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MASTER

An Ultra-High-Vacuum Double-Axis Goniometer
for Use with an Electron Spectrometer*

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ABSTRACT

We describe a double axis goniometer designed for moving and indexing an electron spectrometer for angle resolved photoemission studies. A feature of the design is that the two rotations operate independently and either can be carried out with the analyzer at any position. The goniometer is designed to be installed in a 14" spool piece which makes it possible to add it to an existing 14" UHV system.

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1. INTRODUCTION

Recent experiments in angle-resolved photoelectron spectroscopy require electron analysis and detection with typically $\pm 2^\circ$ acceptance. With the coming availability of the bright synchrotron light sources the trend is to higher resolution in angle and energy. In order to examine electron emission over full emission hemisphere, therefore, it is necessary to move the analyzer about two orthogonal axes. The only exceptions to this are the angularly multiplexed ellipsoidal mirror display spectrometer developed at I.B.M. by Eastman and colleagues and the modified cylindrical mirror analyzer of Lapeyre et al. and Bell Laboratories. (A full review of analyzers is given by N. V. Smith in his article in this issue.) This article addresses the problem of moving an analyzer (typically either a plane mirror or hemispherical type) weighing about 2 kg about two axes. In order to allow for desired changes in the emission spectra caused by changing angles of incidence, the basic design allows full 4π steradian motion, constrained only by external obstacles such as the sample holder.

2. DESIGN CRITERIA

The following constraints were imposed upon the design

- Full 4π steradian movement in the absence of interferences within the chamber.
- Two axes of rotation.
- Rotation axes capable of independent motion.
- Ultra-high vacuum.
- No counterweight above the sample plane.
- To be installed into an existing 14" chamber with no large base flange, i.e. all feedthroughs to come in from the chamber side.
- No slip-ring electrical contacts, only continuous wires.

- As far as possible to be built from off-the-shelf components.
- To be able to move the 50 mm mean radius V.G. Scientific ADES 400 analyzer.
- Angular reproducibility of $1/2^\circ$.

3. ENGINEERING DESIGN

The basic design philosophy was to build the device into a 14" spool piece which was readily inserted between the pump and chamber of the existing equipment (Fig. 1). A schematic of the design in the spool piece is shown in Fig. 2. Several main features are evident from this. First, the parts involved with the rotation about the horizontal axis are carried on a cylindrical supporting system about the chamber center, rather than a large turntable. This provides a sturdy structure with high pumping speed to the chamber above. Secondly, both rotations are provided through matched worms and wheels, actually with a 60:1 reduction. Direct readout of the axial positions is provided by the dials on the center axis.

The effective decoupling of the two motions is accomplished as follows (see Fig. 3). External to the vacuum system the two handles of the upper and lower rotary feedthroughs are connected by a belt and pulley system. The lower feedthrough carries a handle, the upper may or may not be driven by the belt depending on the position of the clutch. To rotate the analyzer about the vertical axis, the clutch is engaged and the handle turned. Now, both axes rotate at the same rate with the resulting vertical axis rotation of the analyzer. To rotate the analyzer about the horizontal axis, the clutch is disengaged. Now only the lower axis rotates when the handle is turned. From any position of the analyzer either motion may be selected.

The analyzer counterweight is supported from the central vertical gear and so cancels the preload at the worm/wheel interface while keeping well away from the sample area.

4. CONSTRUCTION AND OPERATING EXPERIENCE

All the gears and bearings were dichronite coated before assembly, no other lubricants being used. It was expected that the worm and wheel combination would have a tendency to stick under UHV conditions. This has not proved to be the case, however, with our stainless steel worm and copper beryllium wheel. The miter, spur and worm gears were made from #303 stainless steel. The bearings were made from #440 stainless steel. Although the bearings are magnetic, we plan subsequently to replace them with nonmagnetic equivalents. The magnetic field at the sample was measured at 3 m Gauss without degaussing or shielding despite the magnetic properties of the adjacent bearing. It is planned to line the spool section with .01" conetic foil before final use of the instrument.

All components were assembled and pinned before disassembly and cleaning. During this first assembly, the worm/wheel combinations were run-in with grinding pastes to remove irregularities. After this there were still problems due to the huge difference in inertial mass between the worm shaft and the wheel axis. This difference was reduced by increasing the inertia of the axis carrying the worm gear.

To date the system has successfully undergone a 200°C bakeout and functioned well at pressures in the mid 10^{-10} torr range. In operation it was found advantageous to provide clamping facilities on the rotary feedthroughs to guarantee to lock the rotary motions and hence fix the analyzer angles.

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FIGURE CAPTIONS

- Fig. 1 Photograph of the analyzer mounted on the goniometer in the 14" diameter vacuum vessel. The electrical connections and counterweight are not shown.
- Fig. 2 Schematic design of the double axis analyzer goniometer system in the spool piece.
- Fig. 3 Schematic design of the coupling arrangement between the two rotary feedthroughs.

FIG-1

FIG. 2

FIG. 3