



ISO/TC 201
Surface chemical analysis

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BUSINESS PLAN

ISO/TC 201

Surface chemical analysis

EXECUTIVE SUMMARY

1 The main fields of surface chemical analysis

Surface chemical analysis is used extensively for the characterization and development of advanced materials and processes in many technologies. There have been significant industrial applications in such areas as polymers, ceramics, metallurgy, composites, adhesion, tribology, wear, corrosion, thin films and coatings, implant materials, catalysis, microelectronics, and superconductors, and the applications are expanding into the new emerging industries employing nano-, bio-, and environmental technologies where nanomaterials/nanointerfaces, biomaterials/biointerfaces, and ambient surfaces are the essential targets of the surface chemical analysis.

TC201 is and has been on target now for more than 25 years. It has more than 80 documentary standards, published or in development across many methods. It has been very successful and will build upon that success. We foresee no major disruptive developments. All methods, some more mature than others, are developing in response to market demand.

Existing industrial sectors are rapidly developing new materials and products as well as responding to requirements for reduced environmental pollution, toxicity, recycling and energy efficiency by developing new production methods requiring advanced surface or interface characterisation.

Growth in these sectors remains a steady 6% year-on-year with applications across a very wide range of materials and geographical regions. Growth is especially strong in Asia at 8%. New sectors such as pharmaceuticals are using surface analysis to cut development costs. In 2020, the market for surface analysis on the basis of type of instrumentation technology and end user is projected to reach USB\$4.

All surface analysis methods show strong scientific publication levels with growths, for many of the important sectors, of up to and over 10% year-on-year. Total publications are predicted to reach over 100,000 publications in 2020. Some of these methods are maturing and moving to more routine work requiring simpler procedural standards.

2 The size of the markets addressed by the committee

The global surface analysis market size in 2010's shows steady growth regardless of the statistical factors. The following tables were compiled using data in "Surface Analysis Market – Global Forecast to 2020", MarketsAndMarkets BT 3483, 2015.

(1) Global surface analysis market size by instrumentation (USM\$)

	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2020</u> <u>(projected)</u>	CAGR (2015-2020)
Microscopy	1,990	2,118	2,245	2,992	(5.9%)
Spectroscopy	331	356	384	547	(7.3%)
Surface analysers	182	195	210	291	(6.8%)
X-ray Diffraction	102	111	115	160	(6.7%)
Total	2,604	2,779	2,953	3,990	(6.2%)

CAGR: Compound annual growth rate

(2) Global surface analysis market size by industry (USM\$)

	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2020</u> <u>(projected)</u>	CAGR (2015-2020)
Semiconductor	971	1,028	1,096	1,464	(6.0%)
Polymers	607	650	691	946	(6.5%)
Life sciences	372	400	428	696	(7.2%)
Energy	156	164	174	227	(5.5%)
Metallurgy and Minerals	141	153	160	208	(5.4%)
Others*	357	384	405	539	(5.9%)
Total	2,604	2,779	2,953	3,990	(6.2%)

*Food and Beverages, Textile, and Paper and Packaging

(3) Global surface analysis market size by region (USM\$)

	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2020</u> <u>(projected)</u>	CAGR (2015-2020)
North America	991	1,049	1,106	1,467	(5.8%)
Europe	716	760	804	1,053	(5.5%)
Asia	535	578	621	889	(8.0%)
Others	363	392	422	581	(7.1%)
Total	2,604	2,779	2,953	3,990	(6.8%)

(4) Global surface analysis market size by end user (USM\$)

	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2020</u> <u>(projected)</u>	CAGR (2015-2020)
Academic institutes	1,388	1,476	1,562	2,075	(5.8%)
Industries	737	789	842	1,165	(6.7%)
Research Organizations	479	514	549	750	(6.4%)
Total	2,604	2,779	2,953	3,990	(6.2%)

(5) Global surface analysers market size by region (USM\$)

	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2020</u> <u>(projected)</u>	CAGR (2015-2020)
North America	68	72	77	105	(6.4%)
Europe	50	54	58	77	(6.1%)
Asia	37	40	44	64	(8.0%)
Others	27	29	31	44	(7.1%)

3 The publication of scientific papers relevant to surface chemical analysis

The number of the scientific papers in which the surface analysis methods within the scope of TC 201 are employed implies the potential for their needs in industries and hence for the standardization of the methods to be properly used in the industries. The following tables are compiled using data sorted from multiple databases known as *Web of Science*, Clarivate Analytics.

- (1) Publication of scientific papers sorted by conventional surface analysis methods from multiple databases.

	<u>2007</u>	<u>2009</u>	<u>2011</u>	<u>2013</u>	<u>2015</u>	<u>2017</u>
XPS	3,552	4,178	5,103	6,230	7,429	8,035
AES	579	443	434	407	343	282
SIMS	737	810	942	991	891	925
AFM	6,998	7,606	8,099	8,312	8,091	8,174
XRR/TXRF	480	473	502	502	738	864
Ellipsometry	937	973	1,072	991	944	1,013

- (2) Publication of scientific papers sorted by emerging surface analysis methods from multiple databases.

	<u>2007</u>	<u>2009</u>	<u>2011</u>	<u>2013</u>	<u>2015</u>	<u>2017</u>
Atom probe	963	1,076	1,292	1,313	1,496	1,665
MALDI	1,776	1,940	2,205	2,213	2,319	2,084
ATR-FTIR	294	420	480	618	944	1,013
DESI	240	281	331	300	358	282
SERS/TERS	1,512	2,180	2,896	3,516	4,325	4,428
Confocal microscope	3,537	3,746	4,413	4,682	4,961	5,020

4 The benefits realized and expected through the availability of the standards

- (1) Innovation in many industrial fields by providing key analytical standards
Surface chemical analysis techniques are applied to the evaluation of a wide variety of materials.
- (2) Trade enhancement by providing reliable standards for quality management
International trade will be enhanced by the development of procedures to facilitate certification in a quality-management system or to improve efficiency.

5 The main objectives in the work of the committee

To promote the harmonization of requirements concerning instrument specifications, instrument operation, specimen preparation, data acquisition, data processing, qualitative analysis, quantitative analysis, and reporting of results.

1 INTRODUCTION

1.1 ISO technical committees and business planning

The extension of formal business planning to ISO Technical Committees (ISO/TCs) is an important measure which forms part of a major review of business. The aim is to align the ISO work programme with expressed business environment needs and trends and to allow ISO/TCs to prioritize among different projects, to identify the benefits expected from the availability of International Standards, and to ensure adequate resources for projects throughout their development.

1.2 International standardization and the role of ISO

The foremost aim of international standardization is to facilitate the exchange of goods and services through the elimination of technical barriers to trade.

Three bodies are responsible for the planning, development and adoption of International Standards: ISO (International Organization for Standardization) is responsible for all sectors excluding Electrotechnical, which is the responsibility of IEC (International Electrotechnical Committee), and most of the Telecommunications Technologies, which are largely the responsibility of ITU (International Telecommunication Union).

ISO is a legal association, the members of which are the National Standards Bodies (NSBs) of some 162 countries (organizations representing social and economic interests at the international level), supported by a Central Secretariat based in Geneva, Switzerland.

The principal deliverable of ISO is the International Standard.

An International Standard embodies the essential principles of global openness and transparency, consensus and technical coherence. These are safeguarded through its development in a ISO Technical Committee (ISO/TC), representative of all interested parties, supported by a public comment phase (the ISO Technical Enquiry). ISO and its Technical Committees are also able to offer the ISO Technical Specification (ISO/TS), the ISO Public Available Specification (ISO/PAS) and the ISO Technical Report (ISO/TR) as solutions to market needs. These ISO products represent lower levels of consensus and have therefore not the same status as an International Standard.

ISO offers also the International Workshop Agreement (IWA) as a deliverable which aims to bridge the gap between the activities of consortia and the formal process of standardization represented by ISO and its national members. An important distinction is that the IWA is developed by ISO workshops and fora, comprising only participants with direct interest, and so it is not accorded the status of an International Standard.

2 BUSINESS ENVIRONMENT OF THE ISO/TC 201

Scope of the ISO/TC 201 : Surface Chemical Analysis

Standardization in the field of surface chemical analysis in which beams of electrons, ions, neutral atoms or molecules, or photons are incident on the specimen material and scattered or emitted electrons, ions, neutral atoms or molecules, or photons are detected. With current techniques of surface chemical analysis, compositional information is obtained for regions close to a surface (generally within 20 nm) and composition-versus-depth information is obtained with surface analytical techniques as surface layers are removed. Surface chemical analysis also includes techniques in which probes are scanned over the surface and surface-related signals are detected.

Techniques of surface chemical analysis

The three techniques in most common use for practical surface analyses are:

Auger electron spectroscopy (AES)
Secondary ion mass spectrometry (SIMS)
X-ray photoelectron spectroscopy (XPS)

In addition, the following techniques are suitable for certain applications:

Glow discharge spectrometry (GDS)
Total reflection x-ray fluorescence spectroscopy (TXRF)
X-ray reflectometry (XRR)
Ellipsometry
Sputtered neutral mass spectrometry (SNMS)
Fast atom bombardment mass spectrometry (FABMS)

Furthermore the following emerging techniques are gaining more common uses for certain applications:

Atom probe
Matrix assisted laser desorption/ionisation (MALDI)
Attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR)
Desorption electrospray ionization (DESI)
Surface/tip-enhanced Raman scattering (SERS/TERS)
Confocal microscopy and other optical interface analysis method

A common application of surface-analysis techniques is the measurement of surface composition as the surface is eroded by ion bombardment in order to produce a composition-depth profile (CDP) or sputter-depth profile (SDP).

The following techniques of scanning probe microscopy (SPM) are also possible to analyse compositional distribution in certain applications:

Scanning tunnelling microscopy (STM)
Atomic force microscopy (AFM)
Near field scanning optical microscopy (NSOM)

2.1 Description of the Business Environment

The following political, economic, technical, regulatory, legal and social dynamics describe the business environment of the industry sector, products, materials, disciplines or practices related to the scope of this ISO/TC, and they may significantly influence how the relevant standards development processes are conducted and the content of the resulting standards:

2.1.1 General Business Environment

Surface chemical analysis is used extensively for the characterization and development of advanced materials and processes in many technologies. There are significant industrial applications in the following areas: polymers, ceramics, metallurgy, composites, adhesion, tribology, wear, corrosion, thin films and coatings, implant materials, catalysis, microelectronics, and superconductors.

Surface chemical analysis is frequently used to identify regions of different chemical composition on a specimen surface, to determine the concentrations of elements or compounds in these regions, and to measure the variation of composition as a function of position (both parallel and normal to the surface). The sampling depth in a measurement is often between one and a number of atomic layers, depending on the specimen material, the analytical technique, and the experimental approach. In combination with ion sputtering or other sectioning techniques, it is possible to measure the composition as a function of depth.

2.1.2 Technical dynamics in the business environment

High spatial resolution (both parallel and normal to the surface) is required for the analysis of many industrial products and materials. Semiconductor devices, for example, are being produced with smaller dimensions. New classes of materials (e.g. composites) and devices (e.g. sensors) are being developed in which a surface or interface chemical composition needs to be controlled to meet various industrial needs. Nanotechnology (in which devices are fabricated on the nanometer scale) is of growing importance. The other industrial applications mentioned in section 2.1.1 also continue to grow.

There is an increasing need for more detailed and more reliable qualitative surface analyses (for example, the identification of chemical phases present at surfaces and interfaces). There is also an increasing need for quantitative surface analyses with improved accuracy.

Commercial instruments for surface chemical analysis are now being supplied with increasingly powerful computer systems and software. As a result, there are needs to validate and extend new and existing algorithms used for the processing of measured data. Databases are becoming available, but the accuracy of the data in them needs to be assured.

Recommended procedures, reference data, and reference materials will be used to an increasing extent to ensure that surface chemical analyses can be made with the needed reliability and efficiency. International standards will also provide convenient and efficient means of documenting conformance to quality management systems.

2.1.3 Major factors in the business environment

Today one of the major markets of surface analyses is the semiconductor industry. This market also needs improved surface-analytical capabilities. For example, higher sensitivities for detection of trace elements and minor constituents are critical for checking the performance of semiconductor production lines. Higher spatial resolution in surface chemical analysis, the ability to characterize buried interfaces with high spatial resolution, and identification of chemical state of sub-micrometer contaminant particles are very important for characterizing properties of semiconductor products. These growing needs are expected to lead to growth in the market for surface analysis instruments. The standards provided by ISO/TC201 will be useful for checking the specifications of these instruments.

Surface-analysis service laboratories are under pressure to improve the efficiency and to reduce the cost of their analyses. Also, the analytical results obtained by one surface analyst should be compatible with those obtained by other surface analysts, if the specimen is the same. ISO/TC201 standards will provide needed procedures for surface analysts to improve the reliability and efficiency of their services and to ensure compatibility (accuracy) of the analytical results.

The surface analyses are used not only in the semiconductor industry, but also in the steel, polymer, catalysis, food, ceramics, transportation and other industries. The products from these industries have critical surfaces, contacts and interfaces. Therefore, the standards provided by ISO/TC201 will also be useful in these industries for ensuring reliable, efficient, and accurate analyses.

2.2 Quantitative Indicators of the Business Environment

The following list of quantitative indicators describes the business environment in order to provide adequate information to support actions of the ISO/TC 201:

Direct indicators;

- Sales volume and employment of surface chemical analysis instruments
- Sales volume and employment of surface chemical analysis services

Indirect indicators;

Production of the industries using surface chemical analysis

- Semiconductor industry
- Steel industry
- Polymer industry
- Nanomaterial industry
- Biomaterial industry

2.2.1 Direct indicators; Market segments of surface chemical analysis

The market related to TC 201 has three major components: (a) the suppliers (manufacturers) of surface chemical analysis instruments such as AES, XPS, SIMS, GDOS, and TXRF; (b) the suppliers of surface chemical analyses (service sector); and (c) the customers (users of surface chemical analyses) who are widely distributed in modern industries such as steel-making, automobile, electronics, chemical engineering, and so on. In these modern industries, surface characterization of the products is often critical to product properties, fabrication processes, failure analysis, quality control, or the development of new products and processes.

2.2.2 Indirect indicators; Production of the industries using surface chemical analysis

(1) Semiconductor industry

Surface analysis instruments are installed at almost all silicon supplier's plants for quality assurance (Q.A.) and quality control (Q.C.), at major device plants for Q.C., at analytical service organizations to meet requirements from device manufacturers, at chemical and box manufacturers, and at instrument manufacturers especially those that manufacture cleaning instruments.

Sales of semiconductor devices (US\$)(Source: WSTS)

	<u>2012</u>	<u>2014</u>	<u>2016</u>	<u>2018</u>	<u>2019 (expected)</u>
America	54.5	69.3	65.5	100.9	105.5
Europe	33.2	37.5	32.7	43.4	45.5
Japan	41.1	34.8	32.3	39.8	41.4
Asia Pacific	163.0	194.2	208.4	279.4	291.3
Totals	291.6	335.8	338.9	463.4	483.7

(2) Steel and aluminium industry

and aluminium industry

The annual steel production in the world is about 1,800 million tons in 2018. Production of crude steel in the world increased 230 % in these twenty years. About half of this, 900 million tons, is steel sheet and coil. Coated materials are presently more than half of the total production of steel sheet and coil including coatings applied after manufacturing. The annual amount of coated steel is estimated to be 450 million tons.

The annual aluminium production in the world is about 64 million tons in 2018. Production of aluminium in the world increased 160 % in this decade.

Glow discharge spectrometry(GDS) is used for analysis of metal products, especially for surface analysis, using GD-OES(Glow discharge optical emission spectrometry) and GD-MS(Glow discharge mass spectrometry). About 40% of the total application of GDS is estimated for steel and other metal products.

The applications of GD-OES are:

Physical vapour deposition/chemical vapour deposition/hard coating	17%
Alloy coatings on steel	16%

Oxidation/passivation/corrosion	14%
Steel surface	14%
Bulk analysis	11%
Powders	10%
Ion implantation	7%
Polymers/prepainted steel	5%
Others(semiconductor, glass, ceramic coating, thin film)	6%

Zinc-based metallic coatings are applied to steel products for corrosion protection. As an example, the combined effects of market pressure and production automation have forced car manufacturers to look for new high-performance materials and to offer extended warranty for body corrosion. In response to this demand, a range of different coated steel products has been developed. From the combined requirements of corrosion protection and other properties such as formability and weldability, a range of different coating types have been developed. They are produced according to two different main processes, one being based on continuous dipping of steel coil into a zinc-based melt, and the other on electrodeposition of zinc-based layers. The most important alloying elements in existing products are nickel, iron, aluminum and silicon.

Production of crude steel in the world increased 25 % and zinc coat increased more than 50 % in this decade.

(3) Polymer industry

XPS is a common tool to check the properties of organic materials. The chemical structures of organic materials or interface compositions between organic films and substrates are easily analyzed by XPS. The annual production amount of ethylene in the world is about 81 million tons, and the total sales amount of chemical industries is about 951B\$ per year.

3 BENEFITS EXPECTED FROM THE WORK OF THE ISO/TC 201

The benefits from the work of ISO/TC201 are:

- Innovation in many industrial fields by providing key analytical standards
- Trade enhancement by providing reliable standards for quality management

(1) Innovation in many industrial fields by providing key analytical standards

Surface analysis together with surface science is now a major activity contributing to our quality of life through improvements in consumer products, energy, environment, health etc. Specially, surface chemical analysis techniques have been applied to the evaluation of a wide variety of materials: e.g., metals, semiconductors, and inorganic and organic materials. They have also been applied to product and process development and to failure analysis of industrial products in many fields.

Some examples are as follows;

(a) Electronics

- Microcircuit (thin film stability, dopant distribution, failure diagnosis)
- Soldering and metal wetting
- Cleaning

(b) Metal manufacture

- Nitriding
- Rolling
- Welding
- Ball bearings
- Cleaning
- Power metallurgy

(c) Chemicals

- Catalysis
- Plastics
- Pigments
- Detergents
- Fertilizers

(d) Electricity

- Steel failures (temper brittleness, creep embrittlement, stress corrosion cracking, etc.)
- Solar cells
- Fuel cells

(e) Food and drink

- Canning
- Corrosion

(f) Metal goods

- Finishing
- Welding
- Soldering
- Adhesives

(g) Motor vehicles

- Lubrication
- Wear
- Paint adhesion
- Batteries
- Corrosion
- Adhesives

(h) Mechanical engineering

- Machining
- Hard metals
- Oxidation
- Tribology

(2) Trade enhancement by providing reliable standards for quality management

Surface analysis comprises a series of operations which includes instrument setup, specimen handling, data acquisition, and data analysis. Therefore, the final results of surface analysis have uncertainties due to random and systematic errors of the components in the various measurements and the data treatment as stated above. Generally, the systematic error is much greater than the random error in most quantitative surface analyses. For many of the industrial processes and products listed in section (1), international trade will be enhanced by a reduction of the systematic errors in surface analysis and by the development of procedures to facilitate certification in a quality-management system or to improve efficiency.

In order to improve the reliability of surface chemical analysis, many standard methods should be published. Some examples are as follows; calibration method for energy scale in AES and XPS, methods for quantitative analyses, evaluation of depth resolution, specimen handling, instrument setup, manipulation of measured data, development of certified reference materials, and development of reliable reference data.

Any measurement must ensure demonstrated traceability to the relevant basic measurement quantities. This is an essential condition for ensuring the accuracy of the results. The standards established in ISO/TC201 enable those performing surface analyses and the customers of these services to satisfy the requirements of ISO 9000 and ISO 17025.

4 REPRESENTATION AND PARTICIPATION IN THE ISO/TC 201

4.1 Countries/ISO members bodies that are P and O members of the ISO committee

4.2 Analysis of the participation

From the viewpoint of the value of instrument sales, the major techniques for surface chemical analysis are AES, XPS, SIMS, GDOS and TXRF, as shown in 2.2.1. However, the major players are the suppliers of surface-analysis services as summarized in 2.2.1.

ISO/TC 201 currently has thirteen P-members (Belgium, China, Germany, Hungary, Islamic Republic of Iran, Italy, Japan, Republic of Korea, Mexico, Spain, Switzerland, United Kingdom, and USA) and fifteen O-members (Austria, Czech Republic, Egypt, Finland, France, Hong Kong, India, Ireland, Mongolia, Philippines, Poland, Romania, Russian Federation, Sweden, and Turkey). Some of these O-members hold P-memberships on one or more ISO/TC 201 subcommittees (Australia, Philippines, and Sweden). Thus, most industrialized nations of the world are represented on ISO/TC 201.

ISO/TC 201 and nine of its subcommittees have category-A liaisons with ISO/TC 202, ISO/TC 229, IEC/TC 113 the International Union of Pure and Applied Chemistry (IUPAC), the Internal Union of Vacuum Science, Technique, and Applications (IUVSTA), and the Versailles Project on Advanced Materials and Standards (VAMAS). In addition, ISO/TC 201/SC 1 has liaisons with ISO/TC 37 and ISO/TC 202/SC 1, ISO/TC 201/SC 3 has a liaison with ISO/TC 69/SC 6, ISO/TC 201/SC 8 has liaisons with ISO/TC 17/SC 1 and ISO/TC 107, ISO/TC 201/SC 9 has a liaison with ISO/TC 213, and ISO/TC 201/SC 10 has a liaison with ISO/TC 147..

ISO/TC 201 and its subcommittees currently have thirteen Working Groups. Experts have been appointed to these Working Groups by most of the P-members of ISO/TC 201 and its subcommittees.

5 OBJECTIVES OF THE ISO/TC 201 AND STRATEGIES FOR THEIR ACHIEVEMENT

5.1 Defined objectives of the ISO/TC 201

The objectives of ISO/TC 201 Surface Chemical Analysis are:

to promote the harmonization of requirements concerning instrument specifications, instrument operation, specimen preparation, data acquisition, data processing, qualitative analysis, quantitative analysis, and reporting of results;

to establish consistent terminology; and

to develop recommended procedures and to promote the development of reference materials and reference data to ensure that surface analyses of the needed precision and accuracy can be made.

5.2 Identified strategies to achieve the ISO/TC's defined objectives

The topics for standards to be developed by ISO/TC 201 will be chosen to avoid duplication of effort with the current work of existing organizations.

Recommendations from such organizations should be considered as the basis for potential draft international standards whenever appropriate. Such standards can be considered under the ISO fast-track procedures.

ISO/TC 201 will establish liaison with other relevant ISO Technical Committees to ensure compatibility of standards in areas of mutual interest and concern. ISO/TC 201 will also establish liaison with other international bodies to ensure compatibility of standards and recommendations.

ISO/TC 201 should consider the following four factors when considering proposals for new standards:

Standardization is appropriate only when the industrial need is sufficient to justify the effort.

A standard should not be written until an adequate technology and experience base is available.

Standards should only be developed by groups with a balanced representations of users and suppliers (in this context, regulatory and similar interests are considered users).

Industrial standards should emphasize the interests of the user because the supplier intrinsically possesses a greater knowledge of the technology.

6 FACTORS AFFECTING COMPLETION AND IMPLEMENTATION OF THE ISO/TC 201 WORK PROGRAMME

To ensure the continued success of ISO/TC201, the following risks should be considered:

Shortage of funds to support travel to ISO/TC 201 meetings and the work of delegates and experts on ISO/TC 201 business in their home institutions. In addition, experts in many countries have heavy other responsibilities, and it can be difficult for them to make time available for ISO/TC 201 projects.

Shortage of human resources. An active effort needs to be made to find additional experts, particularly younger scientists, to expedite the ISO/TC 201 work program.

7 STRUCTURE, CURRENT PROJECTS AND PUBLICATIONS OF THE ISO/TC 201

This section gives an overview of the ISO/TC structure, scopes of the ISO/TC and any existing subcommittees and information on existing and planned standardization projects, publication of the ISO/TC and its subcommittees.

7.1 Structure of the ISO committee

7.2 Current projects of the ISO technical committee and its subcommittees

7.3 Publications of the ISO technical committee and its subcommittees

Reference information

Glossary of terms and abbreviations used in ISO/TC Business Plans

General information on the principles of ISO's technical work

"Surface Analysis Market – Global Forecast to 2020", MarketsAndMarkets BT 3483, 2015.

Web of Science, Clarivate Analytics.