http://dx.doi.org/10.1595/147106713X668901 •*Platinum Metals Rev.*, 2013, **57**, (3), 230–232•

FINAL ANALYSIS

ZGS Platinum Materials for Improved Glass Manufacturing Equipment and Laboratory Ware

The use of platinum and its alloys is well established in the automotive, chemical, glass, electrical and dental industries. However, many of these applications require high-temperature operation of the alloys. At high temperatures conventional platinum group metals (pgms) are subject to grain growth and, therefore, are weak and subject to creep deformation. They can also be subject to contamination failure.

Johnson Matthey developed zirconia grain stabilised (ZGS) platinum that is resistant to grain growth and contamination and deformation at high temperatures (1). Applications include glass manufacturing equipment (2) as well as a range of laboratory apparatus (3).

ZGS platinum materials are produced by incorporating fine ZrO_2 ceramic particles, dispersed uniformly throughout the platinum metal matrix, a process called dispersion strengthening. These particles slow down the process of degradation in the alloy by pinning dislocation networks formed during thermomechanical processing, so inhibiting the movement of these dislocations to the grain boundaries (**Figure 1**) (2). Microstructural degradation is effectively restricted, giving extended operating lives compared to conventional pgms and alloys.

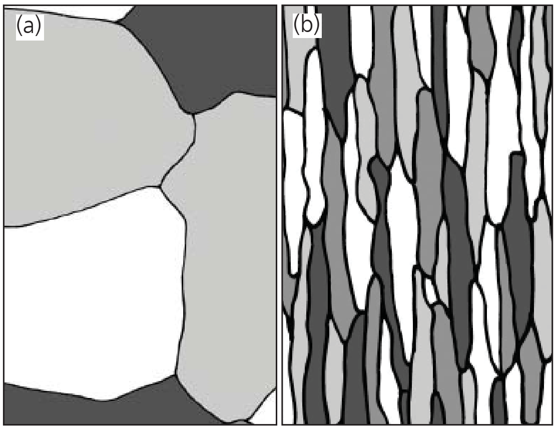

Fig. 1. Representation at 100 × magnification of: (a) Pure platinum sheet after heating for 500 h at 1400ºC; and (b) ZGS platinum sheet after the same treatment, showing significant reduction in grain growth

The principle of grain stabilisation has been established in the base metal world for some time (4). The difficulty had always been in achieving production of grain stabilised material on a large scale and with a stable dispersion of particles of the correct composition and size to be effective that does not coarsen or dissolve at the operating temperature. Johnson Matthey developed a unique process to meet those requirements, and have been using it for over 20 years.

ZGS platinum offers significantly improved performance over conventional platinum materials for use at elevated temperatures as the following examples show.

How ZGS Alloys Behave at Working Temperature

Figure 2 illustrates graphically the improvement in high-temperature life achieved by grain stabilisation. The time to failure at 1400°C under a stress of approximately 10 MPa shows that ZGS Pt lasts up to ten times as long as the conventional Pt-Rh alloy and ZGS Pt-10% Rh lasts more than ten times as long as ZGS Pt. In terms of the rate of deformation before failure, the load to cause a deformation rate of 0.1% h^{-1} is approximately twelve times higher for ZGS

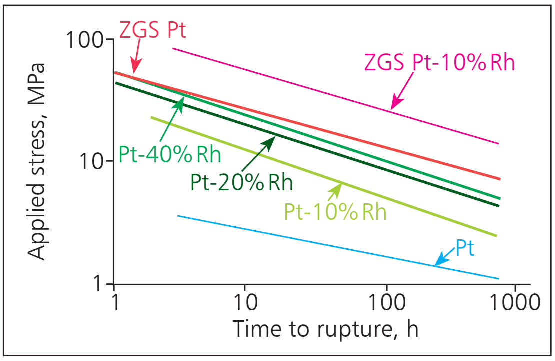

Fig. 2. Stress rupture properties of ZGS platinum, ZGS platinum-10% rhodium and the commercially important conventional alloys. The curves refer to tests carried out at 1400°C in air on 1.5 mm thick sheet specimens

platinum compared to Pt-20% Rh, while at 1% h^{-1} it is three times higher (1).

Other properties of the ZGS platinum alloys are summarised in **Tables I** and **II** (2). All data given is for sheet.

ZGS Platinum Applications

ZGS platinum and platinum alloys find particular application in products where high temperature causes creep, distortion and ultimately failure of unsupported conventional platinum and its alloys. Their principle application is in the glass manufacturing industry where their improved properties allow less material to be used while simultaneously improving equipment lifetimes.

ZGS platinum-rhodium baseplates for bushings, used for the production of continuous filament glass fibre, resist creep-induced sagging and eliminate the need for extra structural platinum supports. ZGS platinum alloys can also be used for glass carrying apparatus designed with thinner wall sections and lower rhodium content; such apparatus can have 50% greater useful life and the reduced rhodium content reduces the potential for discoloration of the glass. Lightweight thermocouple sheaths can be fabricated with walls half the conventional thickness, saving on costs. ZGS platinum can make possible the elimination of molybdenum and ceramic cores for glass stirrers, improving service life and reducing potential inservice problems. ZGS platinum-5% gold is used for crucibles and casting dishes for XRF analysis using borate fluxes.

The recommended maximum operating temperatures for the ZGS platinum and ZGS platinum alloy materials are typically 50–100ºC above those of the conventional alloys. **Table III** (3) shows the maximum temperatures recommended for all applications.

Table I

How ZGS Platinum and Platinum-Rhodium Alloy Behave at Room Temperature Compared to Conventional Platinum and Its Alloys

Property	ZGS Pt	ZGS Pt-10% Rh	100% Pt	Pt-10% Rh	Pt-20% Rh
Specific gravity, g cm^{-3}	21.4	19.8	21.4	20.0	18.8
Electrical resistivity at 20ºC, μΩ cm	11.12	21.2	10.6	19.2	20.8
Temperature coefficient of electrical resistivity per ºC	0.0031	0.0016	0.0039	0.0017	0.0014
Ultimate tensile strength, annealed, kg mm^{-2}	19	36	13	34	49
Vickers hardness, annealed sheet	60	135	40	90	115

Table II

Ultimate Tensile Strength (Annealed) at Elevated Temperatures of ZGS Platinum and Platinum-Rhodium Alloy Compared to Conventional Platinum and Its Alloys

Temperature, ºC	Ultimate tensile strength, kg mm^{-2}				
	ZGS Pt	ZGS Pt-10% Rh	100% Pt	Pt-10% Rh	Pt-20% Rh
1000	5.2	16.7	2.4	8.4	23.5
1100	4.6	14.3	1.7	6.2	16.5
1200	3.8	12.8	1.3	4.8	10.1
1300	3.6	9.4	0.8	3.9	7.0
1400	2.9	8.5	0.4	3.0	5.0
1500	2.4	7.2	–	2.4	3.9

Conclusions

ZGS platinum resists contamination failure for extended periods and extends the life of crucibles and other equipment. ZGS platinum also offers an opportunity to reduce the component weight while maintaining material integrity. Standard products including crucibles and dishes are available in ZGS platinum, ZGS platinum-10% rhodium and ZGS platinum-5% gold. Other alloys are available upon request from Johnson Matthey Noble Metals.

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Table III

Recommended Maximum Operating Temperatures for ZGS Platinum Materials Compared to Conventional Platinum and Its Alloys

Material	Temperature, ºC
Pt	1400
ZGS Pt	1500
Pt-10% Rh	1550
ZGS Pt-10% Rh	1600
Pt-5% Au	1300
ZGS Pt-5% Au	1400

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