First International Symposium on Iridium

CONTINUING INTEREST IN PROPERTIES AND NEW AND EXISTING APPLICATIONS

The First International Symposium on Iridium was held from 13th to 15th March, 2000, in Nashville, Tennessee, U.S.A., as part of the Annual Meeting of The Minerals, Metals and Materials Society (TMS). The symposium, sponsored by the TMS Refractory Metals Committee, drew more than 75 attendees and included more than 40 technical presentations from Australia, Germany, Japan, Netherlands, Russia, South Africa, Ukraine, and the United States. The symposium comes at the end of a decade that has seen increased interest and application of iridium materials as well as important research on iridium-containing materials. While iridium has many unique properties, the number of applications for iridium and the level of research and development on iridium have been historically limited by the modest quantity of material produced. The historically low price for iridium, which lasted for several years during the middle part of the 1990s, provided an incentive to examine new applications for the metal. As a number of new applications were realised, iridium prices rose, creating favourable conditions for new research on improved refining methods and fabrication techniques.

Applications of Iridium

There was great interest at the symposium in both new and existing applications of iridium. The application of iridium and iridium alloys for high-temperature thermocouples was discussed by J. Grossi (Engelhard-CLAL, U.S.A.), crystal growth crucibles by A. Ermakov (Ekaterinburg Nonferrous Metal Processing Plant, Russia), coatings of advanced rocket thrusters by A. J. Fortini (Ultramet, U.S.A.) and automotive spark plugs by L. F. Toth (Engelhard-CLAL, U.S.A.). Jewellery was discussed by C. Volpe (Tiffany & Company, U.S.A.).

The production of isotopically enriched iridium for radiation sources in medical applications was described by D. F. Lupton (W. C. Heraeus, Germany). Recent developments of iridium oxide coatings produced by magnetron sputtering for use in medical implants were discussed by T. Loose (W. C. Heraeus, Germany). T. Shimamune (Furuya Metals, Japan) reviewed the use of iridium oxide coatings, produced by the oxidation of iridium chlorides or other salts, for electrodes for industrial electrolysis. Increasing application is projected for these electrodes in chlor-alkali electrolysis plants and in other processes.

Fabrication and Refining

Papers concerning the fabrication of iridium components were presented on the topics of: welding by S. A. David (Oak Ridge National Laboratory, U.S.A.), electroforming by A. Shchetkovskiy (Engelhard-CLAL, U.S.A.) and plastic forming by A. Ermakov. Presentations related to the topics of refining and recycling of iridium were made by J. D. Ragaini (Engelhard-CLAL, U.S.A.), A. Ermakov, M. J. Nicol (Murdoch University, Australia) and T. Maruko (Furuya Metals, Japan). A series of papers on iridium compounds, including fluoro complexes and beta-diketonates presented by V. N. Mitkin (Institute of Inorganic Chemistry SB, Russia) hold possible important implications for refining and purification of iridium.

Properties of Iridium

The mechanical properties of iridium and iridium alloys were the topic of several papers at the symposium. P. E. Panfilov (Urals State University, Russia) in an invited paper commented that "it is unbelievable that there is a face-centred-cubic metal whose properties continue to be puzzling at the end of the twentieth century". Panfilov attributes the behaviour of significant tensile elongation followed by cleavage failure of iridium single crystals to the limited mobility of dislocations and the formation of nets of dislocations at medium to large strains. The nature of the large dislocation core structure in iridium was discussed by T. J. Balk (Johns Hopkins University, U.S.A.) together with the possible implications for mechanical behaviour. The effects of both alloying and impurity elements on the mechanical behaviour of iridium were discussed in another invited talk by E. P. George (Oak Ridge National Laboratory, U.S.A.). Segregation of trace elements to grain boundaries can result in improved alloy ductility for elements such as thorium and cerium or dramatically reduced ductility for impurities such as silicon and phosphorus. Interestingly, in a subsequent presentation by D. F. Lupton it was shown that heating iridium with a small addition of silicon to near the melting point results in silicon migrating away from the grain boundaries, with no loss of strength or ductility. In contrast, iron impurities, which George showed to have little effect on ductility at high strain rate, were found by Lupton to decrease creep properties.

Eight papers were presented on the topic of iridium-based and iridium-containing alloys with significant quantities of ordered phases. Hafnium, zirconium, niobium and tantalum were reported by Y. Yamabe-Mitarai (National Research Institute for Metals, Japan) to produce ordered phases with improved mechanical properties to 1200°C but without beneficial effects at higher temperatures. Superior compressive yield strength at 1200°C was shown by Y. F. Gu (National Research Institute for Metals, Japan) for an Ir-15% Nb alloy with a nickel addition. H. Hosoda (University of Tsukuba, Japan) reported on the improved oxidation resistance in an IrAl compound alloyed with nickel. The oxidation resistance of (Ir,Ru)Al alloys increased with increasing iridium content, while additions of boron to Ir-Al decreased the oxidation resistance (P. J. Hill and I. M. Wolff, Mintek, South Africa). Other presentations dealt with quaternary Ir-Nb-Ni-Al alloys, X. H. Yu (National Research Institute for Metals, Japan). Iridium additions to NiAl single crystals were discussed by A. Chiba (Iwate University, Japan), while H. Hosoda (University of Tsukuba, Japan) described iridium additions to FeAl alloys. The effect of low-pressure oxygen atmospheres on grain growth in iridium alloys was summarised by C. G. McKamey (Oak Ridge National Laboratory, U.S.A.). Diffusion in the Ir-Re system was reported by A. Smirnov (Engelhard-CLAL, U.S.A.).

The proceedings of the international symposium, "Iridium", ISBN: 0-87339-461-5, edited by E. K. Ohriner, R. D. Lanam, P. Panfilov and H. Harada, are available from TMS, 184 Thorn Hill Road, Warrendale, PA 15086, U.S.A. Cost: U.S.$94.00, Member: U.S.$68.00, Student: U.S.$50.00, Tel: +1-(724)-776-9000, URL: http://www.tms.org/pubs/Publications.html.

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Palladium Oxide Layers as Damage Markers in RAMs

Materials being investigated to replace the traditional dielectrics used for memory storage, in DRAM (direct random access memory) and NVDRAM (nonvolatile DRAM), capacitors, include high permittivity (high-epsilon (HE)) and ferroelectric (FE) perovskites, such as $(Ba,Sr)TiO_3$ and $SrBi_2Ta_2O_9$. The materials for the electrodes used in these capacitors must be able to withstand the high-temperature oxidising conditions needed to deposit the perovskites, so noble metals and/or their conductive oxides have been tested, and platinum, in particular, has improved device properties. However, the reducing environments needed to process the devices can damage the perovskite, by loss of oxygen, resulting in high device leakage.

Scientists at IBM in New York, U.S.A. have now found a way of monitoring the damage to the perovskites (K. L. Saenger, C. Cabral, P. R. Duncombe, A. Grill and D. A. Neumayer, *J. Mater. Res.*, 2000, 15, (4), 961–966). They found an additional decomposable PdO bottom electrode could act as a marker for observing any damage to the perovskite from the reducing environment. Oxygen loss from PdO layer films with and without a HE/FE overlayer was monitored by *in situ* XRD during heating in an inert ambient. The Pd could lose or gain oxygen or form a Pd-Pt alloy with an underlying Pt layer. Oxygen could cross the HE/FE in both directions. The Pt underlayer reduced the temperature at which oxygen left the PdO. The PdO layer could thus act both as a monitor and as an oxygen source for the perovskite.