Synthesis and Oxidation of Cr_2AlC and V_2AlC in Air

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This work is comprised of two parts. The first deals with the first-time synthesis of predominantly single-phase Cr_2AlC and V_2AlC ternary compounds. The second part deals with their oxidation behavior in air.

Oxidation of Cr_2AlC in the 1000°C to 1300°C temperature range was governed by the outward diffusion of Al and inward diffusion of oxygen resulting in two discrete layers; an outer Al_2O_3 rich and inner Cr_2O_3 rich (Fig. 1). Except at 1000°C, the oxide layers formed were non-protective. The formation of Cr_2O_3 nodules that break through the outer Al_2O_3 layer (Fig. 2) had a deleterious effect on the oxidation resistance. Chromia vaporization also becomes noticeable at 1100 °C and higher temperatures. The outer Al_2O_3 layer was loosely adhered and had a tendency to spall. The unanswered question at this time is what causes the spallation of Al_2O_3. At 1000 °C the oxidation is parabolic, with a parabolic rate constant:

$$K_x = 1.3x10^{-16}\ m^2/s$$

After a 300 h oxidation the oxide layer thickness was of the order of 3 -5 μm (Fig. 3).

Oxidation of V_2AlC in the 500°C to 700°C temperature range is governed by the outward diffusion of V and the inward diffusion of O resulting in two layers; an outer V_2O_5 rich and an inner Al_2O_3/V_2O_5 layer. Up to 20 hrs at 500°C and 600°C, the oxidation kinetics was initially rapid and linear (Fig. 4). At longer times, the oxidation kinetics was substantially reduced for reasons that are not entirely clear, but most probably due to the formation of a continuous Al_2O_3 layer. Above 650°C, a liquid oxide layer forms which has an adverse effect on the oxidation resistance (Fig.4).

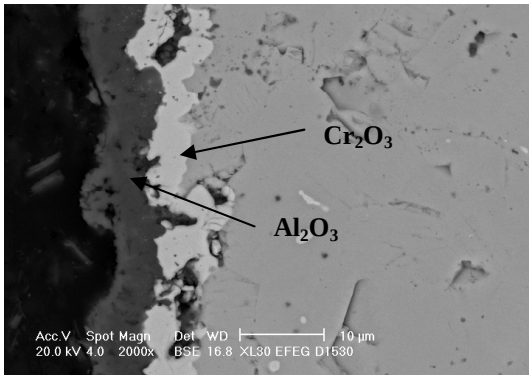

Fig. 1: SEM micrographs of Cr_2AlC (1200°C, 48 hrs. of oxidation)

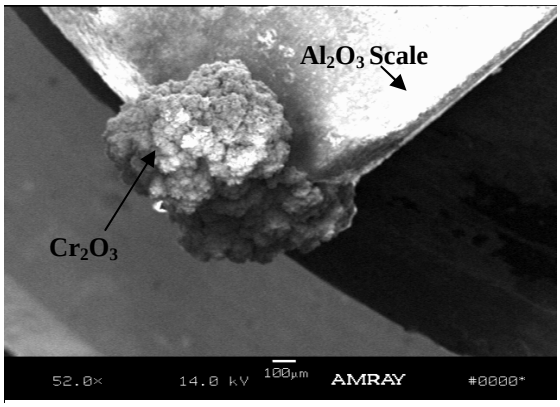

Fig. 2: SEM micrograph of Cr_2O_3 nodules breaking through the Al_2O_3 scale (1100°C, 40 hrs. of oxidation)

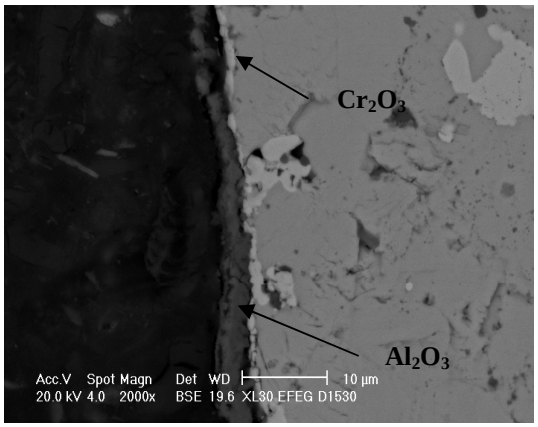

Fig. 3: SEM micrograph of Cr_2AlC oxidized at 1000°C for 300 hrs

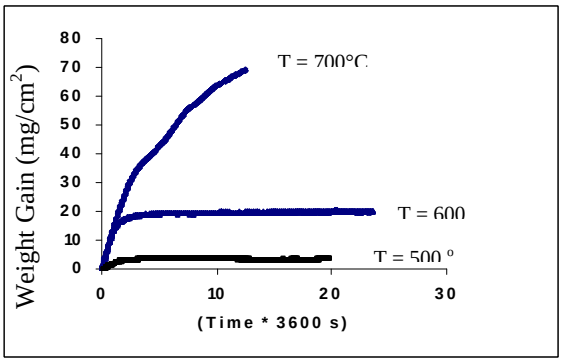

Fig. 4: Oxidation kinetics of V_2AlC oxidized in air