um single crystals. Indeed, experiments have shown that highly pure ruthenium single crystal workpieces crack during treatment at room temperature. In so doing, the poor workability of polycrystalline ruthenium compacted from powder is caused by of different impurities.

References

1 A. V. Bobylev, "Mechanical and Processing Properties of Metals (Handbook)", Metallurgia, Moscow, 1987, 207, (in Russian)

2 R. W. Douglass and R. I. Jaffee, *Proc. ASTM*, 1962, **62**, 627

3 E. M. Savitskii, V. P. Polyakova and N. B. Gorina, *Platinum Metals Rev.*, 1979, **23**, (2), 57

4 R. L. Fleischer, *Platinum Metals* Rev., 1992, **36**, (3), 138

5 R. W. K. Honeycombe, "The Plastic Deformation of Metals", (Edward Arnold, London), Russian Translation, MIR, 1972

6 P. Panfilov, A. Yermakov, V. Dmitriev and N. Timofeev, *Platinum Metals Rev.*, 1991, **35**, (4), 196

7 P. Panfilov, G. Baturin and A. Yermakov, *Int. J. Fracture*, 1991, **50**, 153

8 E. M. Savitskii, V. P. Polyakova, N. B. Gorina and N. R. Roshan, "Physical Metallurgy of Platinum Metals", MIR, Moscow, 1975, (in Russian)

Extending the Life of Reactor Fuel Cladding Tubes

A number of factors determine the length of time that nuclear fuel rods can safely be left in pressurised water reactors, although it is generally accepted that the most important of these is waterside corrosion of the zirconium alloy cladding that contains the fuel. Over the past twenty years standard Zircaloy-4 tubes have performed satisfactorily in reactors throughout the world, but the economic and environmental constraints that determine the present day reactor operating parameters have changed somewhat, and now the fuel has to withstand more arduous working conditions for considerably longer times.

To ensure that fuel cladding materials are capable of meeting the requirements of reactor operators over the next decade a number of new zirconium alloys have already been developed. Now researchers in South Africa have reported the results of an investigation to establish if the oxidation resistance of Zircaloy-4 can be improved by alloying palladium into the surface layer ("Improvement in Oxidation Resistance of Zircaloy-4 by Surface Alloying with a Thin Layer of Palladium", G. A. Eloff, C. J. Greyling and P. E. Viljoen, *J. Nucl. Mater.*, 1993, **202**, (3), 239–244).

A 2 μm thick layer of palladium was electrodeposited onto the surface of test samples cut from standard fuel cladding tube material, which were then vacuum annealed at 950°C for various times to diffuse the palladium into the Zircaloy-4 before they were vacuum quenched to room temperature. Selected samples were then oxidised at 450°C, the rates of oxidation being monitored at intervals by determining the increases in weight of the samples.

The study showed that a substantial improvement in the short term oxidation resistance of Zircaloy-4 was achieved when the electrodeposited palladium layer was diffused into the surface, by annealing for an optimum period of time. This resulted in a high concentration of intermetallic particles at the sub-grain boundaries of the α-Widmannstätten structured outer layer. It is suggested that this increases the plasticity of the oxide layer and permits a greater degree of deformation to take place before the onset of cracking occurs, from the outer surface of the oxide layer.

Platinum 1993 Interim Review

During 1993 it is estimated that consumer demand for platinum in the western world will grow by six per cent to 4.02 million ounces troy. Shipments of primary platinum are expected to grow to 4.21 million oz, so – despite a fall in Russian sales to a four-year low and reduced output from minor primary sources – a surplus of 190,000 oz will result. Demand for palladium amounting to 4.04 million oz will, however, exceed supplies by 100,000 oz. For rhodium, lower shipments and growing demand will leave the market virtually in balance. While a small increase in consumption of ruthenium is forecast, purchases of iridium are expected to be steady.

Supply and demand data, and a discussion of the many factors that determine the market for platinum metals, are presented and summarised in the latest issue of Johnson Matthey's twenty-four page illustrated publication "Platinum 1993 Interim Review".

Organisations requiring such information are invited to request a copy from: Alison Cowley, Johnson Matthey Precious Metals Division, New Garden House, 78 Hatton Garden, London EC1N 8JP, England; Fax 071-269 8389.