Photoelectron Spectrophotometer in Air

Surface Analyzer

Patented by J.PAT. No.3481031
(Co-developed by Institute of Riken Physical and Chemical Research, Japan)
CE approved

Model AC-3

Features

- Atmospheric pressure operation (unique in the world)
- Estimate work function, ionization potential, density of stages (DOS)
- Measure thickness of thin films on the material surface (0-20 nano-meters)
- Measure the sample of powder and liquid
- Low photo-excitation energy (5.0-6.20eV)
- Measurement for just 5 minutes
- Simple operation
- Easy sample introduction and removal
- Full computer control

Photo-Electron Spectroscopy in Air (PESA)

Riken Keiki developed simple photoelectron spectrophotometer in atmospheric pressure condition by applying the open counter as electron detector invented by Rikagaku Institute (Physical and Chemical Research Institute, Japan) and have been marketing it mainly to study organo-electronic materials for organic EL and photocopying.

Now, we have developed a special optical system enable to irradiate the above 6.2eV far ultraviolet rays to the sample although it is said that it is impossible to perform in air.

Features

- Easy to measure the Density of States (DOS) around the highest occupied orbital, work function and ionization potential.
- Information for tiny surface on nanometer order and tiny thin film thickness (0~20nm) can be measured.
- Powder and liquid samples which are unable to bring into the vacuum also can be measured.
- Measurement taken in just 5 minutes (When measured in 5.0~7.0eV energy search range with step 0.1eV)

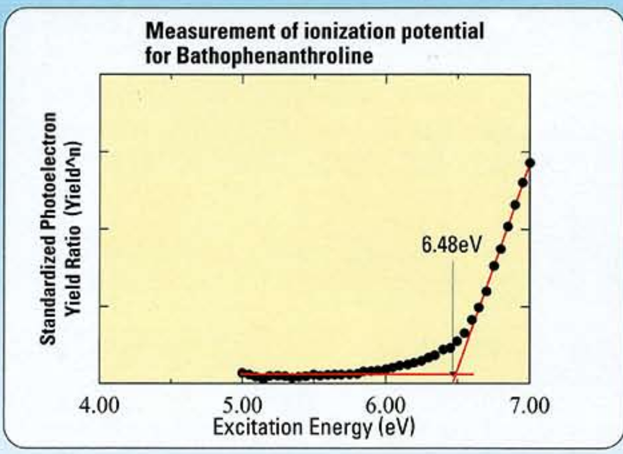
Applications

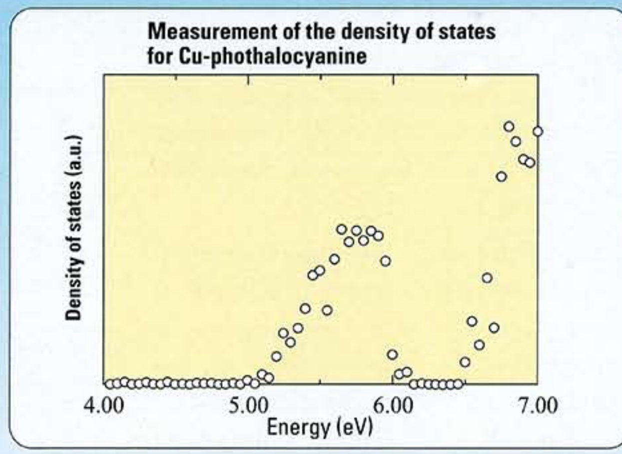
- Measurement of ionization potential on organic materials used in organic solar cell, fuel cell organic EL and organic TFT
- Measurement of ionization potential on photocatalyst.
- Evaluation of MgO film quality on plasma display panel (PDP).
- Measurement of electronic states for carbon nanotube and fullerene.
- Measurement of electronic states on carbon thin film and diamond thin film.
- Measurement of electronic states for cosmetics, medicine and chemicals.
- Measurement of ionization potential on sensitive materials.
- Measurement of contamination and oxidized film thickness for electrode, lead frame, contacts, steel plate, silicone wafer and compound semiconductor wafer.
- Measurement of work function on metallic materials for various electrodes.

Measurement Example

Measurement of HOMO level on materials used in organic EL and organic TFT.
For charge moving device such as organic EL, organic transistor, solar cell, and photocopying drum etc, it is important to measure their Highest Occupied Molecular Orbital (HOMO) energy level.
We have succeeded to expand the limit of excitation energy up to 7.00eV(177nm).
As the result of this expansion, the material which could not measure with AC-2 can be measured.

Measurement of Density of States on work materials.
Properties of many substances are led from the Density of States (DOS) (The number of conditions for photoelectron in some energy). This density of states is quoted from the differential value of photoelectron yield ratio.
It is trying to understand substances of properties logically by comparing the measurement results for density of states with the calculation results of the molecular orbital.

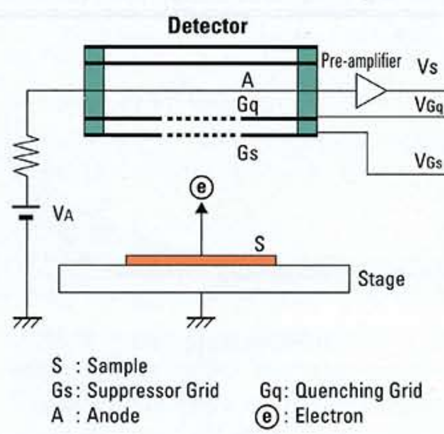


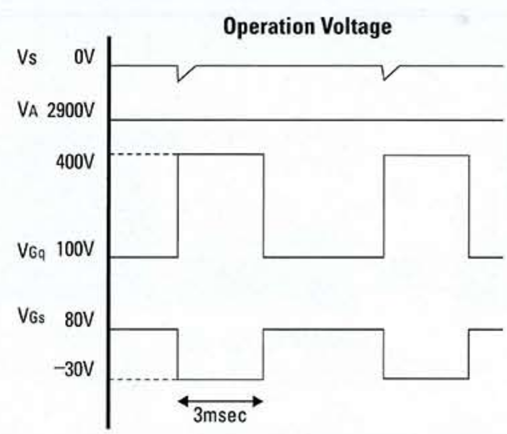


Measurement Principle

An electron emitted from a sample surface moves several meters toward the detector. (This is called the "Mean Free Path of electron in air".) After that, the electron attaches to an oxygen molecule, and it travels to Anode (A) through Suppressor Grid (Gs) and Quenching Grid (Gq). The instensity of the magnetic field is increased by high voltage. When the electron approaches the Anode (A), the speed is accelerated by the intensified magnetic field. Then, an electron slide is triggered. As a result, the energy from a single electron is amplified up to 105 ~ 107 times, and the discharge pulse signal is generated in the preamplifier output (Vs). When the low energy electron counter receives discharged pulse signal it transmits the electron detection signal to the controller, and changes the Quencing Grid Voltage (VGq) and the Suppressor Grid Voltage (VGS) as shown in the drawing below. The Quenching Grid erases the discharge by lessening the voltage gap to the anode (A). The Suppressor Grid captures the positive ion generated at discharge, and prevents the electron from entering into the detector as the discharge is erased.

Principle Diagram





■ Operation

The intensity of light emitted from the ultraviolet lamp enters into the nitrogen substitution chamber and then enters into spectrometer after control it by light adjuster in the chamber.

The spectrometer selects the wavelength (energy selection) *1 of UV light and irradiates to atmosphere through CaF_2 window and condensed to the surface of sample.

As a result, photoelectrons are emitted from surface (several A to hundred A) of the sample due to photoelectron effect *2. This photoelectrons are counted by open counter, processed by personal computer and then displays its data on a CRT.

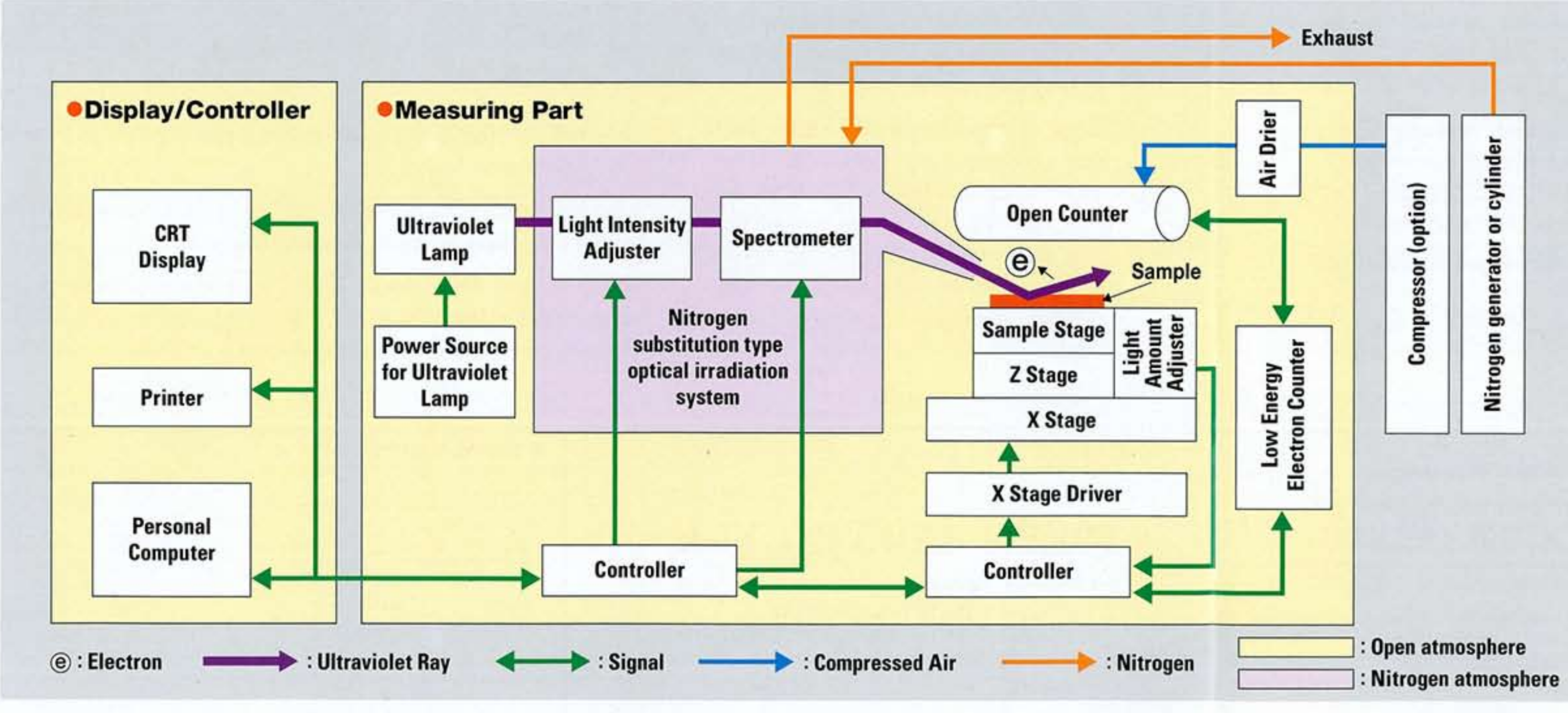
*1 : Light that has one specific wavelength has one specific energy. The conversion formula is as follows :

$$E_{(ev)} = \frac{h \cdot c}{\lambda} = \frac{1240}{\lambda\,(nm)}$$

λ : Wavelength h : Plank's constant
E : Energy c : Eight velocity

*2 : Photoelectric effect is the physical phenomenon that causes some materials that absorb light to emit electrons from the surface.

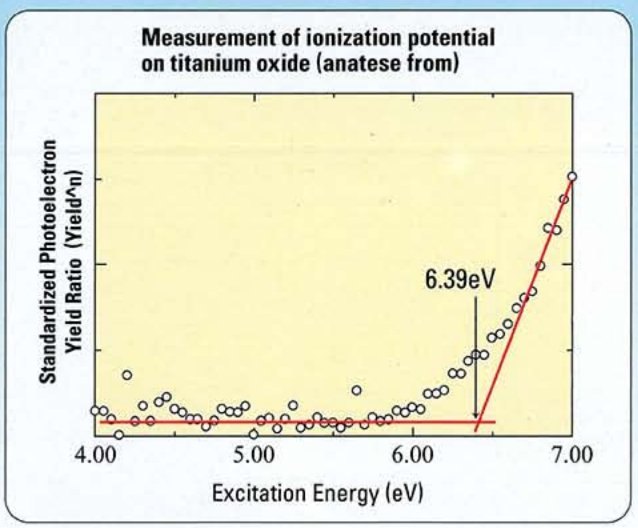
Structure

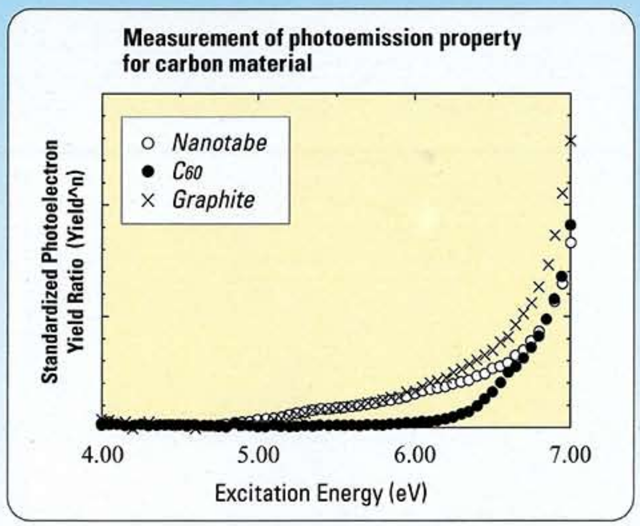


Measurement Example

Measurement of ionization potential on photocatalytic materials.
The oxides to be used as photocatalyst and dielectric have rather high photoemission threshold energy and they are difficult materials to measure with AC-2.
Now we can examine the behavior of photoemission in wide range with AC-3 even in these materials.

Measurement of photoemission property for carbon nanotube and fullerene.
Carbon nanotube and fullerene are noted as the new electronic materials.
The electron emission property is important to use the electrode for electron emission.
The electronic states around the HOMO is also important to use it as for electronic device. We can measure the emission property and the density of states of these materials with AC-3





Specifications

Model	AC-3
Measuring Principle	Low energy electron counter method
Electron Detector	Open counter
Ultraviolet Lamp	Deuterium lamp with lamp house
Spectrometer	Nitrogen substitution type grating method monochrometer
Energy Seearch Range	4.0～7.0eV (310～177nm)
Operating Condition	15～35°C, below 60%RH
Repeatability (Standard Deviation)	Work function 0.02eV
Measuring Time	Approx 5min (When measuring in 5.0～7.0eV energy scanning range with step 0.1eV)
Radiating Ultraviolet Rays	Spot size : 2×5mm (Slit 1.00mm) Maximum intensity : Above 100nW (at 5.9eV)
Sample Size	30×30mm max (Max thickness 10mm) 1 sample measurement
Utility Required	Power source : 100VAC, 50/60Hz, 5A (Max) Compressed air : 0.5～0.6MPa, 5L/min. Nitrogen gas : 0.1MPa, 2L/min (while measurement), 5L/min (while purging)
Software	AC-3 for Windows (Functions to measure photoelectron spectrum, rradiation light spectrum, threshold energy etc.)
Approvals	CE
Overall Dimensions	Approx 740 (W) ×1080 (H) ×680 (D) mm (with caster)
Weight	Approx 120kg

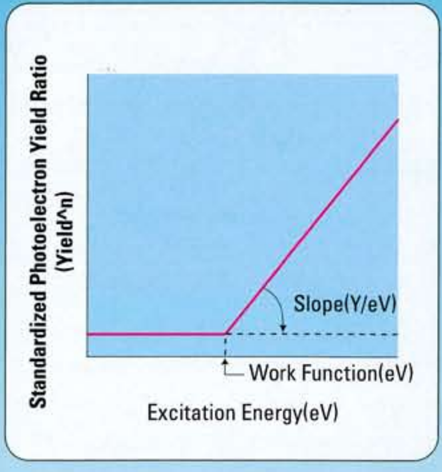
• Specifications subject to change without notice.
To operate this spectrophotometer, it is required to prepare the personal computer additionally.

Basic Properties

When a excitation energy of the ultraviolet rays is scanned from low level to high level, photoelectrons start to emit at a certain energy level. This energy level is called as the "Photoelectron Work Function(Work Function)".

When the photoelectron output is plotted on an X/Y axis, with horizontal axis as the UV energy applied, and the vertical axis as the standardized photoelectron yield ratio (Yield^n, or Y), the result is a line with a specific slope of degree (Y/eV).

*1 Srandardized photoelectron yield ratio (Yield^n) is the ratio of photoelectron yield achieved per unit of UV energy (light) applied to the sample surface, where "n" represents the strength of the UV energy applied. The "n" value is reported as 0.5 for metal and as 0.3 to 1 for semiconductor surfaces, based on the ability of the surfaces to emit electrons.



Basic Analysis Method

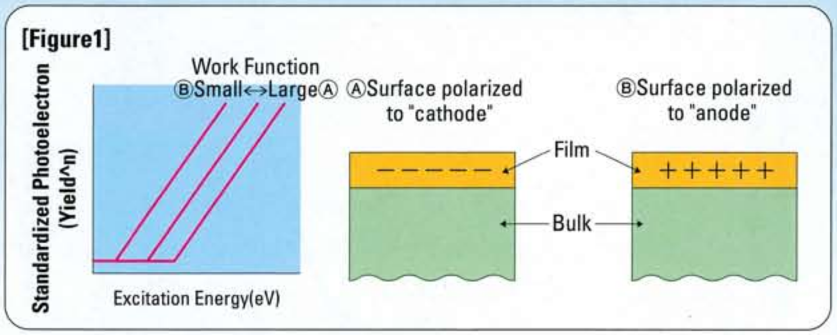
①The Work Function is a particular value for each substance or material, and represents the valence belt maximum of each substance and ionization potential.

②The Work Function charges depending on the surface condition of material. If there is a thin film, contamination or absorption on the surface of the substance, the Work Function changes, depending on the polarization condition. (Figure 1)

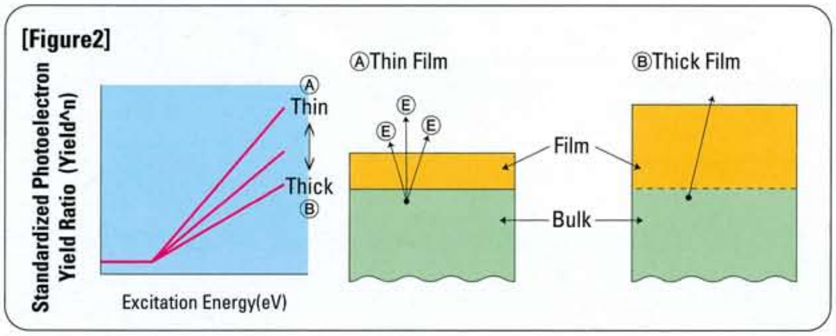
③The slope is related to the quantum efficiency of the photoelectron emitting substance and the thickness of any film on the substance surface (within several hundreds of Å.)

④Slope changes depending on the film thickness on the bulk surface. As a film gets thicker, it is more difficult for the photoelectorons to escape through the film, so they are not emitted to be counted. The slope (quantity) of the emitted electrons becomes less. (Figure 2)

[Figure1]



[Figure2]



⑤The Work Function changes depending on the crystal direction of the substance surface.

⑥If the substance surface is damaged, the initiation point (starting point) of the Work Function becomes scattered.

⑦Bulk materials like ceramic hardly emit photoelectrons. If the ceramic has a film that easily emits photoelectrons, the slope changes depending on the film thickness.

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