

High temperature oxidation of sintered coupons made from Ru-doped NiCoCrAlYTa powders

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Lifetime of high temperature operating nickel-based superalloys used at partly depends on their high temperature oxidation resistance. When used in gas turbines, either for energy or aeronautical applications, these superalloys are protected with an alumina-forming high temperature coating. MCrAlY powders are one of the most used base materials to process such coatings by electrochemical or plasma spray techniques. Addition of rare earth and Pt-group elements is known to improve the high temperature corrosion and/or oxidation of such alumina-forming coatings. Modeling and control of these positive effects is still under development through the systematic investigation of low concentration elemental additions. Previous papers [1,2] showed that spouted-bed metalorganic chemical vapor deposition can be used to deposit Pt-group elements on MCrAlY powders. Sintering of reference (undoped) and such Ru-doped powders allowed to obtain massive test samples of similar microstructure. Their comparison revealed the specific effect of dopants on the high temperature oxidation resistance of MCrAlY.

The resistance to high temperature oxidation of MCrAlY coatings depends on their ability to form a protective alumina scale. To be protective, the oxide scale should have low growth kinetics and good adherence, thus this paper reports the effects of Ru doping on both isothermal (1173 to 1423 K) and cyclic oxidation of MCrAlY and Ru-modified MCrAlY at 1323 K in air. The results are resumed in Figures 1 and 2 for both kind of samples.

Reference and Ru-doped samples present similar isothermal and cyclic oxidation kinetics, except at 1173K where the isothermal oxidation of doped samples is systematically faster. This shift is due to particular CVD conditions of Ru, obtained through the oxidation of the ruthenocene precursor. Alternative CVD routes, involving hydrogenation rather than oxidation of the cyclopentadienyl ligands are not detrimental to the oxidation behavior of the material. The oxidation after one thousand 1h cycles at 1323 K revealed a similar behavior between sintered and plasma sprayed MCrAlY samples as shown in Figure 2.

Specific experiments were designed to characterize the oxide phases formed in relation with the underlying nature and chemistry of the NiCoCrAlYTa phases. The local formation of transition alumina, spinels, and Y3Al5O12 was identified.

The overall results reported here prove that the doping procedure used in this work is suitable for the study of the effect of additions on the high temperature oxidation of coating materials. As Ru has no detrimental effect on the oxidation of NiCoCrAlYTa, it can then be added to improve other than oxidation resistance properties. Its possible diffusion from Ru-containing superalloys to the coating can also be tolerated. Due to the influence of the coating microstructure on the nature of the oxide formed, one should be particularly careful when comparing undoped and doped samples. Powder doping followed with sintering allows this control of microstructure.

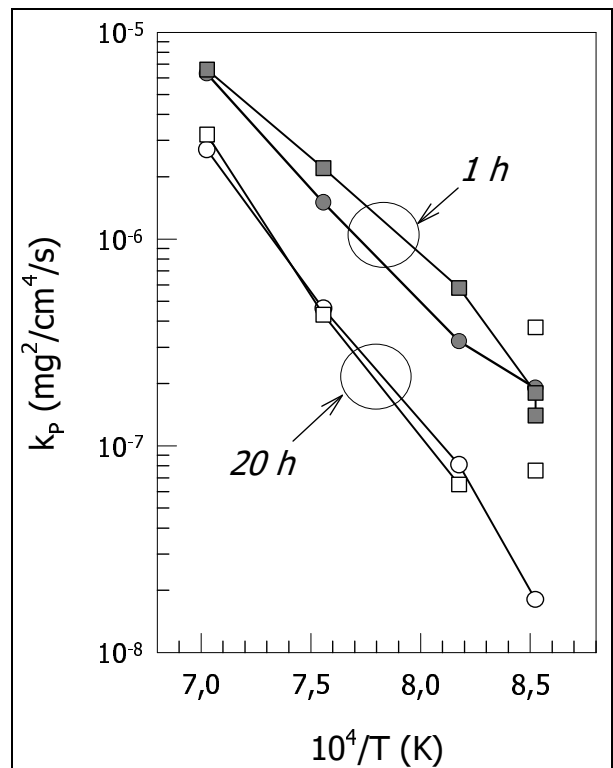


Figure 1. Arrhenius plots of the parabolic rate constants for the oxidation of the undoped (circles) and Ru-doped (squares) samples, for oxidation times of 1 h (gray symbols) and 20 h (white symbols).

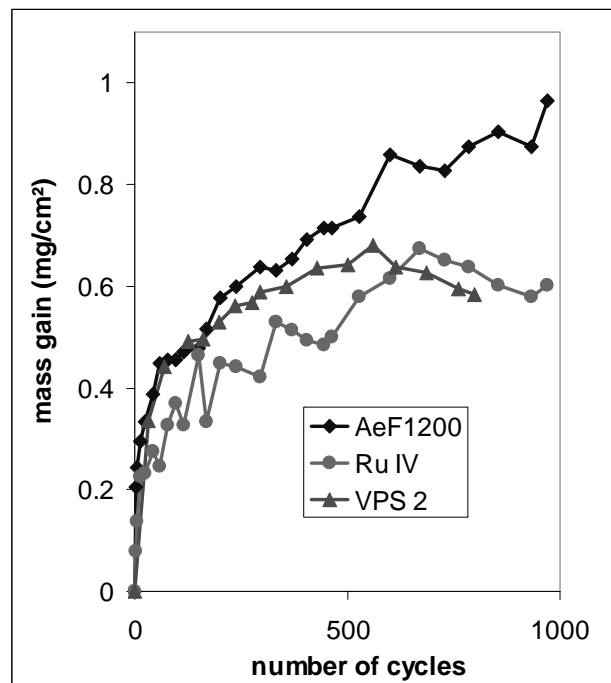


Figure 2. Mass gain of two sintered (reference and Ru-doped) and one plasma sprayed sample of the same raw material, as a function of the number of 15 min at 300K + 1h at 1323K cycles.

[1] Juarez F., Castillo A., Pieraggi B., Vahlas, C., J. Phys. IV, 11 (2001) 1117-1123.

[2] Juarez F., Monceau D., Tetard D., Pieraggi B., Vahlas C., Surf. Coat. Techn., in press.