 5 K (or lower) should be 120 min or better in the absence of magnetic field. | | |
| | ix | The VTI temperature should be controlled by a tunable PID controller with a resolution of ± 50mK (preferably less than ±10 mK ) at a given temperature. | | |
| | x | While the magnet is energized, the temperature stability should be ±100 mK or better at a given temperature. | | |
| | xi | Heater and the cernox sensor should be fitted close to the sample position. All temperature sensors including those at the cold heads should be calibrated. | | |
| | xii | The J-T needle valve should be controlled automatically (motorized) using a separate tunable PID controller. Also, it must have necessary protection from over-closing. | | |
| | xiii | The control electronics for temperature, needle valve position, etc., should have the options for USB, TCP/IP and GPIB 4888 interface | | |
| | xiv | Loading and unloading of the VTI should not lead to clogging of the cooling fluid circulation assembly. | | |
| | xv | The internal surfaces should be free of physical scratches. | | |
| | xvi | Four semi-rigid coax lines (UT85 SS-SS, frequency up to 18GHz) with SMA connector on one end and suitably terminated at the sample end (should not be left free). | | |
| **2.3** | **Top loading variable temperature insert with sample rotation (VTI-SR).**<br><br>The specifications for this probe include following additional requirements i and ii apart from those given for the VTI in point 2.2 of this document. | | | |
| | i | The VTI-SR should allow rotation of the sample about a horizontal axis over the angular range of 0 to 180$^{o}$ such that the sample is always under the uniform magnetic field. | | |
| | ii | Sample rotation should be done using stepper motor and associated controllers with an angular resolution of 0.5 degree or better. It must have the necessary protection mechanism from being rotated beyond the specified angular ranges. | | |
| **2.4** | **$^{3}$He Variable temperature sorption insert (3H-VTSI)** | | | |
| | i | The 3H-VTSI should be a complete system along with $^{3}$He gas and the controller. $^{3}$He gas should have 4N chemical purity or more with an isotopic enrichment of > 99.9 %. | | |
| | ii | The 3H-VTSI should be capable of attaining 300 mK and should be able maintain it for 40 hours or longer with no applied heat load. | | |
| | iii | The 3H-VTSI should be capable of maintaining the temperature in the rang 300mK to 300K, with typical stability of ± 25 mK below 1.2 K and ± 0.1 K above 1.2 K. | | |
| | iv | The 3H-VTSI should have a cooling capacity of maintaining temperatures < 350 mK for at least 6 hours with 50 μW heat load. | | |
| | v | Capacity of $^{3}$He in 3H-VTSI must be at least 4.0 L or higher such that the hold time and cooling power requirements as mentioned in 2.4 (i-iv) are met easily. | | |

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| | vi | The 3H-VTSI should allow rotation of the sample about a horizontal axis over the angular range of 0 to 180$^{o}$ such that the sample is always under the uniform magnetic field. Sample rotation should be done using stepper motor and associated controller. Angular resolution should be 0.5 degree or better. It must have the necessary protection mechanism from being rotated beyond the specified angular ranges. | | |
| | vii | A 20 pin or higher chip carrier with ESD protection should be provided for operation from 300 mK to 300 K and under magnetic fields ±14T. | | |
| | viii | One 24 pin Fischer connectors should be provided to couple the electrical leads outside the 3H-VTSI. Additionally a separate suitable Fischer connector(s) should be provided for taking the electrical leads for heater and temperature sensor. All Fischer connectors must be hermetically sealed type.<br>A minimum of 10 twisted pairs of resistive wiring should be provided with one end wired to the chip carrier sample holder and the other end soldered at the 24-pin Fisher connector. | | |
| | ix | 3H-VTSI should have separate associated electronics like temperature controllers. | | |
| | x | The 3H-VTSI should be equipped with the necessary electrical leads, calibrated sensors and components such that it is ready made for immediate measurements. | | |
| **2.5** | **Magnet and magnet power supply** | | | |
| | i | A compatible superconducting magnet assembly with homogeneity better than 0.1% over 1 cm sphere. | | |
| | ii | The magnet power supply should be capable of 4-quadrant operation. It should have 20-bit resolution and the field stability in constant current mode should be less than 5 ppm/K. | | |
| | iii | The magnet power supply should be capable of continuous field sweep from 0 to ± 14 T and also field sweep in the form of loop like -14 T to +14 T and back to -14 T. It should also have the option to produce ultra-low fields (20 - 30 mT) with a resolution of 1 μT. | | |
| | iv | The current sweep rate should be in the range 0.02 A/min or lower with a maximum sweep rate of 1100 A/min or more. Magnet power supply should have the option to ramp the current in the manual and remote (software control) mode. | | |
| | v | The magnet power supply should have the option to set the magnet in the persistent mode. Also it should have protection circuitry in case of magnet-quench. | | |
| | vi | The magnet power lines must be electrically isolated from the all the insets. | | |
| **2.6** | **Temperature controller** | | | |
| | i | The temperature controller should be compatible with all the sensors with at least 3 PID control loops including the heater temperature and J-T valve. | | |
| | ii | Apart from the primary interfaces it should have an additional GPIB IEEE interface card and a compatible heater card. | | |
| **2.7** | **Compressor** | | | |
| | i | The compressor should be of water-cooled type and should be fully charged with the required high purity helium gas for ready operation. The flexible SS lines connecting the compressor and the system should be at least 15 m long. Also, all helium lines should be electrically isolated. | | |
| | ii | The compressor must be capable of functioning for at least 30,000 hours and the cold head for at least 20,000 hours, before the first maintenance / service. | | |
| **2.8** | **Pumping station** | | | |

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| | i | The system should be provided with a suitable dry pumping station (scroll and turbo pumps) for VTI and cryostat along all essential accessories such as flexible SS bellows, connectors, flanges, center-rings, O-rings, blinds, etc. | | |
| **2.9** | **Software** | | | |
| | i | All essential drivers and unified software should be provided for quick interfacing of the control units (Temperature controller, Magnet power supply, Compressor, etc.,) to a PC. Also, all future upgrades should be made available free of charge. | | |
| | ii | The unified software provided should have the provision to control the magnetic field and temperature with user defined parameters such as start, stop, ramping rate, hold time etc. for all the inserts. | | |
| **2.10** | **Miscellaneous** | | | |
| | i | The supplied system should have the option for the onsite up gradation of the system to achieve temperatures down to 25 mK or below. | | |
| | ii | All essential requirements such as the Electrical power, sockets, back-up power, water flow rate and temperature and other relevant information for smooth installation and running of the system should be communicated well ahead. | | |
| | iii | An estimate of the time frame required for the delivery and installation should be mentioned clearly. | | |
| **2.11** | **Optional Items: To be submitted on a separate quote** | | | |
| | i | Quote for hardware and software required for 2 and 3 terminal (gate sweep)) 2 probe and 4 probe I-V measurements at user defined range of temperatures and magnetic fields. Provide the required arrangements to perform simultaneous measurements of transverse and longitudinal conductivities under AC+DC excitation in a standard hall geometry. | | |
| | ii | Electrostatic Discharge Protection Unit along with all necessary cables (compatible with the Fischer connectors mentioned before) and other accessories. | | |
| | iii | Suitable low pass filters, if possible with a provision to be located close to the sample. | | |
| | iv | Additional Heater wires and calibrated cernox temperature sensors, and twisted resistive wires suitable for 1.6 and 300mK temperature operation. | | |
| | v | Quote for 2 multimode optical fibres to support the optical transmission in the wavelength range of 350 nm or lower to 1100 nm or higher. One end of the fibers should be coupled to a Hermetically sealed fiber couplers to couple the light out of the system. | | |
| **2.12** | **Other Terms And Conditions** | | | |
| | i | Three years onsite warranty for the entire system. | | |
| | ii | Factory-trained engineers must carry out the entire installation. Onsite training including basic knowledge about the installation of the equipment and operation of the system with accessories quoted should be provided without any charge. | | |
| | iii | A list of the total number of other major product lines the supplier deals with in India. This list should also include a list of similar systems supplied in India. In addition, the details of support / service system available in India. | | |

(Note: It is mandatory for the bidders to submit a compliance statement for the aforementioned points in tabular format and required/necessary documents in the technical bid. Failure to comply with which bidders will be formally rejected)