# OXIDATION OF ALUMINA FORMING MATERIALS

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Two types of FeCrAl alloys were studied, either alloys classically elaborated with or without active elements and ODS (oxide dispersion strengthened) alloys produced by mechanical alloying. They all form alumina scales by oxidation in air or oxygen.

The oxidation resistance of these alloys was compared considering various aspects : kinetics and oxidation mechanism, transformation of transition aluminas to α alumina and mechanical characteristics.

ODS alloys oxidation rate is slower than that of classical alloys, and the alumina growth mechanism is clearly controlled by oxygen diffusion, as shown in Fig.1. The profile is clearly associated to the duplex microstructure of the alumina films which show an outer thin equiaxed layer probably due to the cation diffusion, and an inner columnar and thicker film corresponding to the film grown by oxygen diffusion. The deduced diffusion coefficients agree those obtained for $^{18}O$ diffusion in massive alumina doped with yttria.

During heating, transition alumina growth is observed (Fig.2a), consisting in γ phase, contrary to the θ transition aluminas formed on NiAl alloys, and the transformation γ ↔ α was studied using an original deflection test (Fig.2b). The volume decrease due to this alumina phase transformation induces strain which are evidenced by the curvature of a dissymetrical thin sample (Fig.3a). The greater the temperature of the isothermal treatment, and the faster the transformation of the γ phase formed during heating. Fig. 3b shows the microstructure of the α phase obtained at the end of the isothermal treatment of Fig.3a.

In given temperature conditions, an aluminum gradient is observed in the substrate and the analysis of the concentration gradients allows to determine the diffusion coefficients of aluminum in the substrate. From this value, a "chemical" life time of the alloys in oxidising atmospheres, based on the minimum aluminum amount necessary to form a continuous alumina film, can be deduced as shown in table 1 [1]:

Table 1: "chemical" life time

| Durée de vie (h) | 1200°C | 1300°C |
|---|---|---|
| MA 956 | 25 000 h | 5 000 h |
| PM 2000 | 120 000 h | 20 000 h |

The mechanical characteristics of the alumina layers are determined by bending tests at room temperature with simultaneous observation of the morphology of the film surface by scanning electron microscopy (SEM). For a critical strain, cracks perpendicular to the film tested in tension appear, as shown in Fig.4. From this critical strain, it is possible to determine the film toughness $K_{IC}$ and to compare it to the toughness of massive alumina.

Moreover, for greater strains, spalling is observed and the critical strain for spalling can be correlated to the adhesion of the film on the substrates. Consequently, the influence of active elements on the mechanical characteristics of the film can be pointed out.

[1] L. Marechal, Thesis, University Paris-Sud, Orsay, fr, 2002.

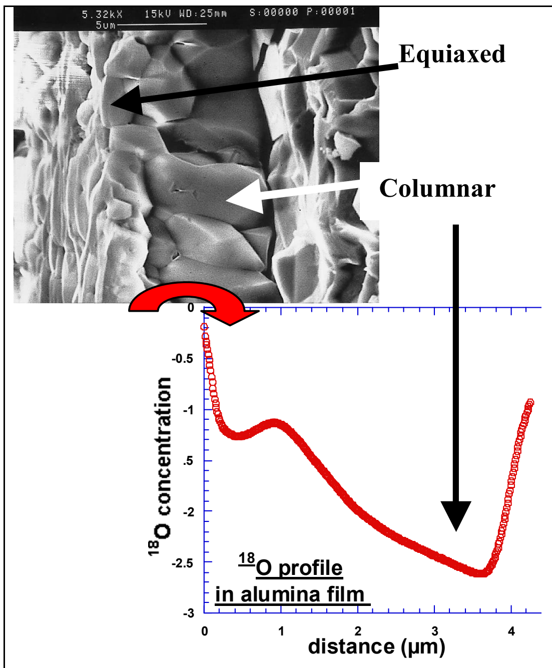


Fig.1: Cross section and $^{18}O$ profile in an alumina scale formed on an ODS FeCrAl alloy.

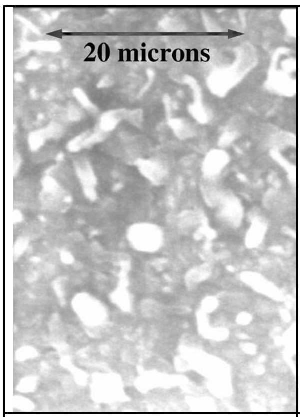


Fig.2a: γ $Al_2O_3$ formed on PM2000, 900°C,1h.

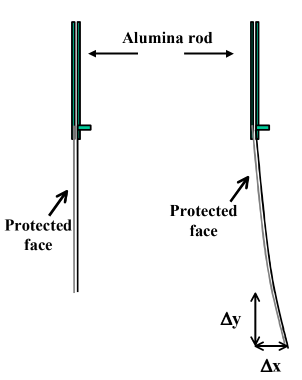


Fig.2b: Principle of the deflection test.

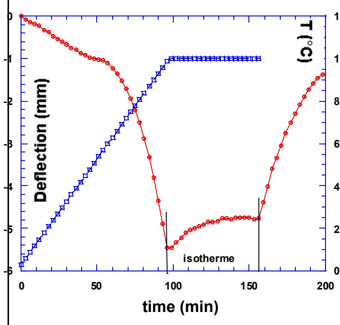
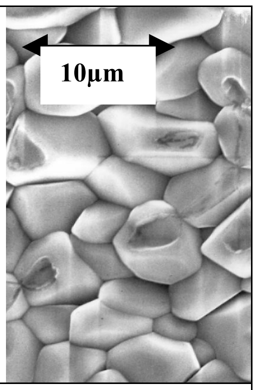


Fig.3a: γ →α transition at 1000°C (PM 2000 FeCrAl).



b) α alumina after transformation.

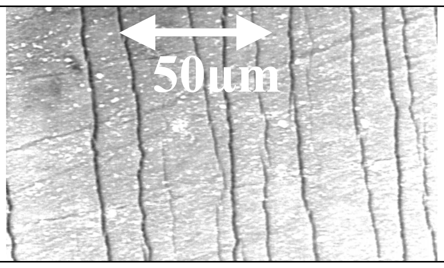


Fig.4: Cracks in the alumina film formed on an ODS alloy oxidised then bended.