論 文 内 容 の 要 旨

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The thermal spraying method is a method of melting or semi-melting a metal or oxide as raw material and spraying the molten metal or metal oxide film on the surface of the material. A coating applied by this method is called a thermal spray coating. The “thermal” of thermal spraying means melting the raw material, and the “spraying”(projection) corresponds to spraying the raw material. It is applied mainly for the purpose of improving the corrosion, abrasion resistance, heat resistance or thermal barrier of the substrate.

The number kind of thermal spraying methods has been developed greatly in the past years for the application of protecting the materials. Among them, the typical spraying methods include the plasma spraying(PS), high-velocity oxygen fuel(HVOF) and flame spray(FS), et al.. In general, the characteristics of these technologies are determined by the flame temperature and the velocity of inflight particles. Hence, the use of different techniques for depositing similar coatings may lead to various results in quality and cost terms. For example, some specific functional coatings such as thermal barrier coatings and oxidation resistant coatings, are more easily achieved using APS and HVOF technologies. Which can be attributed to the following factors: particle the high-temperature(PS:10000-15000 K) and high-velocity(550-800 m/s) of the inflight particles for completely melting the raw-materials and flattening the splats to synthesis the dense or porous structure which can enhance the performance of the coating. However, other techniques, such as flame spraying(FS), are still recommended given their lower cost and high deposition rate. Therefore, it is a key with the choice of raw materials that are more easily melted at low temperatures to obtain similar or better performance of the coating. Hence, the precursor of ethylenediaminetetraacetic acid(EDTA) is suggested in this method as the metal-EDTA complex.

In this study, the EDTA is the most famous chelating agent. As the characteristic, EDTA has achromic crystal powder, and a molecular weight of 292.25 and a decomposition point of 240 ℃. It was reported that the Y_2O_3:(Eu, B) phosphor powder was obtained by the thermal decomposition method the of Y-EDTA, Eu-EDTA at firing conditions. From this study, it can be used that the morphological and compositional design for metal oxide using metal-EDTA complex route. In addition, it is possible to obtain thin film with complicated metallic composition by thermal decomposition of metal-EDTA complexe powders formed by the method. In the follow-up study, the Yttrium(Y^{3+}) ions were selected to form the metal-EDTA complexes, and the metal oxide films were deposited on a stainless steel(SUS) substrate with a H_2-O_2 combustion flame. I called this spray method as the chelate flame spray(CFS). The deposition process of metal oxide film involves two mechanisms, namely chemical reaction, and physical collision. It begins with a chemical reaction in which the precursor material such as the metal-EDTA complex, is decomposed and oxidized to form metal oxide particles. Finally, the physical collision of the molten metal oxide particles with subsequent cooling and solidification processes. Hence, this process exhibits some advantages over PS and HVOF even for high melting ceramic materials such as Y_2O_3 that melts at approximately 2430 ℃. In addition, there are two interesting findings with follow: (1) The Y_2O_3 film synthesized using the rotation apparatus with cooling agents exhibited porosity range of 22.8 - 36.4 %. (2) the Y_2O_3 cubic crystalline phase were confirmed in all films, synthesized with EDTA·Y·H. Thus, it means that the metal oxide films synthesized in this method exhibit the potential for stronger thermal insulation properties, due to the low thermal conductivity of 12.5 W/(m·K)(293 K), high porosity, and stable crystalline structure. From the above described, the chelate flame method can be expected that the low cost and rapidly to synthesis the ceramic coating with thermal insulation capability, and so-called the thermal barrier coating(TBC) for applications in the hot-section metallic components of gas turbines or aero engines, such as burners, turbine blades, vans, and et.al. .

The results indicated that:

(1) The carrier gas plays an important role in determining the thickness and porosity of the resulting film.
(2) The solidification speed of the molten particles deposited on the substrate may be related to the physical properties of the substrate material itself.
(3) The nanolayer of MgO would have role in the Y_2O_3/ aluminum alloy joining formed from the EDTA·Y·H complex and exhibit the strong adhesion and thermal shock properties.
(4) The Y_2O_3 and Er_2O_3 coatings had higher thermal insulation capability by the steady-state test.
(5) The thermal conductivity of Er_2O_3 coatings with porosity of approximately 30 % were investigated. It exhibited low thermal conductivity at the stable phase by flame spraying apparatus.

Thus, the CFS method provides that not only the synthesized the metal-oxide coating exhibit the excellent performance in thermal insulation but also is possible to obtain the thermal conductivity of the coating at different temperature with can simulate engine working environment.