in activity for the alloys containing between 20 and 30 per cent platinum. From some considerations, titanium-20 per cent iridium appeared to be the most active, and tantalum-20 per cent ruthenium the most stable and least active of the alloys studied.

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Joining Ceramics to Metals by Reaction Bonding

Some of the newer ceramic materials have superior physical properties which may enable them to replace metals in certain applications. However these ceramics are relatively expensive and their fabrication costs exceed those for metals. It therefore seems probable that their use will be restricted to particular areas, such as those subjected to high wear or thermal stress. For many years the solid-state bonding of metals to ceramics has been studied at the C.S.I.R.O., Division of Chemical Physics, Clayton, Victoria, Australia (1), and recently a review of reaction bonding has been presented by workers at that establishment (2).

A large number of bond combinations have been studied, including detailed examinations of the bonding of platinum to alumina and palladium to magnesia. By high resolution electron microscopy it has been established that the reaction between palladium and magnesia involves a liquid-like phase, and proceeds at a temperature lower than the melting point of either material. However, micro-diffraction to within 10Å of the metal/oxide interface shows no evidence of any material other than pure palladium or pure magnesium oxide.

When non-noble metals form part of the combination, solid state bonding appears to involve a totally different mechanism with metal diffusing into the ceramic and reaction zones forming. With some metals it may be difficult to produce strong, reliable bonds directly to a ceramic, but the use of an appropriate metal interlayer enables bonding to be successful. Platinum foil is a suitable interlayer for high temperature applications. Platinum-alumina bonds have been tested up to 1100°C, both vacuum-tightness and strength being retained.

Biomedical devices, for implantation, are constructed from materials such as ceramics, stainless steels, titanium and titanium alloys, and often platinum or iridium. The individual materials must be biocompatible, as must any metal/ceramic joints; hence reaction bonding can be advantageous. Here the inert noble metals may be used on their own, or as interlayers to facilitate the bonding of ceramics to metals such as titanium.

Reaction bonding is a versatile process which will be used increasingly as new applications are found for the superior properties of the newer engineering ceramics. For use under arduous conditions it is likely that noble metal bonds will be required. I.E.C.

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Optimising Fuel Cell Cathodes

As phosphoric acid fuel cells move towards commercialisation capital cost is one of the factors influencing their economic viability. Platinum metals catalysts are used in the power section where the conversion of chemical fuel into electric energy takes place, and efforts to improve the performance of the catalysed electrodes continue. Interestingly, a recent study of platinum on carbon catalysts made at Stanford University, suggests that the optimum crystallite diameter for the most efficient use of platinum in fuel cell cathodes is about 3 nanometres ("Oxygen Reduction on Small Supported Platinum Particles", M. Peuckert, T. Yoneda, R. A. Dalla Betta and M. Boudart, *J. Electrochem. Soc.*, 1986, **133**, (5), 944–947).