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High temperature thermal expansion of ThO_2, MgO and Y_2O_3 by X-ray diffraction

There is an increasing need for knowledge of the physical properties of various oxides at high temperatures because of their importance as refractory materials. As limited data exist in the literature on the high temperature thermal expansion of these materials, the purpose of this note is to report some X-ray diffraction measurements of the thermal expansion of ThO_2, MgO and Y_2O_3 between 500 and 1800° C.

The diffractometer, high temperature furnace chamber, and high temperature cell used in this work have been described previously [1]. The sample powder materials were purchased from Mitsuwa Chemical Company and Wakoh Chemical Company and were of nominal purity: ThO_2, 99.99%; MgO, 99.8%; Y_2O_3, 99.8%. All data were obtained using copper radiation, and a graphite monochromator in the diffracted beam was also used. The chamber was evacuated with rotary and

TABLE I Lattice parameters of ThO_2, MgO and Y_2O_3 at various temperatures

Run no.	ThO_2		MgO		Y_2O_2	
	Temp. (° C)	Lattice parameter (Å)	Temp. (° C)	Lattice parameter (Å)	Temp. (° C)	Lattice parameter (Å)
1	25	5.592	25	4.203	25	10.607
2	614	5.621	603	4.240	619	10.655
3	806	5.636	807	4.253	814	10.671
4	1009	5.649	996	4.262	1007	10.689
5	1211	5.659	1209	4.276	1225	10.710
6	1407	5.670	1416	4.287	1408	10.731
7	1603	5.687	1601	4.299	1601	10.757
8	1782	5.698	1739	4.308	1764	10.773
9	25	5.601	25	4.216	25	10.608
10	508	5.619	502	4.234	543	10.645
11	714	5.633	715	4.245	704	10.664
12	905	5.641	906	4.259	917	10.681
13	1096	5.653	1108	4.271	1092	10.697
14	1323	5.664	1317	4.281	1303	10.722
15	1504	5.681	1525	4.296	1511	10.743
16	1711	5.693	1704	4.304	1685	10.767
17	1769	5.698	1765	4.308	1757	10.772

oil diffusion pumps to a vacuum of 3×10^{-6} Torr. The lattice parameters were calculated from measured X-ray intensity patterns by employing the Cohen least-squares method [2]. The lattice parameters were estimated to be uncertain within about ± 0.04%.

The lattice parameter measurements on ThO_2, MgO and Y_2O_3 samples over the temperature range 500 to 1800° C are summarized in Table I. The lattice parameter at room temperature of each unheated oxide sample is almost identical to that reported in ASTM cards. The data in Table I are converted into % linear expansion and plotted in Fig. 1. They are best represented by the following equations;

$$ThO_2 : \Delta a/a_0 = 7.589 \times 10^{-6}(T-298) + 1.552 \times 10^{-9}(T-298)^2 \quad (1)$$

$$MgO : \Delta a/a_0 = 1.241 \times 10^{-5}(T-298) + 8.136 \times 10^{-10}(T-298)^2 \quad (2)$$

$$Y_2O_3 : \Delta a/a_0 = 6.537 \times 10^{-6}(T-298) + 1.440 \times 10^{-9}(T-298)^2, \quad (3)$$

where a_0 is the lattice parameter (Å) at room temperature (25° C), Δa the change in lattice parameter between 298 K and temperature T, and T the absolute temperature. These equations are applicable over the temperature range observed, with a mean deviation of $\pm 0.3 \times 10^{-3}$. The results obtained in this work are in good agreement with those reported previously using the X-ray film method (ThO_2 [3], MgO [4] and Y_2O_3 [4]).

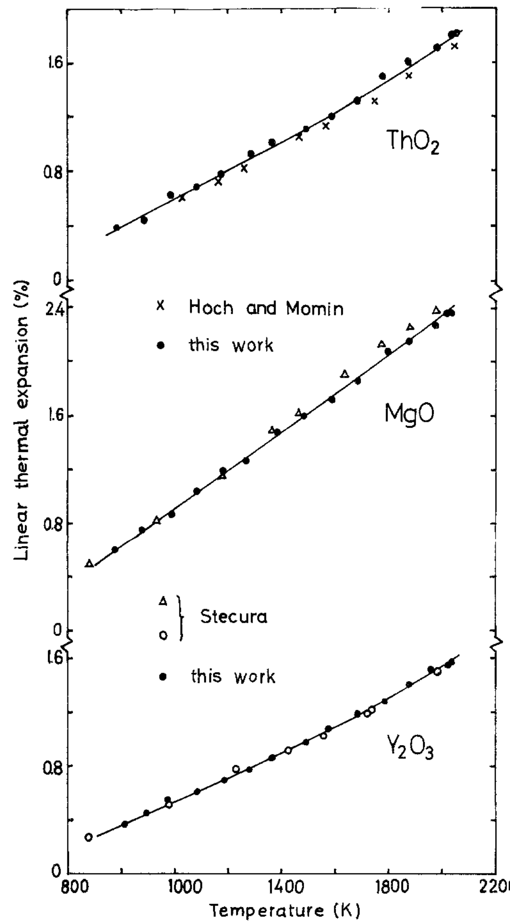

Figure 1 Linear thermal expansion of ThO_2, MgO and Y_2O_3.

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