GENERAL PHYSICS

I. MOLECULAR BEAMS

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A. COMPARISON OF TECHNIQUES FOR SURFACE MEASUREMENTS

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During this early stage in the development of the molecule microscope, we have found it useful to survey and compare various techniques and the microscopy that can be applied to surface measurements. To simplify categorizing the various techniques, surface measurements have been expressed schematically as shown in Fig. I-1. The classification has been made along the following lines: Some form of energy (or particle) (1) is incident on the surface, and one or more forms of energy (or particles) are

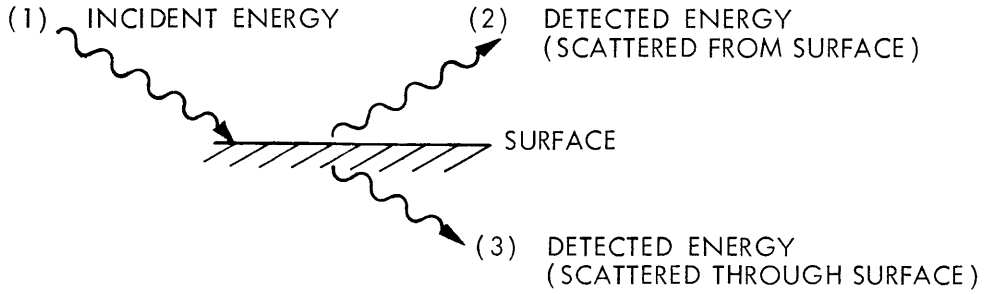

Fig. I-1. Diagram of surface measurements.

detected either (2) from scattering by the surface or (3) by scattering through the surface.

In Table I-1 various surface measurement techniques are compared on the basis of incident energy versus detected energy. Each technique is listed in abbreviated form (standard abbreviations are used for the more developed techniques) and pertinent references are given. Standard reference works are listed for the better established techniques such as electron microscopy. Whenever it is possible we refer to a recent,

Table I-1. Techniques for surface measurements.

PROBING PARTICLE (OR FORM OF INCIDENT ENERGY)	DETECTED PARTICLE (OR FORM OF DETECTED ENERGY): ELECTRON	PHOTON	NEUTRAL MOLECULE	ION	PHONON	E/H FIELD
ELECTRON	CTEM SEM-STEM LEED HEED AES-AEM IS	EM(MA) CIS APS CL	ESD SDMM	ESD SDMM		
PHOTON	PES-PEM AES-AEM XES-XEM	LM COL ELL HOL IRS NMR,ESR MÖSS XRD	PD LMP SDMM	PD LMP		
NEUTRAL MOLECULE	SE	NIR	MBSS $\alpha,\sigma(P)$ MM		ΔH_{ADS}	
ION	SE INS	IIR IMXA	ISD SDMM	ISD SDMM IM(MA) ISS		
PHONON	TE	ES TL	FD SDMM	SI	ASW	
E/H FIELD	FES-FEM	EL		FIS-FIM		CPD SC MS

KEY

CTEM	Conventional transmission electron microscopy[1]
SEM	Scanning electron microscopy[2]
STEM	Scanning transmission electron microscopy[3]
LEED	Low-energy electron diffraction[4]
HEED	High-energy electron diffraction[1]
AES	Auger electron spectroscopy[5]
AEM	Auger electron microscopy[6]
IS	Ionization spectroscopy[7]
PES	Photoelectron spectroscopy[8]
PEM	Photoelectron microscopy[9]
XES	Exoelectron spectroscopy[10]
XEM	Exoelectron microscopy[11]
SE	Secondary emission
INS	Ion neutralization spectroscopy[12]
TE	Thermionic emission
FES	Field-emission spectroscopy[13]
FEM	Field-emission microscopy[13]
EM (MA)	Electron microprobe (mass analysis)[14]
CIS	(X-ray) Characteristic isochromat spectroscopy[14]
APS	(X-ray) Appearance potential spectroscopy[15]
CL	Cathodoluminescence
LM	Light microscopy
COL	Colorimetry: IR, VIS, UV, x-ray, γ-ray absorption spectroscopy[16]
ELL	Ellipsometry[17]
HOL	Holography
IRS	Internal reflectance spectroscopy[18]
NMR	Nuclear magnetic resonance[19]
ESR	Electron-spin resonance[20]
MÖSS	Mössbauer spectroscopy[21]
XRD	(Glancing incidence) X-ray diffraction
NIR	Neutral impact radiation[22]
IIR	Ionic impact radiation[22]
IMXA	Ion microprobe x-ray analysis
ES	Emission spectroscopy
TL	Thermoluminescence
EL	Electroluminescence
ESD	(Low energy) Electron-stimulated desorption[23]
SDMM	Scanning desorption molecule microscopy[24,25]
PD	Photodesorption[26]
LMP	Laser microprobe
MBSS	Molecular-beam surface scattering[27]
α	Accommodation coefficient measurements
$\sigma(p)$	Adsorption isotherm measurements
MM	Molecule microscopy[24]
ISD	Ion-stimulated desorption[28,29]
FD	(Thermal or) Flash desorption
IM (MA)	Ion microprobe (mass analysis)[30]
ISS	Ion surface scattering[29,31]
SI	Surface ionization
FIS	Field ion spectroscopy[32]
FIM	Field ion microscopy[32]
ΔH_{ADS}	Heat of adsorption measurements
ASW	Acoustic surface-wave measurements[33]
CPD	Work-function measurements by contact potential difference
SC	Surface capacitance
MS	Magnetic saturation[34]

relatively accessible review article concerned with the usefulness of a particular technique for surface measurements (for example, LEED, AES, ellipsometry). As for the more recent techniques, we refer either to articles reporting initial results in the construction of prototype instruments (as in photoelectron microscopy or molecule microscopy) or to design studies or project proposals for instruments or techniques that are under investigation (as in scanning desorption molecule microscopy). Unreferenced entries in Table I-1 are those for which we were unable to find a general reference to an application of a technique to surface measurements, although the potential for such an application of the technique exists.

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