



## Standard Terminology Relating to Surface Analysis<sup>1</sup>

This standard is issued under the fixed designation E 673; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>ε1</sup> NOTE—Old term “electron attenuation length” was deleted editorially in November 2000.

### 1. Scope

1.1 This terminology is related to the various disciplines involved in surface analysis.

1.2 The definitions listed apply to (a) Auger electron spectroscopy (AES), (b) X-ray photoelectron spectroscopy (XPS), (c) ion-scattering spectroscopy (ISS), (d) secondary ion mass spectrometry (SIMS), and (e) energetic ion analysis (EIA).

### 2. Abbreviations

2.1 Abbreviations commonly used in surface analysis are as follows:

AES	Auger electron spectroscopy
BS	backscattering spectroscopy
CHA	concentric hemispherical analyzer
CMA	cylindrical mirror analyzer
EIA	energetic ion analysis
eV	electron-volts
ESCA	electron spectroscopy for chemical analysis
FABMS	fast atom bombardment mass spectrometry
FWHM	full width at half maximum peak height
ISS	ion scattering spectroscopy
pp	peak-to-peak
RBS	Rutherford backscattering spectroscopy
RFA	retarding field analyzer
SAM	scanning Auger microprobe
SIMS	secondary ion mass spectrometry
SNMS	sputtered neutral mass spectrometry
XPS	X-ray photoelectron spectroscopy

### 3. Terminology Definitions

**adventitious carbon referencing**—XPS, a method of determining the charging potential of a particular specimen by comparing the experimentally determined binding energy of the C 1s peak maximum from contaminating hydrocarbon or hydrocarbon groups on the specimen to a standard binding energy value.

#### analysis:

**area**—a two-dimensional region of a specimen surface, usually measured in the plane of the specimen surface, from which a specified percentage of the signal is detected.

**volume**—a three dimensional region of a specimen from which a specified percentage of the measured signal is

generated. Also see **information depth**.

**analyzer transmission**— see **spectrometer transmission**.

#### angle:

**collection**—SIMS, the angle between the normal to the original specimen surface and the axis of the secondary ion collection optics.

**of detector**—EIA, SIMS, the angle between the incident beam direction and the direction pointing from the beam spot to the center of the detector.

**of emission**—AES, XPS, the angle of emission or ejection of electrons from a solid measured relative to the normal to the surface.

**of incidence**— the angle between the incident beam and the normal to the surface.

**of scattering**—EIA, the angle between the incident beam direction and the direction in which a particle is traveling after it is scattered. If the particle is incident on the detector, this angle will be the same as **angle of detector**.

**solid, of detector**—EIA, the solid angle intercepted by the detector, with the radius originating at the beam spot.

**takeoff**—AES, XPS the angle at which particles leave a specimen measured relative to the plane of the specimen surface. (see **angle of emission**).

**angle lapping**—a method of specimen preparation in which a specimen is mechanically polished at an angle so that changes in composition as a function of position, usually depth, can be more easily determined.

**angle resolved AES**—the recording of Auger electron spectra as a function of angle emission.

**angular distribution of secondary ions**—see **secondary ions**.

**attenuation coefficient**—for a parallel beam of specified particles or radiation, the quantity  $\mu$  in the expression  $\mu\Delta x$  for the fraction removed in passing through a thin layer  $\Delta x$  of a substance in the limit as  $\Delta x$  approaches zero, where  $\Delta x$  is measured in the direction of the beam.

#### Auger:

**analysis volume**—see **volume** under **analysis**.

**chemical effects**—AES, see **chemical**.

**chemical shift**—AES, see **chemical**.

**current**—the electron current due to the emission of Auger electrons.

**electron**—an electron emitted as the result of an Auger process.

**electron yield**— the probability that an atom with a vacancy

<sup>1</sup> This terminology is under the jurisdiction of ASTM Committee E42 on Surface Analysis and is the direct responsibility of Subcommittee E42.02 on Terminology.

Current edition approved Nov. 10, 1998. Published March 1999. Originally published as E 673 – 79a. Last previous edition E 673 – 97.

in a particular inner shell will relax by an Auger process.  
*line scan*—a plot of Auger signal strength as a function of displacement along a designated line on the specimen surface. Normally, the abscissa is the line along which the signal is measured and the ordinate is directly proportional to signal strength.

*line shape*—the energy distribution in an Auger spectrum for a particular Auger transition.

*map*—two dimensional image of the specimen surface showing the location of emission of Auger electrons from a particular element. A map is normally produced by rastering the incident electron beam over the specimen surface and simultaneously recording the Auger signal strength for a particular transition as a function of position.

*matrix effects*—see **matrix effects**, *Auger*.

*parameter*—XPS, the kinetic energy of the sharpest Auger peak in the spectrum minus the kinetic energy of the most intense photoelectron peak from the same element; the energy of the ionizing photons must be specified.

*peak energy for  $dN(E)/dE$ ,  $N(E)$* —the designation of the energy of the Auger electron distribution. In  $dN/dE$  spectra, peak energies should be measured at the most negative excursions of the Auger features. In  $N(E)$  spectra, peak energies are measured at peak maxima. (Peak energies in  $dN/dE$  spectra are not the same as those in  $N(E)$  spectra.)

*process*—the relaxation, by electron emission, of an atom with a vacancy in an inner electron shell.

*signal strengths*—AES, XPS, in  $dN/dE$  spectra, signal strengths are measured as the peak-to-peak heights of the Auger features. In  $N(E)$  spectra, signal strengths are measured as the heights of the Auger peaks above background. In  $I(E)$ , signal strengths are measured as the areas under the electron energy distribution,  $N(E)$ .

*spectrum,  $dN(E)/dE$ ,  $N(E)$ ,  $I(E)$* —AES, the display of Auger signal strength as a function of electron energy. Auger spectra from solids may be measured as the first derivative of the electron energy distribution and may be designated by  $dN/dE$ . The Auger electron energy distribution may be designated as  $N(E)$ . With certain type analyzers (for example, the CMA) the displays are  $dEN(E)/dE$  and  $EN(E)$ . The area under Auger peaks may be designated as  $I(E)$  with background subtraction method, and integration limits specified.

*transition*—transitions involved in electron emission by an Auger process are designated by indicating the electron shells. The first letter designates the shell containing the initial vacancy and the last two letters designate the shells containing electron vacancies created by Auger emission (for example, KLL, and LMN). When a bonding electron is involved the letter V is used (for example, LMV and KVV). When a particular subshell involved is known this can also be indicated (for example,  $KL_1L_2$ ). Coupling terms may also be added where known ( $L_3M_{4,5}M_{4,5}, ^1D$ ). More complicated Auger processes (such as, multiple initial ionizations and additional electronic excitations) can be designated by separating the initial and final states by a dash (for example, LL-VV and K-VVV). When an Auger process involves an electron from the same principal shell as the initial vacancy

(for example,  $L_1L_2M$ ) it is referred to as a Coster-Kronig transition. If both electrons are from the same principal shell as the initial vacancy (for example,  $M_1M_2M_3$ ) it is called a super Coster-Kronig transition.

*transition rate*—the probability per unit time for two bound electrons to undergo energy state transitions such that one will fill an initial core hole vacancy and the other will go to a final state in the positive energy continuum.

**Auger electron spectroscopy**—the measurement of Auger signal strength as a function of electron energy.

**average emission function decay length**—the negative reciprocal slope of the logarithm of a specified exponential approximation to the emission depth distribution function over a specified range of depths, as determined by a straightline fit to the emission depth distribution function plotted on a logarithmic scale versus depth on a linear scale.

**background:**

*inelastic*—ISS, the response of the energy filtering and detection system to probe ions that have undergone inelastic scattering events at the specimen surface.

*instrumental*—ISS, the response of the energy filtering and detection system to events other than those induced by bombardment of the specimen surface by a beam of probe ions.

*secondary ion*—ISS, the response of the energy filtering and detection system to secondary ions produced by bombardment of the target material with probe ions.

*signal*—for a specific measurement, any signal present at a particular position due to processes or sources other than those of primary interest.

**backscattered electrons**—AES, electrons originating in the incident beam which are emitted after interaction with the target. By convention, electrons with energies greater than 50 eV are considered as backscattered electrons.

**backscattering:**

*energy*—EIA, energy of a particle from the analyzing beam after it has undergone a backscattering collision and escaped the specimen.

*factor*—AES, the fractional increase in the Auger current due to backscattered electrons.

*spectrum*—EIA, a plot of backscattering yield (ordinate) versus backscattering energy (abscissa).

*yield*—EIA, the number of particles detected (counts) per unit backscattering energy per incident ion.

**ball cratering**—a method of specimen preparation in which a specimen is polished by a sphere in order to expose compositional changes below the original surface of a specimen with the intent that the depth of these layers can be related to the position on the surface created by the ball.

**beam:**

*analyzing*—same as *incident*.

*current*—the total current incident on the specimen by the primary particle source.

*current density*—the current incident on the specimen per unit area.

*diameter*—in surface analysis, the full width of the incident beam at half maximum intensity measured in a plane normal to the beam direction. This plane must be specified and is

often taken at the intersection of the beam center with the specimen.

*divergence, convergence*—angles spanned by the directions of all particles of the incident beam.

*energy*—the energy of the particles incident on the specimen surface, expressed in electron volts (eV).

*energy, primary*—the kinetic energy of the primary beam, usually expressed in kiloelectronvolts (keV).

*incident*—the energetic particles incident on the specimen.

*particle*—atomic or molecular species contained in the incident beam, regardless of state of ionization.

*primary*—a directed flux of particles (ions or neutrals) incident on the specimen.

*profile, primary ion*—the spatial distribution of the primary ion current in a plane perpendicular to the primary ion beam axis.

*size*—the full width at half-maximum of the beam at a given point in space that must be defined.

*spot*—the area on the specimen surface illuminated by the incident beam.

**binary elastic scattering event**—*ISS*, the collision between an incident probe ion and a single surface atom in which the total kinetic energy and momentum are conserved.

**binary elastic scattering peak**—*ISS*, an increase in the spectrometer detection system response above the background level which can be attributed to binary elastic scattering of the probe ion from a surface atom of a particular mass.

**binding energy**—the work that must be expended in removing an electron from a given electronic level to a reference level, such as the vacuum level or the Fermi level.

**blocking geometry**—*EIA*, experimental situation wherein the atom rows or planes of a single crystal target are aligned parallel to a vector from the specimen to the detector.

**Bragg's rule**—an empirical rule formulated by W. H. Bragg and R. Kleeman that states that the stopping cross section of a compound specimen is equal to the sum of the products of the elemental stopping cross sections for each constituent and its atomic fraction, that is,

$$\epsilon(A_xB_y) = x\epsilon_A + y\epsilon_B \quad (1)$$

where:

$\epsilon(A_xB_y)$  = the stopping cross section of the compound, and

$A_xB_y$  and  $\epsilon_A$  and  $\epsilon_B$  = the stopping cross section of elements *A* and *B* respectively.

**bremsstrahlung**—*XPS*, photon radiation, continuously distributed in energy up to the energy of the incident electrons, emitted from an anode due to deceleration of incident electrons within the anode. The bremsstrahlung from a conventional X-ray source contributes to the background and the Auger signal strengths in an XPS spectrum.

**cascade mixing**—the rearrangement of the constituents of a solid, within the penetration depth of an incident particle, caused by collisions between the incident particles and the atoms of the solid.

**channel**—*EIA*, an interval of the measured energy of back-scattered particles defined by adjacent energy thresholds in

the analog-to-digital converter used for spectrum production.

**channeling**—motion of energetic particles along certain axial or planar directions of a crystalline solid as the particles penetrate the specimen. The potentials of the individual atoms of the solid combine to reduce scattering with those atoms.

**channeling**—*SIMS*, the process by which particles preferentially penetrate crystalline specimens in certain crystallographic directions because of the relatively open arrangement of atoms presented to the impinging particle beam.

**characteristic electron loss phenomena**—*AES*, the inelastic scattering of electrons in solids that produces a discrete energy loss determined by the characteristics of the material. The most probable form is due to excitation of valence electrons. For some solids (for example, nontransition metals), inelastic scattering is dominated by plasmon excitations (a collective excitation of valence electrons). For other solids, the inelastic scattering may be due to a combination of plasmon excitation and single valence electron excitations. Inelastic scattering can also occur through the excitation of core level electrons when this is energetically possible.

**characteristic X-rays**—photons emitted by ionized atoms and having a particular distribution in energy and intensity characteristic of the atomic number and chemical environment of the atom; in XPS, the term is ordinarily used in reference to the X-ray source of the spectrometer.

**charge:**

*charge modification*—any method used to alter the amount or the distribution of charge on a specimen surface.

*charge neutralization*—*ISS*, *SIMS*, a technique in which a surface under ion bombardment is maintained at a known potential by compensating for the accumulated charge.

*charge referencing*—any method used to adjust the energy scale calibration of a spectrometer to accommodate the effects of steady-state charging of a specimen surface.

**charging potential**—*in surface analysis*, the electrical potential of the surface of an insulating specimen caused by irradiation. If the specimen is heterogeneous, there may be different charging potentials on different areas of the surface.

**chemical:**

*effects*—*AES*, any change in the shape of an Auger spectrum or in the Auger peak energy for an element which is due to chemical bonding.

*shift*—*AES*, *XPS*, a change in peak energy because of a change in the chemical environment of the atom.

*collection angle*—See **angle**.

**collision cascade**—a sequential energy transfer between atoms in a solid as a result of bombardment by an energetic species.

**compositional depth profile**—the chemical composition and the atomic concentration measured as a function of distance from the surface.

**constant energy resolution**—*AES*, *XPS*, a mode of operation in which the instrumental resolution is constant over the spectrum. See **fixed analyzer transmission**.

**Coster-Kronig transition**—*AES*, *XPS* Auger process involving an electron from the same principal shell as the initial vacancy (for example,  $L_1 L_2M$ ).



**counts**—*EIA*, events recorded by the detector and registered in a channel of a backscattering spectrum. Counts constitute the ordinate of a BS spectrum.

*integrated*—sum of all counts registered in a given set of channels or their corresponding energy ranges.

*per channel*—number of counts in a single channel; unit of the ordinate of a backscattering spectrum.

**crater edge effect**—*SIMS*, a signal caused by secondary ions that originate from depths shallower than the maximum depth of the crater formed by primary bombardment.

**cross section:**

*enhanced elastic*—*EIA*, cross section for elastic scattering that is larger than that predicted by *Rutherford* due to partial penetration of a nucleus in the specimen by the incident particle.

*nuclear reaction*—*EIA*, the probability of a particular nuclear reaction as a function of energy and the emission direction of the detected product. Usually expressed as an area in units of barns =  $10^{-28} \text{ m}^2$ .

*Rutherford*—*EIA*, nuclear reaction cross section for the particular case of elastic scattering as calculated from classical mechanics. First evaluated by *Rutherford*.

*stopping*—*EIA*, the energy loss of a particle incident on the specimen per unit area density of specimen atoms. Usually expressed in units of  $\text{eV}\cdot\text{cm}^2/\text{atom}$ .

**cross-sectioning**—a method in which a specimen is mechanically cleaved, cut, or polished in a plane perpendicular to the interface under study, so that associated compositional differences or gradients in the plane of the polished surface may be observed.

**current integration**—the measurement of total electric charge deposited into a specimen by the incident beam.

**curve resolving**—the construction of the individual peaks of a spectrum that consists of overlapping peaks, also called curve fitting or peak fitting.

**deconvolution**—*AES*, *XPS*, a mathematical procedure to (1) remove the contribution to a peak of one of the factors contributing to its line width, for example, X-ray linewidth, analyzer broadening; or (2) remove the energy loss background by deconvoluting the spectrum with an electron energy loss spectrum.

**deep emission function decay length**—the asymptotic emission function decay length for increasing depths from the surface.

**depth profiling**—*AES*, *XPS*, *SIMS*, monitoring the signal strength as a function of some variable (for example, sputtering time) that can be related to distance from the surface.

**depth resolution**—*AES*, *XPS*, *SIMS*, the depth range over which a signal increases (or decreases) by a specified amount when profiling an ideally sharp interface between two media. By convention, the depth resolution corresponds to the distance over which a 16 % to 84 % (or 84 % to 16 %) change in signal is measured.

**depth scale**—*EIA*, a relationship between energy loss and target depth that allows a direct correlation between multi-channel analyzer channel number and depth in the specimen.

**detection limit**—the smallest concentration of an element or

compound that can be measured for specific analysis conditions and data collection periods.

**DISCUSSION**—By convention, the detection limit is often taken to occur when the total signal minus the background signal is two or three times the standard deviation of the background signal above the background signal. This convention may not be applicable to all measurements.

**detector:**

*angle*—*EIA*, see **angle of detector**:

*efficiency*—*EIA*, fraction of particles incident on the detector that actually generate a detectable signal.

*foil*—*EIA*, a thin sheet, usually metal or plastic, placed over a detector to absorb low energy or high mass products, or both, from nuclear reactions, while transmitting other reaction products.

*solid angle*—see **angle, solid, of detector**.

**dose**—number of beam particles per unit area that impinge on the specimen. Alternatively, the dose may be defined as the charge per unit area that impinges on the specimen.

*rate*—number of beam particles per unit area per second that impinge on the specimen. Alternatively, the dose rate may be defined as the current per unit area that impinges on the specimen.

**dynamic SIMS**—*SIMS* analysis at a primary ion current density and dose such that more than one monolayer of material is removed during the analysis.

**effective attenuation length**—the average emission function decay length when the emission depth distribution function is sufficiently close to exponential for a given application.

**electron:**

*flooding*—in *surface analysis*, irradiation of a specimen with low-energy electrons in order to change (generally to reduce) or stabilize the charging potential.

*inelastic mean free path*—the average of distances, measured along the trajectories, that particles with a given energy travel between inelastic collisions in a substance.

*retardation*—*AES*, *XPS*, a method of measuring the kinetic energy distribution by retarding the emitted electrons before or within the analyzer.

*spectrometer*—see **electron energy analyzer**.

**electron energy analyzer**—*AES*, *XPS*, a device for measuring the number of electrons as a function of kinetic energy. (See also **spectrometer**)

*pass energy*—*XPS*, *AES*, the mean kinetic energy of electrons in the energy dispersive portion of an electron energy analyzer that will allow them to traverse the analyzer and be counted.

*fixed analyzer transmission*—*AES*, *XPS*, a mode of analyzer operation that varies the electron retardation but keeps the pass energy constant in the final analyzer stage.

*fixed retarding ratio*—*AES*, *XPS*, a mode of operation in which the electron kinetic energy is analyzed by varying the retarding potential on lens elements preceding the analyzer and the analyzer pass energy so that the analyzer pass energy is a constant fraction of the kinetic energy.

**electron energy loss spectrum**—*XPS*, the energy spectrum of electrons from a monoenergetic electron source after interaction with the specimen, exhibiting peaks due to inelastic

loss processes. The spectrum obtained using an incident electron beam of about the same energy as an XPS peak approximates the loss spectrum associated with that XPS peak. Also see **characteristic electron loss phenomena**.

*electron flooding*— see **electron**.

*electron retardation*— see **electron**.

*electron spectrometer*— see **electron energy analyzer**.

**emission depth distribution function (for a measured signal)**—for particles or radiation emitted from a surface in a given direction, the probability that the particle or radiation leaving the surface in a specified state originated from a specified depth measured normally from the surface into the material.

**emission function decay length**—the negative reciprocal slope of the logarithm of the emission depth distribution function at a specified depth.

**energy:**

*per channel*—*EIA*, energy differences between two successive channels.

*edge*—*EIA*, values of the backscattering energy in a BS spectrum for an element (or isotope) that is located at the surface of the specimen.

*loss*—*EIA*, energy dissipated by the particles of the incident beam as they penetrate through the specimen.

*of incident beam*— average energy of analyzing particle in the incident beam at the moment of impact.

*pass*—(See *pass energy* under **electron energy analyzer**.)

*surface approximation*—*EIA*, see **surface energy approximation**.

**equilibrium surface composition**—see **sputtering**.

**ESCA**—acronym for “electron spectroscopy for chemical analysis,” a term historically used to describe a technique whereby one generates electron spectra by irradiating a specimen with narrow band characteristic X-rays.

**excitation depth distribution function**— the probability that specified excitations are created at specified depths measured normally from a surface into the material by a beam of specified particles or radiation incident on the surface in a given direction.

*extra-atomic relaxation energy*—*XPS*, see **screening energy**.

**fast atom bombardment mass spectrometry (FABMS)**—the technique in which a mass spectrometer is used to measure the mass-to-charge ratio and abundance of secondary ions emitted from a target as a result of the bombardment of fast neutral atoms.

**Fermi energy (level)**— *for metals*, the energy of the top-most filled electron level at zero Kelvin. *For insulators and semiconductors*, the Fermi level is usually between the valence and conduction bands.

**Fermi level referencing**— *XPS*, a method of establishing the binding energy scale for a particular specimen by assigning the kinetic energy corresponding to the Fermi level, as determined by analysis of the specimen’s *XPS* or *UPS* spectrum, as the point of zero binding energy. See also **Fermi energy (level)**.

*fixed analyzer transmission*—see **electron energy analyzer**.

*fixed retarding ratio*— see **electron energy analyzer**.

**fluence**—the number of beam particles per unit area, where

that area is defined perpendicular to the direction of the beam.

**flux**—the number of beam particles per unit area per second, where the area is defined to be perpendicular to the direction of the beam.

**fractional ion yield**— *SIMS*, the ratio of the number of secondary ions of a particular species to the total number of secondary ions emitted by a specimen.

**glancing exit**—*AES*, *EIA*, *XPS*, geometrical arrangement in which the scattered (or emitted) particles are near 90° from the normal to the specimen surface. This results in improved depth resolution.

**glancing incidence**—*AES*, *EIA*, geometrical arrangement in which the incident particles are near 90° from the normal to the specimen surface. This results in improved depth resolution.

**gold decoration**—*XPS*, a method whereby a very thin coat of evaporated gold on an insulator is used as a charge reference; the gold should be deposited as unconnected islands covering the area analyzed.

*grazing exit (incidence)*—*EIA*, same as **glancing exit (incidence)**.

**image depth profile**— *AES*, *XPS*, *SIMS*, a three-dimensional representation of the spatial distribution of a particular elemental or molecular species (as indicated by emitted secondary ions or electrons) as a function of depth or material removed by sputtering.

**incident particle energy**—the effective energy of the primary particles incident on the specimen surface, usually expressed in kiloelectronvolts (keV) per atomic particle.

**inelastic:**

*inelastic mean free path*— see **electron**.

*scattering correction to background*—*XPS*, a method of correcting background for contributions of inelastic scattering processes, most often approximated by simulating the background through a peak by assuming that the rise in background is proportional to the peak area at higher kinetic energy. A more accurate correction is done by deconvolving the energy loss spectrum itself.

*scattering cross-section*—*AES*, *XPS*, a measure of the probability that an electron traversing a material will undergo an inelastic scattering process, expressed as an area per unit event.

*scattering event*—*ISS*, a collision process in which a fraction of the kinetic energy imparted by the probe ion contributes to an increase in the internal energy of the target material, and is not recovered as kinetic energy of the scattered probe ion or target atom recoil.

**information depth**—maximum depth, normal to the specimen surface, from which useful signal information is obtained.

**DISCUSSION**—The information depth can be identified with the specimen thickness from which a specified percentage (for example, 95 % or 99 %) of the detected signal originates. The information depth can be determined from a measured, calculated, or estimated depth distribution function for the signal of interest.

**instrumental detection efficiency**—*SIMS*, the ratio of ions for a particular species detected to ions produced.

**interatomic Auger process**— *AES*, *XPS*, an Auger transition

in which final electron vacancies are in valence levels or molecular orbitals, some of which may be predominantly orbitals of a neighboring bonded atom.

**interface**—a boundary between two phases with different chemical or physical properties.

**interface width, observed**—*AES, XPS, SIMS*, the distance over which a 16 % to 84 % (or 84 % to 16 %) change in signal is measured at the junction of two dissimilar matrices.

**interfacial region**—that volume adjacent to an interface having physical or chemical properties different from either bulk phase as a result of its proximity to the interface.

**interference signal**—*SIMS*, signal measured at the mass position of interest due to another, undesired species.

**internal carbon referencing**—*XPS*, a method of determining the charging potential of a specimen by comparing the experimentally determined binding energy of the C1s peak maximum from a specific carbon group within the specimen to a standard binding energy value for that carbon group. A hydrocarbon group within the specimen is often used for this purpose.

**interphase**—the region between two distinct phases over which there is a variation of a property.

**intrinsic linewidth, of specimen**—*AES, XPS*, the linewidth contribution arising from the specimen. The measured linewidth is a convolution of this function and broadening contributions of the instrument (for example, X-ray source radiation linewidth, spectrometer energy resolution).

**ion beam**—a directed flux of charged atoms or molecules.

*current*—the measured rate of flow of charged atoms or molecules incident upon the specimen per unit time, usually expressed in amperes (A).

*current density*—the ion beam current incident on the specimen per unit cross-sectional area, usually expressed in amperes per square centimetre ( $A/cm^2$ ).

*energy*—in surface analysis, the mean kinetic energy of the ions in the beam (see **beam, energy**).

**ion image**—*SIMS*, a two-dimensional representation of the spatial distribution of a particular secondary ion emitted from a specific area of the specimen.

**ion implantation**—the injection of ions into a specimen.

**ionization cross-section**—the probability that an incident particle traversing a gas or solid will produce an ionizing collision. The total ionization cross-section includes all electron vacancies produced by a primary collision and subsequent Coster-Kronig or Auger decay process. The partial ionization cross-section results from one particular process such as a primary collision to produce an initial innershell vacancy in a particular shell, a Coster-Kronig process, or an Auger ejection process to produce particular distributions of electron vacancies.

**ion lifetime**—the average time that an ion exists in a particular electronic configuration, for example, a vacancy in a particular shell in an atom.

**ion neutralization**—*ISS, SIMS*, the charge exchange processes in which a probe is neutralized by the material surface or gas phase species with which it interacts.

**ion-scattering:**

*spectrometer*—*ISS*, an instrument capable of generating a

beam of principally monoenergetic, singly charged, low-energy ions and determining the energy distribution of the probe ions that have been scattered from the solid surface through a known angle.

*spectrometry*—*ISS*, a technique to elucidate composition and structure of the outermost atomic layers of a solid material, in which principally monoenergetic, singly charged, low-energy (less than 10 keV) probe ions are scattered from the surface and are subsequently detected and recorded as a function of the energy or scattering angle, or both.

*spectrum*—*ISS*, a representation in which the scattered ion intensity is presented as a function of the ratio of the scattered ion energy to the incident ion energy.

**ion species**—type and charge of ion such as  $Ar^+$ ,  $O^-$ , and  $H_2^+$ . If an isotope is used, it should be specified.

**knock-on**—the movement of a constituent of the specimen deeper into the specimen matrix as a result of collisions with the primary particle.

**Koopmans energy**—a calculated energy of an electron in an orbital, on the assumption that its removal to infinity is unaccompanied by electronic relaxation.

**K-value**—*EIA*, a kinematic factor (between 0 and 1) that relates the backscattered energy to the incident energy.

**mass:**

*analyzer*—a device for dispersing ions as a function of their mass-to-charge ratio.

*resolution*—the ratio  $M/\Delta M$  where  $\Delta M$  is the full width at half-maximum peak height for the ion peak of mass  $M$ .

*resolving power*—the peak-to-valley ratio between adjacent, equal-sized peaks, separated by one mass unit.

*spectrum*—a plot of the measured ion signal as a function of mass-to-charge ratio.

**matrix effects:**

*Auger*—any change of an Auger spectrum (for example, shape or signal strength) due to the physical environment (for example, amorphous/crystalline, thin layer/thick layer, or rough/smooth surface) of the emitting element and not due to chemical bonding or changes in concentration.

*SIMS*—any change in the secondary ion yields which are caused by changes in the chemical composition or structure of a particular specimen.

*AES*—see **Auger**.

**mean escape depth**—the average depth normal to the surface from which the specified particles or radiations escape as defined by:

$$\int_0^\infty z\phi(z,\theta)dz / \int_0^\infty \phi(z,\theta)dz \quad (2)$$

where  $\phi(z,\theta)$  = the emission depth distribution function for depth  $z$  from the surface into the material and for direction of emission  $\theta$  with respect to the surface normal.

**mean free path**—See **electron, inelastic mean free path**.

**modified Auger parameter**—the Auger parameter plus the photon energy, which equals the kinetic energy of the sharpest Auger peak plus the binding energy of the most intense photoelectron peak.