additive on Pt-15Pd-3.5Rh alloy should include at least the mechanisms of the solid solution and of the precipitated phase.

On the other hand, the creep rupture for alloys containing Ce was affected by the stress put on the alloy samples. Figure 10 shows the morphologies of fracture sections of PPR-7 alloy under different loads. The fracture was ductile under higher stress due to the shorter creep time, and brittle under lower stress due to the longer creep time. During the longer creep process particles of the precipitated phase grow and cerium oxide is also formed by internal oxidation along grain boundaries.

Conclusions

[1] Increasing the Pd content in Pt-Pd-Rh alloys can increase the strength properties of the alloys at room temperature, but reduce them at high temperatures; the tendency to brittleness in the alloys at higher temperatures should also increase.

[2] Adding a small amount of Ru (for example ≤ 0.5 wt.%) has a good strengthening effect on the Pt-15Pd-3.5Rh alloy from solid solution strengthening and a protective effect from the Ru solute in the alloy matrix being preferentially oxidised and vaporised. Higher Ru concentrations could decrease the mechanical properties at high temperature and increase the tendency to brittleness due to the formation of a large number of porosities and porosity groups or strings.

[3] Ce additions to Pt-15Pd-3.5Rh alloy have a much bigger strengthening effect than Ru additions whether at ambient or high temperatures. Adding a small amount of Ce (for example ≤ 0.1 wt.%) can greatly increase the mechanical properties of the alloy by strengthening mechanisms in the solid solution and secondary phases. Ce additions of higher concentrations are not desirable for strengthening Pt-15Pd-3.5Rh alloy because of the growth of secondary phase particles along grain boundaries.

References

1 V. I. Chernyshov and I. M. Kisil, *Platinum Metals Rev.*, 1993, **37**, (3), 136

2 Yuantao Ning, *Precious Met. (Chin.)*, 1994, **15**, (2), 61

3 Huachun He, Changyi Hu, Jinxin Guo and Fusheng Chen, *Precious Met. (Chin.)*, 1991, **12**, (2), 19

4 Kunyu Zhao and Dingxin Li, *Precious Met. (Chin.)*, 1993, **14**, (2), 9

5 Changyi Hu, Huachung He and Fusheng Chen, *Precious Met. (Chin.)*, 1998, **19**, (1), 1

6 Yuantao Ning, Fei Wen, Huaizhi Zhao and Deguo Deng, *J. Mater. Sci. Technol.*, 1993, **9**, (2), 89

7 Yuantao Ning, *Platinum Metals Rev.*, 2002, **46**, (3), 108

8 Xin Hu and Yuantao Ning, *Precious Met. (Chin.)*, 1998, **19**, (2), 1

9 G. Reinacher, *Z. Metallkde.*, 1962, **53**, 444

10 A. S. Darling, *Platinum Metals Rev.*, 1973, **17**, (4), 130

11 Yuantao Ning and Yongli Wang, *Acta Metall. Sinica (Chin.)*, 1979, **15**, (4), 548

12 Fei Wen, Yuantao Ning, Huaizhi Zhao and Deguo Deng, *Precious Met. (Chin.)*, 1992, **13**, (3), 10

The Authors

Yuantao Ning is a Professor of Physical Metallurgy at Kunming Institute of Precious Metals, China. His main research interests are related to the principles of alloying and to new materials based on precious metals, particularly the platinum metals and their alloys, including ones modified by the rare earth metals. He has worked in the field for more than 30 years. He has published around 200 papers in national and international periodicals and won national prizes for his scientific achievements.

Xin Hu is a Senior Engineer at Kunming Institute of Precious Metals, China. He has a Master's Degree of Physical Metallurgy. His research interests are mainly in developing and producing new materials for industrial application based on precious metals, including catalytic and catchment gauzes based on platinum and palladium alloys. He has published several papers and won national prizes for his work.

Videos of Palladium Hydride Phases

The storage of hydrogen in metals is one way to provide the fuel needed for fuel cells. Palladium (Pd) and its alloys are well-known absorbers of large quantities of hydrogen and the mechanisms of this have been reported here frequently, for instance (1). Now scientists in Ukraine, at the Donetsk State Technical University (2), where the Pd-hydrogen system has been studied for several years, latterly by recording optical microscopy, report video evidence of the mechanism of the generation and growth of the reverse $\beta \rightarrow \alpha$ hydride phase transformation in subsurface layers of Pd β-hydride at 270–100°C (3).

References

1 X. Q. Tong, F. A. Lewis , S. E. J. Bell and J. Čermák, *Platinum Metals Rev.*, 2003, **47**, (1), 32

2 M. V. Gol'tsova, G. I. Zhirov and Yu. A. Artemenko, *Phys. Met. Metall.*, 2001, **92**, (6), 562; G. I. Zhirov and M. V. Goltsova, *ibid.*, 2002, **94**, (1), 63

3 M. V. Goltsova, Yu. A. Artemenko, G. I. Zhirov and V. I. Zaitsev, *Int. J. Hydrogen Energy*, 2002, **27**, (7–8), 757