Low-temperature high magnetic field electron transport and spectroscopic measurement station

Low-temperature high magnetic field electron transport and spectroscopic measurement station is an advanced experimental system by incorporating quantum transport measurements and spectroscopy measurements under extreme conditions including low temperatures and high magnetic fields, which provides a unique tool to investigate the novel properties of quantum materials, topological quantum states, and manipulations of quantum devices. The low temperature and strong magnetic field environment is provided by two sets of home-made ^{3}He refrigerator equipped with 20 T and 9 T/3 T/1 T superconducting magnet, respectively. The station also provides a SM4000 Spectromag magneto-optical Dewar measurement unit to make quick sample screening at higher temperatures (2-300 K) and in lower magnetic fields (10 T). Spectroscopy measurement instruments include a millimeter wave network analyzer (10 MHz -100 GHz), a microwave spectrum analyzer (3 Hz -75 GHz) and a microwave signal generator (250 kHz – 67 GHz). Electrical measurement instruments include lock-in amplifiers, pre-amplifiers and low-noise source measure units. By carefully electromagnetic shielding and electrical grounding, the station has a noise level as low as 10 nV.

Photos of the experimental station

This station provides the following three measurement configurations:

- Quantum transport measurement
- Spectroscopy measurement (including microwave and infrared) (under construction)
- Spectroscopy measurement + Quantum transport measurement (under construction)

Table 1-3 shows the specifications of three measurement units.

Table 1. Technical data of Low temperature magneto-optical measurement unit

Items	Parameters
Superconducting magnet	● Type: split magnet ● Guaranteed magnetic flux density at 4.2 K: 10 Tesla ● Operating current at full field: < 140 A ● Homogeneity within10 mm diameter sphere: < 0.6%
Variable temperature insert	● Sample space diameter: 25 mm ● Temperature range: 1.5-300 K
Cryostat	● Helium can volume: 20 L ● Static helium reservoir evaporation rate: 185 cc/hr ● Nitrogen can volume: 24 L ● Static nitrogen reservoir evaporation rate: 392 cc/hr ● Optical windows: 4 quartz windows in the sample plane, two are along with magnetic field direction and the other two are perpendicular with the magnetic field direction.

Table 2. Technical data of 9 T/3 T/1 T-22 T- ^{3}He measurement unit

Items	Parameters
Vertical solenoid (z axis)	● Guaranteed magnetic flux density at 4.2 K: 9 Tesla ● Operating current at full field: < 120 A ● Homogeneity within10 mm diameter sphere: < 0.1% ● Bore size: 52 mm
Horizontal split pair (x axis)	● Central field at 4.2 K: 3 Tesla ● Operating current at full field: < 120 A ● Homogeneity within10 mm diameter sphere: < 0.5%
Horizontal split pair (y axis)	● Central field at 4.2 K: 1 Tesla ● Operating current at full field: < 120 A ● Homogeneity within10 mm diameter sphere: < 0.5%
Max 360° rotating field	3 T (z-x plane); 1 T (all direction)
Helium can volume	70 L
Static helium reservoir evaporation rate	320 cc/hr
Nitrogen can volume	66 L
Static nitrogen reservoir	250 cc/hr

evaporation rate	

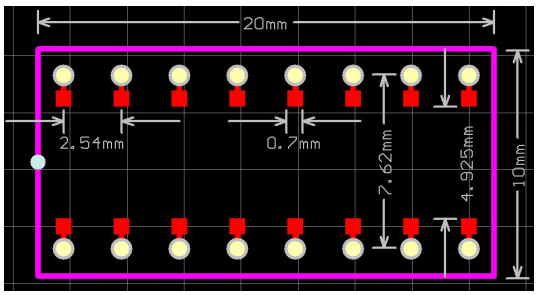
Table 3. Technical data of 22 T- ^{3}He measurement unit

Items	Parameters
Guaranteed magnetic flux density	20 Tesla@4.2 K; 22 Tesla@2.2 K
Homogeneity within 10 mm diameter sphere	0.1%
Bore size	52 mm
Operating current at 22 Tesla	~180 A
Helium can volume	70 L
Static helium reservoir evaporation rate	220 cc/hr
Nitrogen can volume	66 L
Static nitrogen reservoir evaporation rate	250 cc/hr

Station measuring interface:

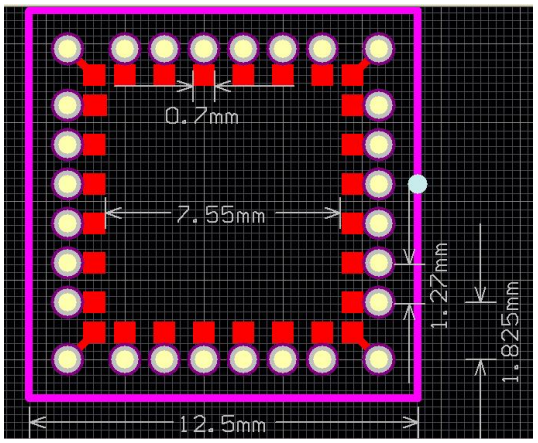
This station provides two electrical interfaces:

1. 16 Pin standard IC socket.



For conductive silver adhesives and wire bonding.

2. 24 Pin custom socket.

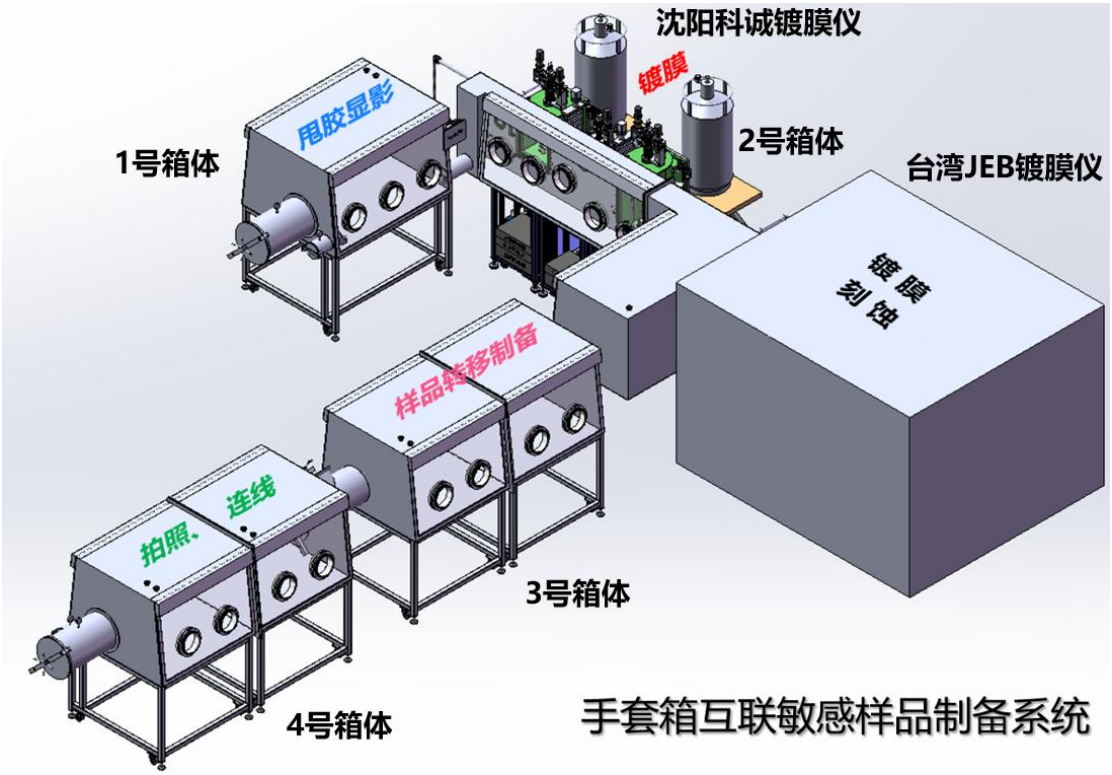


For conductive silver adhesives and wire bonding.

Glove box system:

Glove box system can realize air-sensitive devices fabricating in an inert gas

atmosphere. It will fulfil the dry transferring and metal film coating of van der Waals devices and twistronics devices, and optimize device electrical performance, like high mobility and good Ohmic contact. The Glove box system provide a good platform to investigate low dimensional topological quantum states. This system offers plasma cleaning, dry transferring, metal film coating, wire bonding, and four probe electrical testing for device fabricating. The schematic of glove box system is shown blow, including four glove boxes:



Box 1: for spin coating and developing.

Including: spin coater and baking station

Box 2: for plasma cleaning and electron beam evaporation.

Including: two electron beam evaporation equipment and plasma cleaner.

Box 3: for dry transferring and van der Waals devices fabricating.

Including: Olympus microscope, Zeiss microscope, and microscope with electronically controlled dry transfer station.

Box 4: for ozone cleaning and wire bonding

Including: ozone cleaner, westbond wire bonding machine, and probe station.

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