

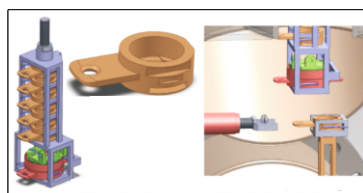
# Automation

## Remotely Operated UHV Compatible Sample Manipulator for Spectroscopy Synchrotron Beamline at Indus-2

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Sample Cartridge, Picking tool and Magazine of the Sample Manipulator

### ABSTRACT

Remotely operated UHV compatible Automated Precision Sample Manipulator assembly is an import substitute and has been developed indigenously for Angle Resolved Photo Emission Spectroscopy (ARPES) synchrotron beam-line (B.L.) at INDUS-2, RRCAT, Indore. Various samples, with the help of fully automated sequential mechanism can be loaded, transferred, coated and stored in a UHV ( $10^{-8}$  mbar) for further experimentation in Energy Analyzer of Beamline. Indigenous development of fully automated sample manipulator proved to be more compact and user friendly. Innovative design concepts are implemented for sample holding cartridge, sample picking adapter tool & cartridge magazine for precise pick up and transfer of the sample. The working principle, basic design features and remote operation of Sample Manipulator are discussed in this article.

KEYWORDS: UHV, Indus-2, Beamline, Automation, Precision Sample Manipulator Assembly, Energy Analyzer, Hybrid manipulators

### Introduction

Remotely operated UHV compatible Sample Manipulator is one of the critical equipment of ARPES beam-line of INDUS-2, Raja Ramanna Centre for Advanced Technology (RRCAT). It is developed indigenously to prepare samples for ARPES experiments. ARPES is “Angle Resolved Photo Emission Spectroscopy” in which synchrotron radiation is focused on the sample inside the Toroidal Analyzer to study energy and momentum distribution of photo electrons. It is an import substitute for the scientific instruments such as imported thin film deposition manipulator by SVTA Associates, USA, Analytical & preparation manipulator by PREVAC, Poland, Toroidal spectrometer by La Trobe University, Australia.

Sample Manipulator is a fully automated sequential mechanism to load the sample, transferring the sample, coating the sample and storing it in a magazine inside the UHV ( $10^{-8}$  mbar) to pick it up as and when required for spectroscopy in the analyzer.

The assembly consist of load lock chamber, sample preparation chamber, stacking chamber, and manipulators for loading/unloading, pick up and transferring the sample. Manipulators are magnetic coupler remotely operated feed-throughs to actuate desired movements.

Prepared Sample is comprises of substrate material with coating of material to be analyzed for ARPES study. Substrate of glass, stainless steel or Si crystal of size 10 x 10 x 1mm thick will be used as base material and then coated with material of U, Ti, Zr etc. as thin film & single crystal for sample preparation.

### Specifications of Sample Manipulator

- Fully automated transferring system
- Accommodate maximum 5 nos. of sample holders with maximum 5mm thickness
- Ultra High Vacuum (UHV: $10^{-8}$  mbar) compatible system
- Backlash free Magnetic coupler remotely operated feed-throughs manipulators
- Resolution: 2 microns
- Positional accuracy: 10 microns
- 7-axes manipulation for sample transfer (by 4 nos. of manipulators to feed motion from outside and 1 no. inside U H V chamber)

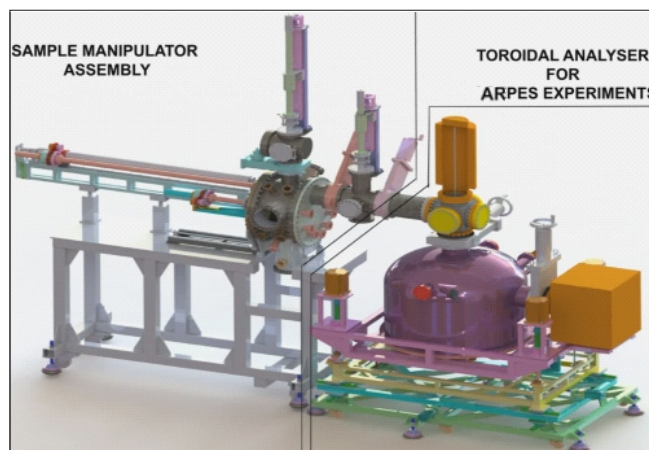


Fig.1: Sample Manipulator for ARPES B.L.

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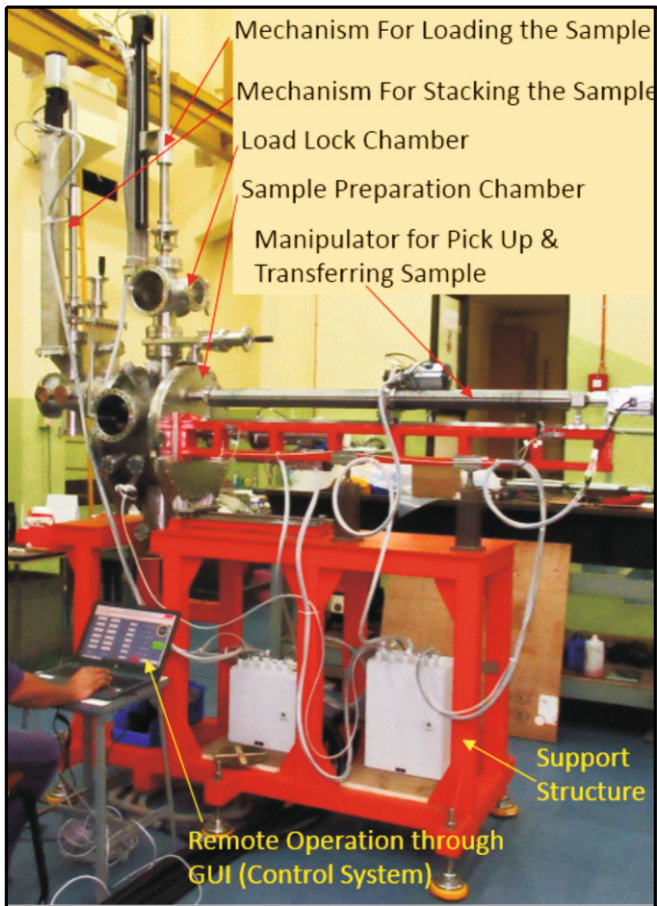


Fig.2: Sample Manipulator developed in CDM.

magazine inside the UHV compatible load lock chamber. The sample is then transferred to the preparation chamber by means of UHV compatible manipulator. It is then loaded on R-θ manipulator by means of transfer manipulator of the preparation chamber. By R-θ manipulator the sample can be radially as well as angularly positioned to respective ports of preparation chamber. Sample treatment, preparation and inspection are carried out inside the preparation chamber. Manipulator transfers and maneuvers the sample inside the preparation chamber for cleaning by Argon ion bombardment and then coating it with required ion deposition from respective gun port of preparation chamber. Quality checks are carried out by bringing the coated sample towards ports having requisite instruments. Prepared samples are then transferred and stored in cartridge magazine of stacking chamber for future use of spectroscopy inside the Toroidal analyzer. All the functions i.e. sample transfer, sample preparation and sample stacking are fully automated sequential operation and controlled through GUI based control system.

**Design Features**

Critical design features includes manipulation of sample at different stages, positional accuracy, sequential mechanism, UHV compatibility, remote operation & compactness of the equipment. Advanced UHV compatible remotely operated feed-throughs with linear as well as rotary mechanism are developed to manoeuvre samples inside the vacuum between predetermined stages. Such Hybrid manipulators are used in load lock chamber, preparation chamber and stacking chamber.

Innovative design is incorporated for holding sample cartridges, sample pick up adapter tool and cartridge magazine for precise maneuver of the sample. Cartridge magazine can house five sample cartridges and one thermal cartridge. It permits 1mm pick up and placement positional inaccuracy of sample cartridges inside magazine and is interchangeable.

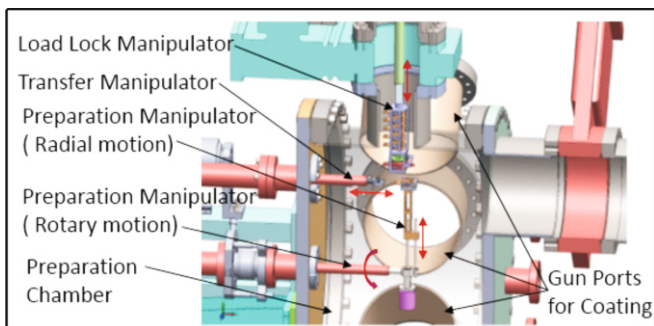


Fig.3: Sample manipulation carried using the manipulator.

- Manipulator-1 ('X' = 1200 mm &  $\theta_x = 360^\circ$ )
- Manipulator-2 ('X' = 300 mm &  $\theta_x = 360^\circ$ )
- Manipulator-3 ('Y' = 600 mm)
- Manipulator-4 ('Z' = 60mm- inside chamber)
- Manipulator-5 ('Y' = 600 mm)

- Interchangeability between sample holders
- Compact and user-friendly.

Sample Manipulator is a fully automated sequential mechanism to load the sample, transferring the sample, coating the sample and storing it in a magazine inside the UHV ( $10^{-8}$  mbar) to pick it up as and when required for spectroscopy in the analyzer.

**Working Principle**

Firstly samples substrates are arranged in cartridge

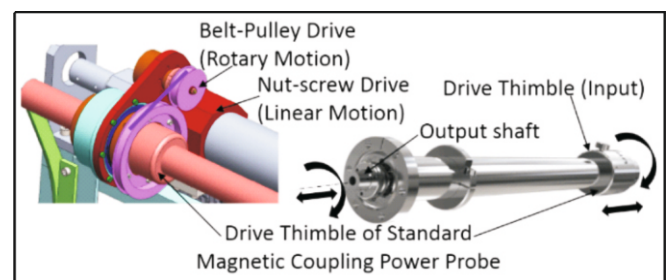


Fig.4: UHV compatible hybrid feed-throughs.

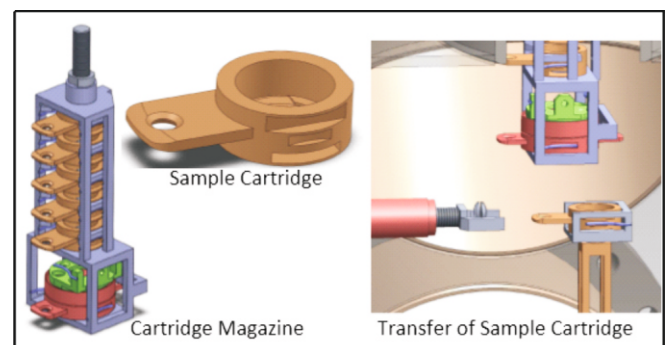


Fig.5: Sample cartridge, picking tool, Magazine.

GUI of control system will ensure sequential operation of hybrid manipulators with interlock between stages and also allows manual override or jog mode to bypass sequential stages.

### **Equipment Validation**

The Sample manipulator assembly was manufactured with quality control and vacuum components were tested successfully for Helium leak test for allowable leak rate ( $10^{-9}$  mbarlit/sec). All the manipulators are individually tested

for functionality and positional accuracies of 10 microns. The system is then checked for errors cumulative in nature. The manipulators have been calibrated to achieve intended requirement of the system inside UHV of  $10^{-8}$  mbar. Indigenously developed fully automated sample manipulator has proved to be more compact and user-friendly.

### **Bibliography**

- [1] O&M of Toroidal spectrometer by La Trobe University, Australia.
- [2] Power probe manual by UHV Design, UK.