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Alloy Surface Composition Resulting from Fabrication, as Determined by s.i.m.s. (Secondary Ion Mass Spectrometry)

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Alloy surface composition resulting from fabrication, as determined by s.i.m.s. (secondary ion mass spectrometry)*

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In s.i.m.s. the sample surface is ion bombarded and the emitted secondary ions are mass analysed. When used in the static mode with very low primary ion beam current densities (10^{-11} A/mm^2), the technique analyses the outermost atomic layers with the following advantages (Benninghoven 1973, 1975): the structural–chemical nature of the surface may be deduced from the masses of the ejected ionized clusters of atoms; detection of hydrogen and its compounds is possible; sensitivity is extremely high (10^{-6} monolayer) for a number of elements.

Composition profiles are obtained by increasing the primary beam current density (dynamic mode) or by combining the technique in the static mode with ion beam machining with a separate, more powerful ion source.

The application of static s.i.m.s. in metallurgy has been explored by analysing a variety of alloy surfaces after fabrication procedures in relation to surface quality and subsequent performance. In a copper–silver eutectic alloy braze it was found that the composition of the solid surface depended markedly on its pretreatment. Generally there was a surface enrichment of copper relative to silver in melting processes while sawing and polishing enriched the surface in silver.

The high sensitivity of s.i.m.s. enabled a wide range of additive and residual elements to be detected on the surface of free-machining brass swarf after 'burning' to remove machining oil. These included lead, tin, arsenic, antimony, iron, manganese and the alkali metals. Copper, zinc and tin hydroxides had also been formed on the swarf surface.

The oxide layers on ground and hot rolled surfaces of $3\frac{1}{2}$NiCrMoV low alloy steel were enriched in most of the alloying elements and in manganese. They also contained aluminium, sodium and potassium to which s.i.m.s. is very sensitive. Hydrogen, hydroxyl groups, halides and hydrocarbons were also present but may have been due in part to adsorption of residual gases in the unbaked vacuum system.

A profile through the oxide layer (approx. 0.25 μm thick) formed at 1000 °C in air on a superalloy Ni–Cr–Al–γ-γ'-Cr_3C_2 eutectic doped with yttrium showed that it was enriched in chromium and aluminium oxides but depleted in nickel oxide. Yttrium oxide was present throughout the layer but with a sharp increase in concentration at the air–oxide interface and also with a broad maximum concentration in the region of the oxide-metal interface. The location of yttrium oxide at the oxide–metal interface, suggesting its role in improving adhesion of the oxide, is in agreement with element profiles obtained by Auger electron spectroscopy (Bullock *et al.*, this symposium). S.i.m.s. showed in addition the decarburization of the oxide layer and the presence of Cr–Al spinel and also the presence of combined hydrogen, particularly at the outer surface.

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* **Extended abstract.**

These investigations have shown that static s.i.m.s. can provide useful information, not easily obtained by other surface analysis techniques, for the solution of a wide range of materials problems.

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