surfaces

Editorial

Impact of Surface Science in Current Science and Technology: Some Basic Considerations

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More than half a century has passed since the establishment of surface science as a specific discipline [1]. The period of 1960–1970 documented the transition from a macroscopic (see *Langmuir* contributions to the chemistry of surfaces [2]) to a microscopic approach, e.g., structural studies using electron diffraction [3] and the exploitation of electron inelastic scattering for the chemical analysis of surfaces [4]. In fact, it was the combination of the rigor of condensed matter physics and physical chemistry with the macroscopic approach to traditional colloidal chemistry and heterogeneous catalysis that allowed surface science to evolve as a distinct discipline.

It is important to consider the impact that surface science can have on current science and technology following the long period of methodological development during which a rather limited community of specialists [5] established the basis for understanding the innovative properties of materials (both inorganic and bio-organic) induced by surfaces and interfaces. While this conceptual framework was established by such a limited community of surface scientists, today, an extended interdisciplinary community is undertaking the implementation of past achievements to achieve technological outcomes. As a consequence, surfaces and interfaces have become a prevalent aspect of many different disciplines. I would like briefly outline some basic considerations and critical issues that must be addressed in order to guarantee the maintenance of the original rigorous approach taken since the naissance of surface science.

First, a question remains regarding the lack of a common view of what a surface or an interface represents. Generally speaking, a surface or an interface is a zone of **discontinuity in the structure and properties of an object.** In chemistry and material science, such a discontinuity arises when two different chemical phases (solid, liquid, gas or vacuum) are interconnected. In most cases, a completely new phase (the interphase) with new properties is interposed between the two [6]. A main issue is that the metric definition of a surface/interface can vary between different technological areas. To address this point, it is useful to introduce of the concept of *selvedge*, which is a layer of variable depth which plays different roles depending on the specific technological field. In Figure 1, the definition of selvedge in the case of a solid surface is described, and in Table 1, the different depth regimes are summarized.

The important message conveyed by Table 1 is that specialists in different fields usually associate the idea of a surface/interface with different entities. So, to avoid a "Babel tower" and the use of inappropriate methods for the preparation and characterization of their surfaces, the above-reported Table has to be available to all scholars reporting surface science data. This would prevent the issue of *shooting an elephant with a blowpipe* or *a butterfly with a bazooka*.

Secondly, scholars without specific competence in surface science (i.e., only users of the data provided by surface science) should be well aware of the tricks and limitations of the methods adopted for surface characterization, e.g., the relative accuracy of the data and the different depth information. Unfortunately, the complexity and high cost of the equipment and instruments required for surface investigations result in the sharing of resources that

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are routinely managed by technicians, who do not necessarily have the required surface science skills to correctly interpret the data and are often not aware of the scientific problem to be addressed. The consequence is that in the literature, either scientific papers are full of incorrect interpretations of surface characterization data or the data themselves are *over-interpreted* or *under-interpreted*. This problem is particularly severe for XPS data, which are currently required for the publication of scientific studies on catalysts, electrodes, polymers and thin films. However, the same is true for many other characterization techniques (not necessarily surface characterization, e.g., SEM, TEM, XRD, contact angle, etc.). Very often, interdisciplinary papers present lists of different characterization data, but do not properly discuss them. So, in order to increase the reliability and impact of such papers, I would like to call for all scholars using surface science data to consult with surface scientists when reporting such data in their valuable papers.

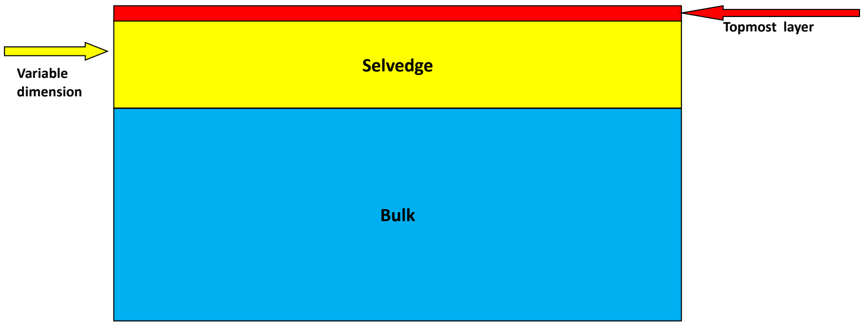

Figure 1. Definition of selvedge.

Table 1. Selvedge depths and regimes in different technological fields.

Selvedge Depth	Main Fields of Interest	Preparative Procedures	Characterization Procedures
Outermost layer ≈0.1 nm	Catalysis, sensors, surface tension, electrochemistry, molecular lubrication	gas-dosing, MBE, PVD, CVD, ALD, electrodeposition, drop casting	IRAS, LEED, LEIS, UPS, STM, HAS, NEXAFS
Ultrathin films (up to 1–2 nm)	Model catalysts, strained and not-bulk-like phases, SAM, release agents, high-k dielectrics		XPS, UPS, XPD, LEED, EXAFS, STM, SXRD, ARXPS, ARUPS
Thin films (up to 100 nm)	Langmuir-Blodget films, MOSFET, CCD, ferroelectric memories, emulsions, membranes, anti-reflection coatings, emulsions, tribological control	PVD, CVD, sputtering, LPE, plasma assisted methods, laser-ablation, wet chemistry (colloidal chemistry, sol-gel)	AES, XPS, SEM, AFM, SXRD, SAXS, RBS
Near surface (up to 10 µm)	Semiconductor devices, optical recording media, photographic films, biodegradation		EDX, SEM, SIMS, AFM, XRD
Thick film (from 10 µm)	Anti-corrosion films, phosphors, adhesives, magnetic recording films	Spray pyrolysis, sol-gel, adhesive bonding	XRD, SEM, optical Microscopy

This commitment should also be made by the Editorial Boards of journals in which such interdisciplinary studies are reported. Unfortunately, the more interdisciplinary the journal, the more difficult it is to undertake proper peer reviewing of all aspects of related studies. In this sense, it is my contention that sectorial journals on surfaces and interfaces can have a relevant role in maintaining the original approach to surface science.

Conflicts of Interest: The author declares no conflict of interest.

References and Notes

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5. Surface scientists can also be considered the forerunners of Nanoscience. Again, it was the wedding of atomic and molecular physics with surface science that led to nanoscience, which is the study of the prevalence of surface over bulk effects with the addition of quantum confinement as well.
6. The ancient latin sentence *Natura non facit saltus*, assigned to Aristotle and reprised by Leibniz, is well in tune with such a concept.