First International Workshop on Diffusion and Stresses

STRESS/STRAIN EFFECTS OF HYDROGEN PERMEATING THROUGH PALLADIUM ALLOY MEMBRANES

An increasing general appreciation of the importance of stress and accompanying strain factor involvement in solid state physicochemical processes has resulted recently in the formation of the First International Workshop on Stress and Diffusion, organised by Professor D. L. Beke of L. Kossuth University, Debrecen, Hungary and held in Balatonfüred, from 26th to 29th May, 1995.

The consequences of stress involvement were reported by internationally well-recognised authorities, in plenary contributions which covered a wide range of topics, including phase relationships, internal friction, precipitate growth and thermodynamic features. In the general study area of thin film interdiffusion and multilayer growth processes, a review by F. M. d'Heurle, I.B.M. Research Center, Yorktown Heights, U.S.A., and O. Thomas of MATOP, URA CNRS, Marseilles, France, of stresses developed during silicide formation included a specific platinum group element participation in terms of the compositions Pd_2Si and Pt_2Si.

The influence of stresses which develop in reaction zones as a result of the relatively higher mobility of one of the components, such as platinum in a platinum/silicon carbide diffusion couple, was considered to be a probable controlling source of layer distortions. This was reported in a paper on periodic layer formation in ternary diffusion couples by M. R. Rijnders, A. A. Kodentsov and F. J. van Loo, Laboratory of Solid State Chemistry and Materials Science, Eindhoven and C. Cserháti of L. Kossuth University.

A study of solid state interactions in successively deposited components of thin films, reported by F. B. Barna, G. Zsigmond, A. Csanády and Zs. Radi, Research Institute for Technical Physics, Hungarian Academy of Sciences, Budapest, considered the levels of importance of stresses concurrently developed in platinum films which were grown upon aluminium film substrates.

Uphill Hydrogen Diffusion Effects

Evidence of stress/strain factor influences noted during studies of hydrogen permeation through palladium and palladium-alloy membranes has been centred on observations of Uphill Effects.

Uphill Effects are broadly indicative of the presence of membrane cross-sectional regions of hydrogen flux, which are acting in opposition to the concentration gradient, and are "self produced" by the Gorsky-Diffusion-Elastic Effect strain gradients, the latter being associated with expansions of the interstitial sites effected by permeating hydrogen. Uphill Effect observations in sheet and tubular diffusion membranes, which were recorded using measurements of hydrogen gas pressures and of electrode potentials at catalytically active surfaces, have been substantially extended recently by experimental studies from the research groups of B. Baranowski, Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw, and Y. Sakamoto, University of Nagasaki.

In addition, previous results have also been extended by increased variations of temperature, membrane thickness and other constructional geometries, in further series of measurements that have now also been obtained over a wider range of membrane compositions. Overall progress in such recent experimental and complementary theoretical aspects were outlined in a workshop contribution entitled "Gorsky-Diffusion-Elastic Effects of Hydrogen Interstitial Strain Gradients in Palladium and Palladium Alloys", presented by F. A. Lewis, Queen's University, Belfast, Y. Sakamoto, University of Nagasaki, K. Kandasamy, University of Jaffna and X. Q. Tong, University of Birmingham.

Uphill Effect research studies, using a tubular form of membrane having a composition similar to that of the initially investigated, and subsequently well-characterised $Pd_{81}Pt_{19}$ alloy have been extended recently by employing a wider range of temperature, in combination with accurately correlated results from corresponding isothermal equilibrium pressure-hydrogen content (p-n) relationships, by Professor Baranowski and colleagues. A survey of consolidated results and current research progress was comprehensively outlined in a contribution to the Workshop by D. Dudek and B. Baranowski concerning strain gradient influences on hydrogen diffusion coefficients in the $Pd_{81}Pt_{19}$-H system.

A total of some fifty participants in the Workshop drawn from 12 different countries, contributed to a programme of approximately twenty-five verbal and fifteen poster presentations. Corresponding refereed articles prepared from these contributions are planned to be published in a forthcoming issue of the journal *Defect and Diffusion Forum*. F.A.L.

Platinum 1995

DEMAND FOR PLATINUM A RECORD HIGH

Since 1985 Johnson Matthey has been publishing an annual survey of the commercial aspects of the platinum group metals, with particular emphasis on platinum. Following tradition, the launch of "Platinum 1995" took place in London during Platinum Week and was well received by the analysts, financial journalists, mining engineers and industrialists who attended. Based, in essence, on information gathered from numerous sources worldwide and well supported by statistical data, "Platinum 1995" details the progress of the platinum metals during 1994 and the events which affected both supply and demand, with forecasts for the coming year.

The price of platinum during the year averaged $405.25 per ounce, an eight per cent increase over 1993, peaking to $427.50 in July. This was upheld by factors such as economic recovery, speculation and spasmodic uncertainty over supply. However, prices began a further climb in late March 1995 and soared to reach a four year high of $459 per ounce on 4th April 1995, following the announcement of a new platinum-based technology for the reduction of ozone and carbon monoxide.

Supplies of platinum during 1994 rose by three per cent to 4.53 million ounces. A fall in output from South Africa was offset by a significant increase in exports from Russia. Supply and demand were closely matched.

The motor industry again led the way in the consumption of platinum, chiefly for the manufacture of autocatalysts, with the U.S.A. consuming an increased 32 per cent bringing the total for 1994 to 1.86 million ounces. This was followed closely by the Japanese jewellery industry with its eleventh consecutive year of growth. An increase in the fabrication of Platinum 1000 jewellery resulted in escalating demand with sales spiralling by 100,000 ounces to reach 1.45 million ounces. Growing appreciation of platinum jewellery in North America has encouraged established manufacturers to step-up production and also new participants to develop products.

In addition to dealing with industrial and investment demand, "Platinum 1995" has devoted a chapter to mining and exploration, principally in South Africa. It also contains special features covering mining the platinum group metals in Russia, worldwide coverage of emissions legislation and the use of platinum in the car. On a lesser scale, there are also surveys of the other platinum group metals markets, in particular palladium.

This fifty-two page analysis of trends in the platinum group metals market worldwide is regarded as the authoritative source of such information and is highly respected throughout the financial world. If you would like to receive your free copy of "Platinum 1995" or be added to its distribution list, please contact Alison Cowley, Johnson Matthey PLC, 78 Hatton Garden, London EC1N 8JP, England; Fax : 0171-269-8389.