Chapter - 5

Summary and future outlook

5.1 Summary of the thesis

In this thesis, we have successfully developed a dc SQUID-vibrating coil magnetometer for measuring the dc magnetization of extremely small volume of samples. In the presence study, the development of SVCM with position differentiating technique is used for the magnetic measurement very accurately down to liquid helium temperature. In this study, we have measured the performance of the SVCM, which depends on the 1) degree of cancellation of the unwanted signals induced in the detection coil and 2) the uniformity of its vibration. In SVCM the noises produced due to the vibration of the superconducting (Nb-Ti) wire, which is eliminated by standard noise rejection procedure. The uniformity of the actuator vibration is maintained by a negative feedback circuit. Hence, this system can be used for magnetic measurements of extremely small volume of samples.

Also in this thesis, we have successfully developed a simple design of the uniaxial pressure device for measurement of ac-susceptibility at low temperatures using closed cycle refrigerator system (CCRS) is presented for the first time. This device consists of disc micrometer, spring holder attachment, uniaxial pressure cell, and the ac-susceptibility coil wound on stycast bobbin. It can work under pressure till 0.5 GPa and at the temperature range of 30 K to 300 K. The performance of the system at ambient pressure is tested and calibrated with standard paramagnetic salts [Gd_2O_3, Er_2O_3, and $Fe(NH_4SO_4)_2\ 6H_2O$], Fe_3O_4, Gd metal, Dy metal, superconductor ($YBa_2Cu_3O_7$), manganite ($La_{1.85}Ba_{0.15}MnO_3$), and spin glass material ($Pr_{0.8}Sr_{0.2}MnO_3$). The performance of the uniaxial pressure device is demonstrated by investigating the uniaxial pressure dependence of $La_{1.85}Ba_{0.15}MnO_3$ single crystal with

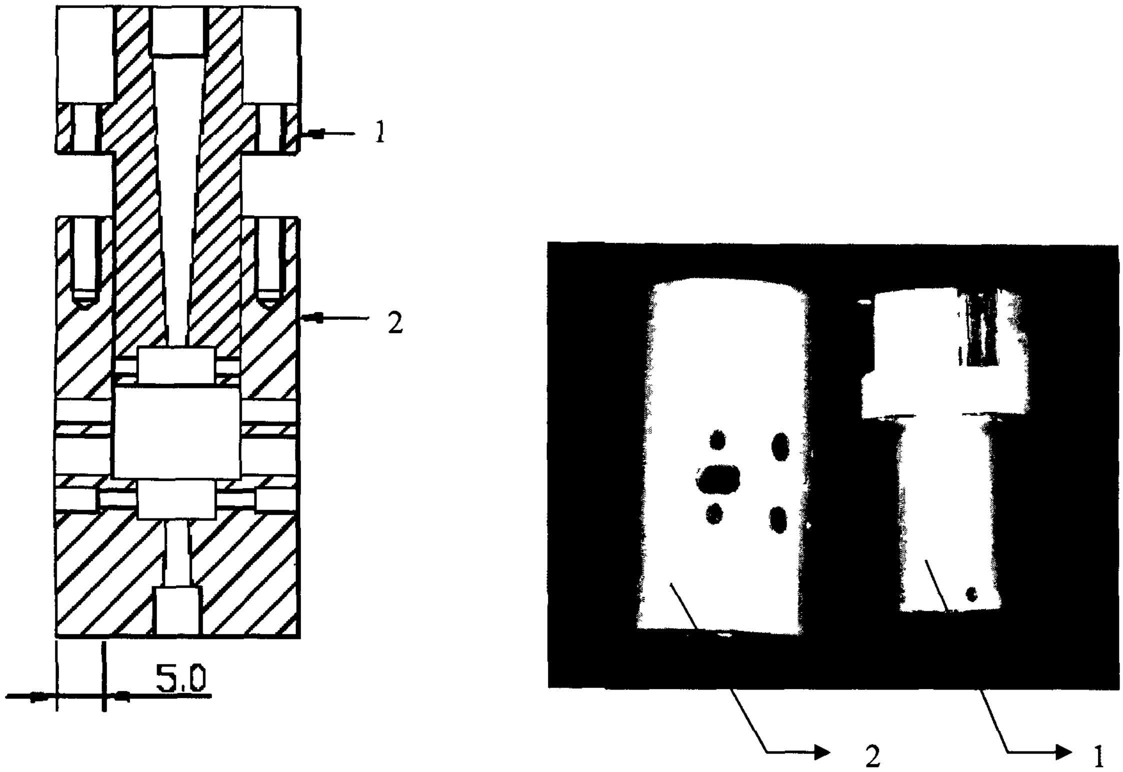
P | | c-axis. The Curie temperature (T_c) decreases as a function of pressure with P | | c-axis ($dT_c/dP_{||c\text{-}axis}$ = - 11.65 K/GPa) up to 46 MPa. The design is simple, user friendly, and does not require pressure calibration. Measurement can even be made on thin and small size oriented crystals. The failure of the coil is remote under uniaxial pressure. The present setup can be used as a multipurpose uniaxial pressure device for the measurement of Hall effect and thermoelectric power with a small modification in the pressure cell.

5.2 Future directions

We have designed and fabricated a DAC piston-cylinder type as shown in Appendix A. Two numbers of flawless high purity gem quality diamonds (~0.35 carats each) has been procured form M/s. Aditi diamonds, Pondicherry, India, which are used as anvils to the DAC. The gaskets were made by stamping out from SS disk of 8mm and 0.25mm thickness. The upper and lower culets in the diamond anvils were selected to have slightly different diameters to provide large space for positioning the detection coil due to concave deformation of the gasket during indenting at room temperature. The sample holder in the SVCM experimental setup is replaced by the DAC, the photograph and schematic diagrams are shown in Appendix B (a) and (b) respectively. A suitable Helmholtz type electromagnet coil was wounded on DAC using a copper wire (1.0mm) and it can produce a DC magnetic field of 1Oe for 100mA current. Magnetic field of 1 Oe is sufficient to get a good signal from the Pb sample in the present experimental setup. The optimization of the DAC-SVCM (Appendix C) setup with Pb sample (~10 microns) mounted on a DAC is under progress.

The measurements of ac-susceptibility under uniaxial pressure for standard sample were carried out with out any external electronic compensatory circuit. Inorder to improve the sensitivity of the present setup the offset voltage should be further minimized using electronic compensatory circuit. The offset voltage appears due to the following reasons: 1) Vibration of cold-head in the CCRS, 2) Unbalanced offset signal from the secondary coils, 3) Noise from the uniaxial pressure device, 4) Noise from the electric circuits and cables and 5) External noises. Hence we have designed an electronic compensatory circuit to minimize some of the above said noises to improve the sensitivity of the setup. The electronic compensatory circuit is shown in Appendix D. The process of minimizing the offset voltage using the electronic circuit with the ac-susceptibility setup is being carried out.

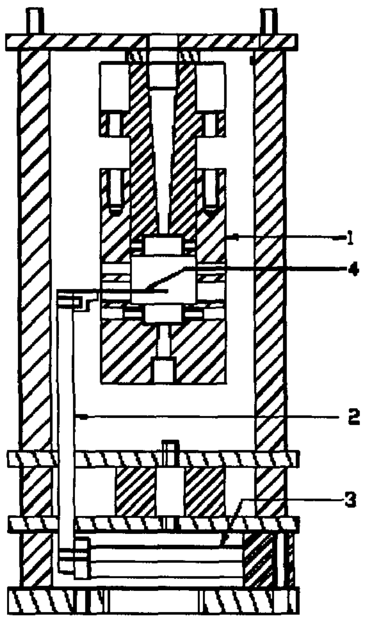
5.3 Appendix A: Schematic diagram of piston-cylinder diamond anvil cell



Material: Be-Cu

Figure 5.1 Schematic diagram of piston-cylinder type diamond anvil cell
[1. Piston, 2. Cylinder]

5.4 Appendix B: Schematic diagram of the DAC-SQUID vibrating coil magnetometer

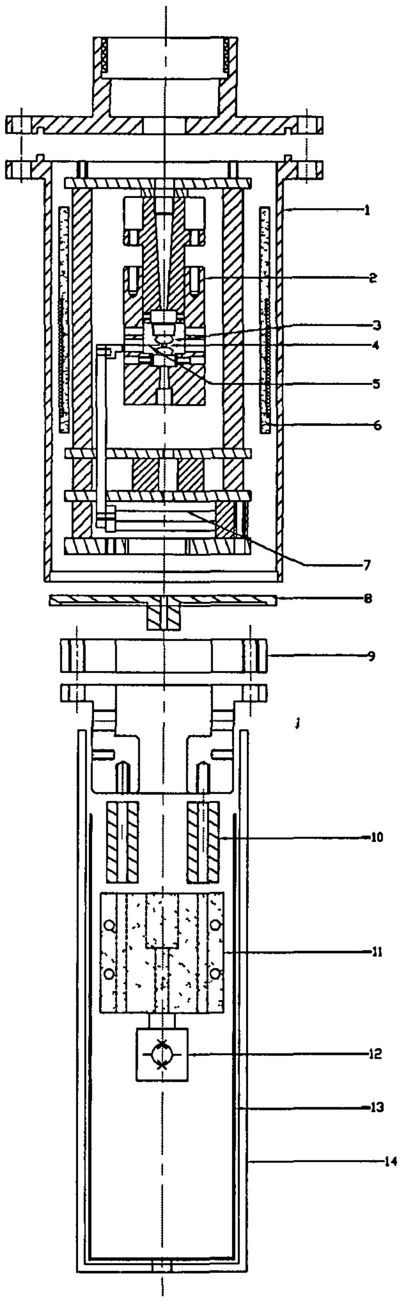


5.4 (a) 5.4 (b)

Figure 5.4(a) Schematic diagram and **(b)** Photograph of DAC-SQUID vibrating coil magnetometer experimental setup

[1. Diamond anvil cell, 2. Transmitting rod (stycast # 1266), 3. Bi-morph piezoelectric actuator assembly, 4. Pick-up coil]

5.5 Appendix C: Assembly diagram of the DAC-SQUID vibrating coil magnetometer (DAC-SVCM)



[1. Exchange gas chamber, 2. Piston-Cylinder type DAC, 3. Diamond, 4. Sample, 5. SC pick-up coil (Gradiometer type), 6. Magnetic Solenoid, 7. Bi-morph Piezoelectric actuators, 8. OFHC Copper bottom, 9. SQUID Assembly holder - Mat. Brass, 10. OFHC copper tube, 11. SQUID electronics board holder - Mat. Hylem, 12. dc SQUID, 13. Pb shield, 14. Cryoperm shield]

5.6 Appendix D: Compensatory circuit diagram for uniaxial ac-susceptibility measurement