The incompressibility of osmium metal at ultrahigh pressures and temperatures

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(Work performed at the ALS, HP-CAT, GSECARS, and also using the COMPRES gas-loading system at GSECARS)

Osmium is a third row transition metal in the iron group with a hexagonal close-packed structure, and is characterized by its high density, extremely low compressibility and high hardness. For these reasons it has been used to synthesize a number of ultra-hard materials of composed of a high valence transition metal covalently bonded to a lighter element. The behavior of ultra-hard materials is of significant interest for high temperature applications. We measured the thermal equation of state of osmium in the laser heated diamond anvil cell at pressures up to 50 GPa and temperatures up to 3000 K.

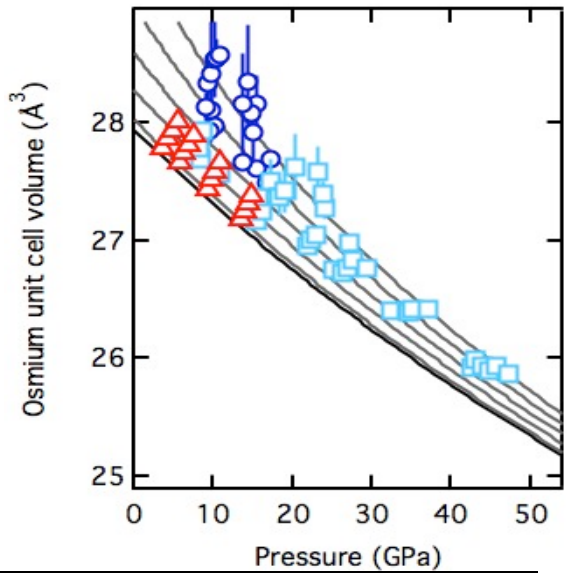

Figure 1. Measurements of osmium's unit cell volume as a function of pressure and temperature. High temperature measurements include those taken at COMPRES supported beamlines: 12.2.2 at the Advanced Light Source (circles), at HPCAT at the Advanced Photon Source (squares), and multianvil measurements by Voronin *et al* (2005). Isotherms at 300, 500, 1000, 1500, 2000, and 2500 K are plotted as a guide to the eye.

V_0 (Å^3)	K_0 (GPa)	K_0'	γ_0	q
27.941 (fixed)	421 (3)	4 (fixed)	2.32 (0.08)	7.2 (1.4)

Table 1. Fitted equation of state parameters for osmium metal. Data was fit to the isothermal third order Birch-Murnaghan equation with a Mie-Grüneisen-Debye thermal pressure correction.

The equation of state of osmium is notable both for its very high bulk modulus and for its very high q value. The later correlates to very small thermal expansions at elevated temperatures.

References

M. M. Armentrout* and A. Kavner, Incompressibility of osmium metal at high pressures and temperatures, *J. Appl. Phys*. Vol. 107 (9) 093528 (2010).
G. A. Voronin, C. Pantea, T. W. Zerda, L. Wang, and Y. Zhao, J. Phys. Chem. Sol. **66**, 706 (2005).