The Effects of Water Vapor and Hydrogen on the High-Temperature Oxidation of Alloys

G. H. Meier
Department of Mechanical Engineering and Materials Science
University of Pittsburgh

Essentially all alloys and coatings and non-oxide ceramics that are resistant to corrosion at high temperature require the formation of a protective (slowly-growing and adherent) oxide layer by a process known as *selective oxidation*. The fundamental understanding of this process has been developed over the years for exposure in pure oxygen or air. However, the atmospheres in most technological applications contain significant amounts of water vapor which can greatly modify the behavior of protective oxides. Two of the most serious effects of water vapor or steam on the high temperature oxidation of alloys are the increased spalling tendencies of Al_2O_3 and Cr_2O_3 layers [1], and the increased volatilization of certain oxides [2]. Recently, it has also become apparent that the presence of water vapor can alter the selective oxidation process [3, 4].

This seminar will begin with a brief review of the fundamentals of selective oxidation followed by a description of recent experimental results regarding the effect of water vapor in atmospheres typical of those in gas turbines and solid oxide fuel cells (SOFCs). The topics to be discussed include:

i. Water vapor effects on oxide evaporation in SOFCs.
ii. Water vapor effects on the internal oxidation of alloys containing Cr or Al.
iii. Dual atmosphere effects in SOFCs.

The seminar will conclude with a brief presentation of some rather surprising results in which exposure of an Fe-Cr alloy to water vapor affected the formation of sigma-phase on grain boundaries in the alloy [5].

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5. J. E. Hammer, S. J. Laney, R. W. Jackson, K. Coyne, F. S. Pettit, and G. H. Meier, "The Oxidation of Ferritic Stainless Steels in Simulated Solid Oxide Fuel Cell Atmospheres", Oxid. Metals, 67, 1 (2007).