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Mechanical dispersion of platinum particles and its effect on the microstructure of MCrAlY alloy prepared by SPS

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ABSTRACT

Spark plasma sintering (SPS) technique was used to densify fine Pt-particles with a MCrAlY alloy powder, at temperatures ranging between 1000 and 1050 °C in order to obtain consolidated tablets. Fine dispersion of Pt-particles into a full densified matrix was achieved on the products while the overall SPS processing time did not exceed 30 min. Both chemical constitution and microstructure, as well as porosity evaluation were investigated by using scanning electron microscopy, chemical analysis and X-ray diffraction. The fine Pt-particles embedded into the MCrAlY matrix have no marked influence over the final microstructure but in its sintering consolidation behavior. The effect of Pt-particles, as-deposited on the surface of MCrAlY/Pt might mean important technical advantages on the obtained products due to the refined microstructure and the solubility level attained, which can lead to attractive applications for high temperature corrosion systems.

1. Introduction

The Ni-alloys are subject of extensive research efforts to develop applications in gas turbine due to their high specific Young's modulus and strength, and to their good oxidation and corrosion resistances. However, these alloys suffer from limited ductility at room temperature and creep resistance at service temperature (1273–1373 K) [1–4]. From a technological point of view, the current limitations are due to a large scattering in mechanical properties resulting from correlated chemical and structural heterogeneities to manufacturing difficulties and high costs.

Additions of platinum are well known to be beneficial for improving the oxidation behavior of β-NiAl based alloys [5–12]. Full interpretation of the oxidation behavior of Pt-modified alloys is partly hindered by the fact that there is a lack of information pertaining to the phase equilibrium in the Ni–Al–Pt system. This information is important not only from the standpoint of interpreting the oxidation behavior, but also for designing products, such as overlay coating compositions and the stability of material. At present, Ni base superalloys are the most advanced alloys for use in high temperature applications up to about 1100 °C. These alloys consist of a matrix of γ phase (Ni solid solution) and ß phase (with a composition close to Ni3Al), and could contain up to 10 alloying additions for volume fractions below 70% [13]. At this volume fraction, the highest creep strength is observed [14]. However, the application of Ni base superalloys is limited by the melting point of Ni (1455 °C), where considerably larger service temperatures require the development of materials based on elements with higher melting points. Platinum is one of the promising base elements since it has a high melting temperature of 1770 °C. Alloys having Pt as a base element are used for example in bushings for glass fiber fabrication [15]. In the glass industry, Pt alloys are generally used for their outstanding corrosion and oxidation resistance combined with good mechanical strength at ultra-high temperatures. Precipitation hardened Pt base superalloys are analogous to the Ni base superalloys [16–21] in terms of a face centered cubic (fcc) matrix strengthened by coherent precipitations of L12 ordered γ particles.

The question then rests whether the doping with Pt has an effect during the MCrAlY alloy powder sintering process. Concerning full densification, the spark plasma sintering (SPS) technique is found to be an effective route to consolidate powder through the simultaneous application of direct-pulsed current and uniaxial pressure [22–23]. Assisted by axially applied pressure, the driven electric current density induces an increase temperature within the sample through Joule's effect, thus leading to powder sintering.

The advantages of SPS over other sintering routes include: lower sintering temperature, shorter holding time, and markedly improvements on the properties of materials consolidated by this method [22–24]. The use of the hot-pressing techniques to optimize microstructure of MCrAlY alloy for high temperature application has been scarcely documented [25–28]. In this context, the present work aimed to determine the sintering parameters and microstructural characteristic of MCrAlY alloys doped with platinum by using the SPS conditions. Thus,

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the powder characteristics are firstly introduced. The mechanical mixing procedure of powder/particles and experimental record of the SPS sintering processing are then presented. Scanning electron microscopy (SEM), High Resolution Scanning Electron Microscopy (HRSEM) and X-ray diffraction (XRD) analyses were carried out to determine the morphology and microstructure of sintered specimens. Vickers hardness tests of the sintered specimens and analysis of transversal section of specimens are presented.

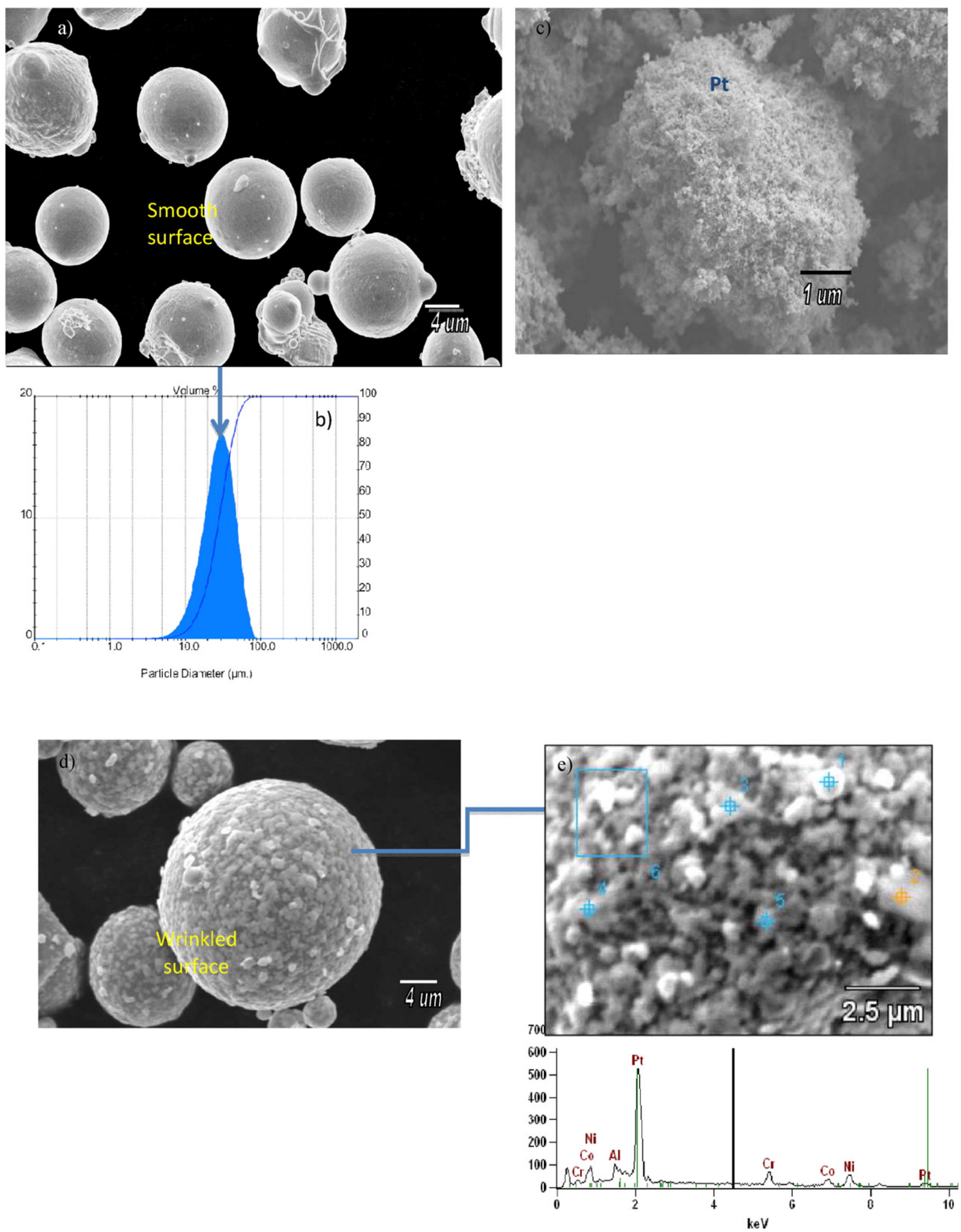

Fig. 1. Scanning electron micrograph of the: a) as-received MCrAlY powder with spherical morphology, b) as received MCrAlY powder size distribution, c) as received platinum particles, d) MCrAlY/Pt doped powders, and e) magnification of MCrAlY/Pt doped powders and corresponding platinum EDS analysis on surface.