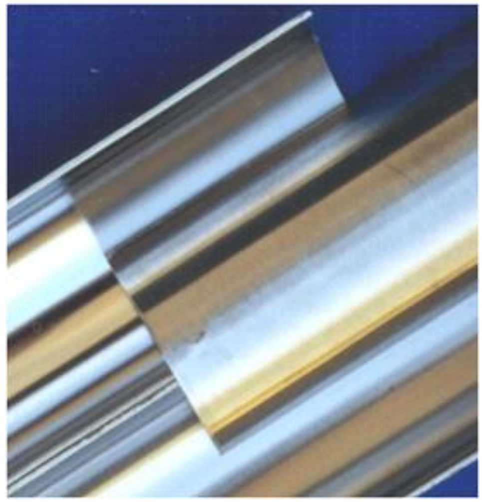
Minimox®

Stainless Steel Surface Analysis at Material Interface, Inc.

Technical Bulletin

Stainless Steel Surface Analysis



Stainless steel is defined as a steel alloy with a minimum of 10.5 weight percent chromium. Although stainless steel does not generally corrode as easily as ordinary steel, different grades are necessary for different environments. For example, several manufacturing groups (including semiconductor and pharmaceutical) have stringent requirements for stainless steel surfaces.

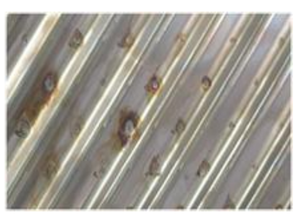
The corrosion-resistant properties of stainless steel are due to the formation of a passive chromium oxide surface layer. Although this layer forms naturally when the material is exposed to the atmosphere, additional chemical treatments (passivation) can improve the relative amount of chromium at the surface.

The surface chemistry changes due to passivation occur within the outer ~50Å of the surface. In order to measure these changes, surface analytical tools such as x-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES) are necessary. One of the stainless steel measurements that is made using Auger and XPS is the near-surface chromium/iron (Cr/Fe) ratio.

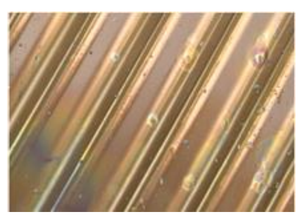
Effect Of Chromium/Iron Ratio

A sample of corrugated 304L panel was exposed to a chloride-containing environment. The chromium/iron ratios and the sample appearance are shown. A lower Cr/Fe ratio results in more corrosion.

Good appearance
Cr/Fe = 2.1



Sporadic corrosion
Cr/Fe = 0.6



Substantial corrosion
Cr/Fe = 0.3

Specific procedures have been developed by Material Interface to document the surface chemistry of these samples. The analysis can also be conducted according to specifications in standards published by Sematech[1] and SEMI[2].

1-877-606-9610
minimox.com
Material Interface, Inc.
info@materialinterface.com

Minimox®

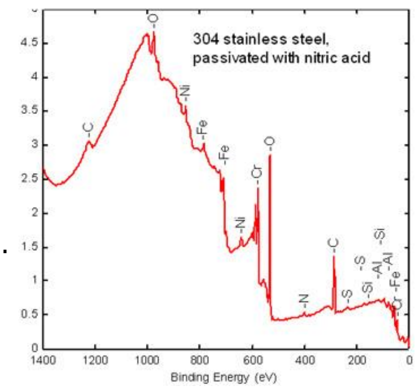
Technical Bulletin

Stainless Steel Surface Analysis

When stainless steel is analyzed with XPS or Auger, four steps are included.

Step 1. Stainless steel survey spectrum

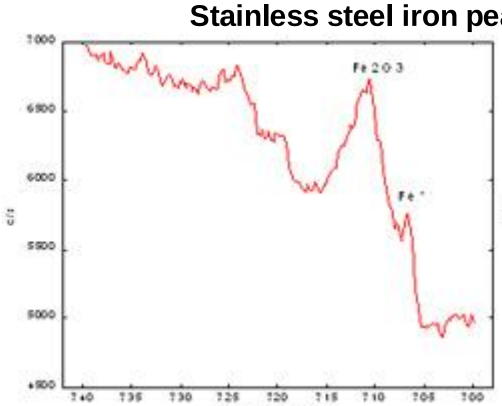
A survey scan determines the overall elemental composition of the surface from atomic numbers 3-92. This determines the composition of the passive layer elemental composition and surface Cr/Fe ratio. High C and O are typical on metals exposed to the air. Other elements are present due to processing and to handling.



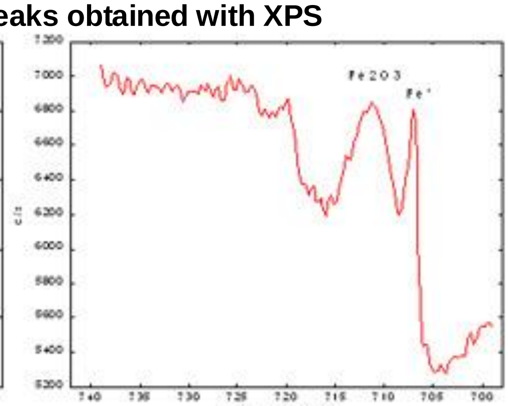
Step 2. Chemical state information

If the analysis is conducted with XPS, the major elements detected (usually carbon, oxygen, silicon, chromium, iron, nickel, and molybdenum) are analyzed in high energy resolution mode to determine their binding energies and then to make some inferences about the compounds present on the surface. This measurement determines the relative amounts of metals versus oxides for chromium, iron, and nickel and the distribution of organic carbon states

Stainless steel iron peaks obtained with XPS



Traditional passivation process. Low level of metallic iron; good corrosion resistance



Experimental passivation. High level of metallic iron resulting in subsequent rust formation.

1-877-606-9610
minimox.com
Material Interface, Inc.
info@materialinterface.com

Minimox®

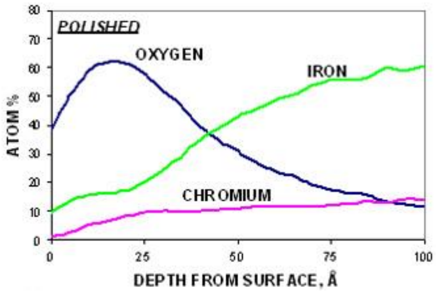
Technical Bulletin

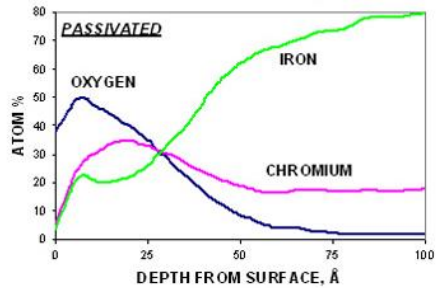
Stainless Steel Surface Analysis

Step 3. Depth Profile

The third step in the analysis includes a depth profile to determine the concentration of the primary elements (C, O, Cr, Fe, and Ni) as a function of depth. This also yields the Cr/Fe ratio as a function of depth and the oxide thickness.

As an example, for the polished sample (left graph), the iron concentration is always higher than the chromium concentration. For the passivated sample (right graph), the concentration of chromium is greater than the concentration of iron in the near-surface region.





Step 4. After-profiling composition of all elements (for quantitative comparison).

Susan Kerber of Material Interface has been actively involved with ASTM International on the development of a new stainless steel passivation standard. The new standard is currently undergoing round-robin testing.

Please contact our office for additional information or for a quote.

[1]Sematech, 2706 Montopolis Drive, Austin, TX 78741, Specifications 90120403B-STD and 91060573B-STD.

[2]SEMI Global Headquarters, 3081 Zanker Road, San Jose, CA 95134, Specifications F30-0306 (XPS), F72-1102 (Auger), F73-1102 (SEM).

1-877-606-9610
minimox.com
Material Interface, Inc.
info@materialinterface.com