Thermophysical Properties of Some F Elements in Their Solid and Liquid States

M. Boivineau
Commissariat a l'Energie Atomique
Centre de Valduc
F-21120 Is-sur-Tille, France

The thermophysical properties at high temperature of some pure 4f (Ce) and 5f (Th, U) [1, 2, 3] elements have been studied in our laboratory. These experiments have been conducted by use of the isobaric expansion experiment (IEX). This submillisecond resistive heating technique, has been used to investigate both solid and liquid states of pure and alloyed metallic materials. Such a device is very useful since numerous measurements such as electrical resistivity, enthalpy, volume expansion (and therefore density), enthalpy, temperature, specific heat (C_p), and sound velocity [2,4] are available.

A systematic study of some liquid lanthanide (4f) and light actinides (5f) has been investigated to well understand the role of f electrons with a specific attention onto sound velocity measurements. Indeed, literature data claim that liquid Ce and Pu (5f) present an atypical behavior since sound velocity increases as a function of temperature [5, 6] as for some semimetals (Bi, Ga, Sb, Si, Te) and H_20, whereas most materials present a negative temperature coefficient. It has been shown these abnormal cases are correlated to a volume contraction at melting [7]. For the f elements (Ce, Pu), such a densification and consequently the rise of sound velocity is interpreted as an effect of the hybridization of 4f and 5f electrons with the 5d6s and 6d7s conduction band of Ce and Pu, respectively.

Sound velocity measurements in liquid Ce [1] have been carried out at very high temperature and confirm the earlier mentioned anomaly before indicating a negative temperature coefficient (normal behavior) from around 2800 K up to the vicinity of the boiling point (~ 3700 K). Recent measurements of liquid Th present a very similar behavior as for cerium (both abnormal and normal behaviors, this latter starting from~ 3400 K). The case of uranium [2] is significantly different since one observes a nearly constant value (slight decrease) of sound velocity in the liquid state, meaning it is an intermediate case between normal and abnormal materials. New experiments are in progress in order to confirm this behavior.

[1] M. Boivineau, J.B. Charbonnier, J.M. Vermeulen and Th. Thevenin, *High Press. -High Temp.* **25**, 311-321 (1993).
[2] M. Boivineau, J. M. Vermeulen and Th. Thevenin, *Physica B* **190**, 31-39 (1993).
[3] M. Boivineau, H. Colin, J.M. Verrneulen and Th. Thevenin, *Int. J. Thermophys.* **17(5)**, 1001-1010, (1996).
[4] A. Berthault, L. Arles and J. Matncon, *Int. J. Thermophys.* **7**, 167-179 (1986).
[5] S.P. McAlister and E.D. Crozier, *Solid State Commum.* **40**, 375-378 (1981).
[6] M.D. Merz, J. H. Hammer and H.E. Kjarmo, *J. Nucl. Mater.* **51**, 357-358 (1974).
[7] L.J. Wittenberg and R. DeWitt, J. *Chem. Phys.* **56(9)**, 4526-4533 (1972).