Méthodes d'analyse des surfaces
M2 Matériaux avancés et management industriel

Références :

.*Les Surfaces solides : concepts et méthodes* - S. Andrieu, P. Müller - EDP Sciences 2005
.*Analyse Structurale et Chimique des Matériaux* - J.-P. Eberhart - Dunod 1989,
.*Concepts in Surface Physics* - M.C. Desjonquères, D. Spanjaard - Springer Verlag Berlin Heidelberg 1996,
.*Fundamentals of Surface and Thin Film Analysis* - L.C. Feldman, J.W. Mayer - North-Holland 1986,
.*Surfaces and Interfaces of Solid Materials* - H. Lüth - Springer Verlag Berlin Heidelberg 1995,
.*Surface Science techniques* - J.M. Walls and R. Smith - Pergamon 1994,
.*Techniques de l'ingénieur* http://www.techniques-ingenieur.fr
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Sigles et acronymes courants des méthodes d'analyse de surface :

AAS *atomic absorption spectrometry,*
ADES *angular dispersive electron spectrometry,*
AEAPS *Auger electron appearance potential spectrometry,*
AEM *Auger electron microscopy,*
AES *Auger electron spectrometry,*
AFM *atomic force microscopy,*
AFS *atomic fluorescence spectrometry,*
AMEFS *Auger Monitored Extended fines structures,*
APECS *Auger photoelectron coincidence spectrometry,*
APFIM *atom probe field ion microscopy (FIM),*
APS *appearance potential spectrometry,*
ARAES *angle-resolved AES,*
ARNPD *angle resolved normal photoelectron diffraction,*
ARPEFS *angle resolved photoemission extended fine structure,*
ARPES *angle resolved photoelectron spectroscopy,*
ARSES *angle resolved secondary electron spectroscopy,*
ARUPS *angle resolved UV photoelectron spectrometry,*
ARXPD *angle resolved SPD,*
AS *absorption spectrometry,*
ATR *attenuated total reflection,*
BEEM *ballistic electron emission microscopy,*
BIS *bremsstrahlung isochromat spectrometry,*
CBED *convergent beam electron diffraction,*
CFM *chemical force microscopy,*
CL *cathodo-luminescence,*
CLSM *confocal laser scanning microscopy,*
CP *channeling pattern (Kikuchi),*
CPD *contact potential difference,*
DAFS *diffraction anomalous fine structure,*
DAPS *disappearance potential spectrometry,*
DEL *diffraction d'électrons lents,*
DFM *dynamic force microscopy,*
DNPA *diffusion des neutrons aux petits angles (SANS),*
DRIFTS *diffuse reflectance infra-red Fourier transform spectrometry,*
DXPA *diffusion des rayons X aux petits angles (SAXS),*
EAPFS *extended appearance potential fine structure,*
EBIC *electron beam induced current,*
ED *electron diffraction,*
EDS *energy dispersive X-ray spectrometry,*
EDAX *energy dispersive X-ray analysis,*
EDX *energy dispersive X-ray spectrometry,*
EELS *electron energy loss spectrometry,*
EFM *electrostatic force microscopy,*

EFOM *evanescent field optical microscopy (PSTM),*
EID *electron impact desorption*,
ELNES *electron energy loss near edge structure,*
ELS *energy loss spectroscopy,*
EM *electron microscopy*,
EMMA *electron microscope micro analyser,*
EMS *electron momentum spectrometry,*
ES *ellipsometry spectrometry,*
EPMA *electron probe micro analysis,*
ERDA *elastic recoil detection analysis,*
ESCA *electron spectroscopy for chemical analysis (AES + XPS + UPS),*
ESD *electron stimulated desorption*,
ESDIAD *electron stimulated desorption of ion angular distribution,*
ESR *electron spin resonance,*
EXAFS *extended X-ray absorption fine structure,*
EXELFS *extended energy loss fine structure,*
EXEELFS *extended electron energy loss fine structure,*
FAB *fast atom bombardment,*
FDS *field desorption spectrometry*,
FEED *field emission energy distribution*,
FEM *field emission microscopy*,
FEEM *field electron emission microscopy,*
FEES *field electron energy spectrometry,*
FES *field emission spectrometry,*
FIM *field ion microscopy,*
FIS *field ion spectrometry,*
FS *fluorescence spectrometry,*
FTIR *Fourier transform infra-red,*
FTMS *Fourier transform mass spectrometry,*
FT RA-IR *Fourier transform reflectance-absorbtion infra-red,*
GDMS *glow-discharge mass spectrometry,*
GDOS *glow-discharge optical spectrometry,*
GDS *glow-discharge spectrometry (SDL),*
HA *heat adsorption,*
HAS *helium atom scattering,*
HEED *high energy electron diffraction,*
HEIS *high energy ion scattering*,
HFS *hydrogen forward scattering,*
HREELS *high resolution electron energy loss spectrometry,*
HREM *high resolution electron microscopy,*
HVEM *high voltage electron microscopy,*
IAP *imaging atom probe,*
ICISS *impact collision ion scattering spectroscopy,*
IETS *inelastic electron tunneling spectrometry,*
IFTS *infrared Fourier transform spectrometry,*
IIDS *ion-impact desorption spectrometry,*
IILE *ion-induced light emission,*
IIRS *ion-impact radiation spectrometry,*
IIXS *ion-induced X-ray spectrometry,*
ILS *ionisation loss spectrometry*,
IMMA *ion microprobe mass analysis,*
IMXA *ion microprobe X-ray analysis*
INS *ion neutralization spectrometry,*
IPES *inverse photoemission spectrometry*,
IPM *ion probe microscopy,*
IRAS *infra-red absorbtion spectrometry*,
IRS *infra-red spectrometry*,
IRTF *infrarouge par transformée de Fourier (IFTS),*
ISD *ion stimulated desorption,*
ISS *ion scattering spectrometry,*
KRIPES *k-resolved inverse photoemission spectrometry,*
LACBED *Large angle convergent beam electron diffraction,*
LAMA *laser microprobe analysis,*
LAMMA *laser microprobe mass analysis,*
LEED *low energy electron diffraction,*
LEELS *low energy electron loss spectrometry,*
LEEM *low energy electron microscopy,*
LEF *laser excited fluorescence,*
LEIS *low energy ion scattering,*
LEPD *Low energy positron diffraction*,
LFM *lateral force microscopy*,
LID *Lase-induced desorption*,
LIF *Laser-induced fluorescence*,
LIMS *laser ionization mass spectrometry,*
LOES *laser optical emission spectrometry,*
LRS *light Raman scattering,*
LS *light scattering,*
LMP *laser microprobe,*
MBRS *molecular beam surface reactive scattering,*
MBSS *molecular beam surface scattering,*
MCXD *magnetic circular X-ray dichroism*,
MDS *metastable deexcitation spectrometry*,
MEB *microscope électronique à balayage,*
MEBT *microscope électronique à balayage en transmission,*
MEED *medium electron energy diffraction*,

MEHT *microscope électronique à haute tension,*
MEIS *medium energy ion scattering*,
MET *microscope électronique à transmission,*
MFM *magnetic force microscopy,*
MIES *metastable impact electron spectrometry,*
MFM *magnetic force microscopy,*
MOKE *magneto-optic Kerr effect*,
MOSS *Mössbauer spectrometry*,
MPI *multi-photon ionization*,
MS *mass spectrometry,*
NAA *neutron activation analysis,*
NEXAFS *near edge X-ray absorption fine structures (XANES),*
NIS *neutron inelastic scattering*,
NIXSW *normal incidence X-ray standing wave,*
NMA *nuclear microanalysis*,
NMR *nuclear magnetic resonance,*
NPD *normal photoelectron diffraction*,
NRA *nuclear reaction analysis,*
OPD *off-normal photoelectron diffraction*,
PAES *positron annihilation Auger electron spectrometry*,
PD *photodesorption*,
PEELS *parallel energy loss spectrometry*,
PEEM *photoelectron emission microscopy,*
PED *photoelectron diffraction,*
PES *photoelectron spectrometry,*
PhD *photoelectron diffraction,*
PIES *Pennig ionization electron spectrometry*,
PIXE *particle induced X-ray emission,*
PL *photon luminescence*
PLEED *polarized LEED*,
PSD *photon stimulated desorption*,
PSDIAD *photon stimulated desorption ion angular distribution*,
PSTM *photon scanning tunneling microscopy (EFOM),*
RAIRS *reflection-absorption infrared spectrometry,*
RAS *reflectance anisotropy spectrometry*,
RBS *Rutherford backscattering spectrometry,*
RDS *reflectance difference spectrometry*,
REELS *reflection electron energy-loss spectroscopy,*
REFLEXAFS *reflection extended X-ray absorption fine structure,*
REM *reflection electron microscopy,*
RHEED *reflection high energy electron diffraction,*
RIMS *resonant ionization mass spectrometry,*
RRS *resonant Raman scattering,*
SAD *selected area electron diffraction,*
SAM *scanning Auger-electron microscopy,*
SAES *scanning AES*,
SANS *small angle neutron scattering (DNPA),*
SAXS *small angle X-ray scattering (DXPA),*
SC *surface capacitance,*
SDL *spectrométrie de décharge luminescente (GDS),*
SDMM *scanning desorption molecule microscopy,*
SEAM *scanning electron acoustic microscopy,*
SEE *secondary electron emission*,
SEELFS *surface extended energy loss structures*,
SEELS *slow electron energy loss spectrometry (ou* LEELS),
SEM *scanning electron microscopy,*
SEMPA *scanning electron microscopy with polarisation analysis*,
SERS *surface enhanced Raman scattering,*
SEWS *surface electromagnetic wave spectrometry,*
SEXAFS *surface EXAFS,*
SFG *surface frequency generation,*
SFM *scanning force microscopy,*
SHG *second harmonic generation,*
SH-MOKE *second harmonic magneto-optic Kerr effect,*
SI *surface ionization,*
SIMS *secondary ion mass spectrometry,*
SIM *scanning ion microscopy,*
SIS *surface infrared spectrometry,*
SLEEM *scanning low energy electron microscope*,
SM *spectrométrie de masse,*
SMOKE *surface magneto-optic Kerr effect*,
SNMS *secondary neutral mass spectrometry,*
SNOM *scanning near field optical microscopy*,
SOM *scanning optical microscopy,*
SP-LEEM *spin polarized low energy elctron microscopy*,

SPA-LEED *spot profile analysis low energy electron diffraction,*
SPC *surface photoconductivity spectrometry,*
SP-EELS *spin polarised electron energy loss spectrometry,*
SPEEM *scanning photoelectron emission microscopy*,
SPEM *scanning photoelectron microscopy*,
SPI *surface Pennig ionization*,
SPIES *surface Pennig ionization electron spectrometry,*
SPIPES *spin polarised inverse photoemission spectrometry*,
SPLEED *spin polarised low energy electron diffraction,*
SPLEEM *spin polarised low energy electron microscopy,*
SPM *scanning probe microscopy,*
SPUPS *spin polarised ultraviolet photoelectron spectrometry*,
SPV *surface photovoltage spectrometry*,
SPXPS *spin polarised X-ray photoelectron spectrometry*,
SRS *surface reflectance spectrometry,*
SREM *scanning reflection electron microscope,*
SSIMS *static SIMS*,
STEM *scanning transmission electron microscopy,*
STIPE *scanning tunneling inverse photoemission,*
STM *scanning tunneling microscopy,*
STOM *scanning tunneling optical microscopy,*
STP *scanning thermal probe,*
STS *scanning tunneling spectrometry,*
SXAPS *soft X-ray appearance potential spectrometry*,
SXES *soft X-ray emission spectrometry,*
SXPS *soft X-ray photoelectron spectrometry*,
SXRD *surface X-ray diffraction,*
TDMS *thermal desorption mass spectrometry*
TDS *thermal desorption spectrometry*,
TEAS *thermal energy atom scattering,*
TED *transmission electron diffraction*,
TES *thermionic emission spectrometry,*
TEM *transmission electron microscopy,*
THEED *transmission high energy electron diffraction*,
TL *thermoluminescence,*
TLM *transmission light microscopy,*
TOF *time of flight (mass spectrometer),*
TPD *temperature programmed desorption*,
TPRS *temperature programmed reaction spectrometry*,
TREELS *time resolved EELS*,
TSM *tandem optical microscopy,*
TXRF *total reflection X-ray fluorescence*,
UPS *ultraviolet photoelectron spectrometry,*
VLEED *very low energy electron diffraction*,
XANES *X-ray absorption near edge structure,*
XAES *X-ray stimulated AES*,
XAS *X-ray absorption spectrometry,*
XPD *X-ray photoelectron diffraction*,
XPS *X-ray photoelectron spectrometry,*
XRD *X-ray diffraction,*
XRFA (XRF) *X-ray fluorescence analysis*
XRR *X-ray reflectometry*,
XSW *X-ray standing wave.*

Méthodes d’analyse des surfaces
Méthodes physico-chimiques d'élaboration et de caractérisation des matériaux et des micro-systèmes en couches minces.

1. *Introduction aux méthodes d’analyse des surfaces,*
   Spectrométrie de photoélectrons – XPS, UPS, ESCA, PEEM,
   Spectrométrie des électrons Auger – AES, SAM.

2. *Spectrométrie d’émission d’ions secondaires - SIMS, SIM,*
   Diffraction d’électrons lents – DEL (LEED),
   Diffraction d’électrons rapides – RHEED.

3. *Spectrométrie de perte d’énergie des électrons – HREELS, EELS, EXELFS,*
   Spectrométrie par faisceau d’ions – ISS, LEIS, MEIS, HEIS, RBS.

4. *Spectrométrie d’absorption des rayons X - XAS, XANES, EXAFS,*
   Microscopies à effet tunnel, à force atomique - STM, AFM.

5. ***Spectrométrie d’absorption des rayons X - XAS, XANES, EXAFS (1/2),***

6. ***Spectrométrie d’absorption des rayons X - XANES, EXAFS (2/2),***

7. ***Microscopies à force atomique - AFM, DFM, LFM, MFM, EFM,***

8. ***Diffraction d'électrons lents - DEL/LEED, LEEM (1/2),***

9. ***Diffraction d'électrons lents - DEL/LEED, LEEM (2/2),***

10. ***Spectrométrie de diffraction de photoélectrons - XPD, PhD, ARPEFS, ARUPS.***

11. ***Visite Laboratoire CEA Saclay DSM/IRAMIS/SPCSI (STM, AFM, ESCA, XPS, UPS, AES, DEL, PEEM, LEEM, HREELS…).***

italique introduction
Gras approfondissement
1 séance = 2heures

Supports de cours

https://iramis.cea.fr/en/spec/lepo/pisp/ludovic-douillard/