# Microstructural effects in oxidation of nickel and iron aluminides

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Investigated were intermetallic materials based on NiAl (50:50 in at%) and FeAl (60:40) manufactured in different ways. In addition to classical metallurgical methods (nickel aluminide modified with chromium), novel technologies were applied, i.e. self-propagating high-temperature synthesis (SHS) followed by arc melting (AM) or hot forging (HF) (iron aluminide). The environmental resistance was studied by thermogravimetric methods. Testing procedure comprised oxidation in air at a constant temperature (950$^o$C) and in thermal cycling conditions (24 h at 950$^o$C followed by rapid cooling to room temperature). Selected specimens were purposely contaminated with a salt deposit ($Na_2SO_4$). The oxidation experiments were continued for up to 400 hr.

Different manufacturing routes affected microstructure and properties of materials. The products of classical metallurgical technology had grain sizes of a few hundred micrometers, while the SHS products densified by hot forging or hot pressing were fine grained, their grain sizes being related to those of the starting elemental powders. All of the investigated intermetallics showed very slow degradation in the oxygen-containing atmosphere (air), their oxidation rates being typical of alumina formers, i.e. on the order of $10^{-12}kg^2/m^4s$. The differences in oxidation behavior observed in the initial period were attributed to compositional and microstructural effects. Both chromium in nickel aluminides and iron in iron aluminides affect the phase composition of oxide scales by promoting the formation of $\alpha$-alumina, the most protective oxidation product. Microstructure, i.e. grain sizes, and imperfections of the oxidized material, visibly influence the grain sizes and adherence of the oxide scale. This relation is evidenced by comparing the oxidation behavior of arc-melted and forged iron aluminides produced by SHS. In the series of nickel aluminides modified with chromium, the non-typical dependence of oxidation rate on composition (Fig.1) is ascribed to microstructural effects (two-phase and single-phase materials with a uniform and non-uniform distribution of chromium). In addition, noticeable compositional changes take place in the vicinity of the substrate/scale interface after prolonged oxidation (Fig.2). The growth rate and transport properties of scales formed on transition metal aluminides are continually modified during the oxidation process by elements other than aluminium contained in the substrate. The extent of this modification is characteristic of each particular system. Important parameters are diffusivities and solubilities of alloy components in the substrate and in the scale.

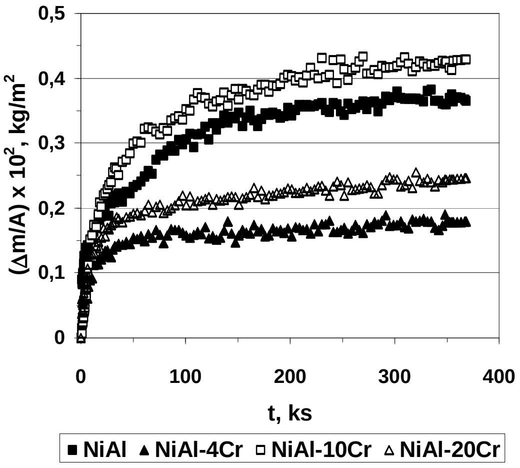

Fig.1 Isothermal oxidation of chromium-modified NiAl in air at 950$^o$C.

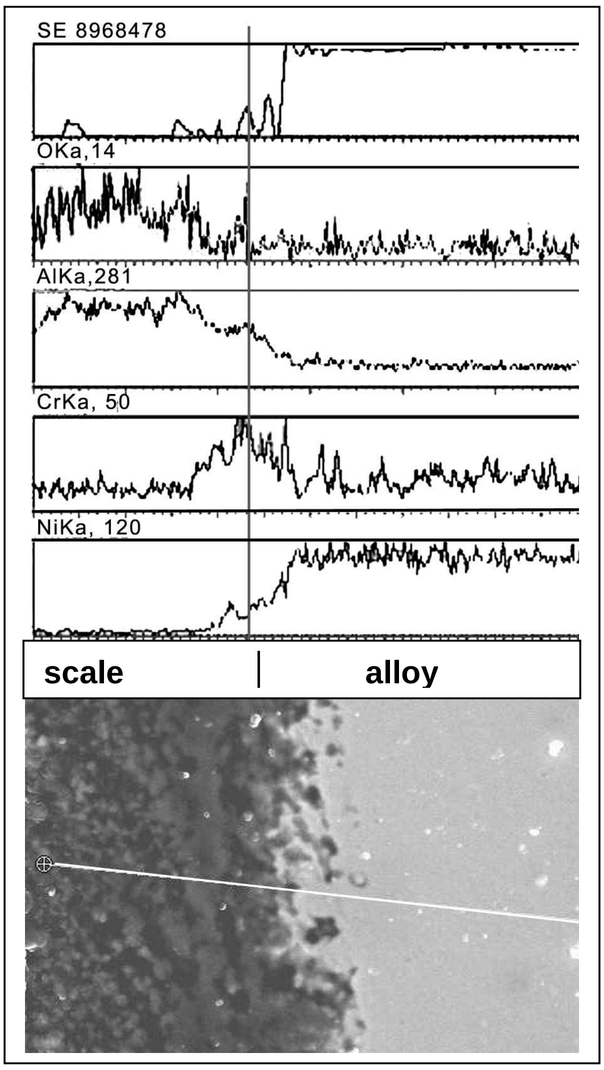

Fig.2 EDS profiles of elements across the scale/alloy interface on the NiAl-4Cr sample oxidized in air for 400 h in thermal cycling conditions (24 h at 950$^o$C + rapid cooling to room temperature).