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Research Progress of High Temperature Resistant Coatings and Their Properties and Characterization

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Abstract: High temperature resistant coating refers to the coating material that can protect the substrate from oxidation, corrosion or thermal shock under high temperature environment. With the increasing demand for high temperature equipment in aerospace, energy, chemical and other fields, the research and application of high temperature resistant coatings have become more and more important. The research of high temperature resistant coating can provide theoretical basis and technical support for its application in aerospace, energy, chemical and other fields.

Keywords: High temperature resistant coating; Performance characterization; Study

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Introduction:

The development of high temperature coating has gone beyond the traditional aluminide coating and entered the era of thermal barrier coating and intelligent coating. This progress is not only reflected in the evolution of single layer, multi-layer gradient coating and micro-stack coating, but also reflected in the leap from alloy coating to ceramic coating, and even composite ceramic coating. In addition, the range of coating materials has also been significantly expanded from metal materials to diversified composite materials. By adding active elements, the properties of these materials are further optimized and improved.

1. Classification of high temperature resistant coatings

When it comes to high temperature resistant coatings, the common classification method is based on the function of the coating and how it is applied. The two main types of high temperature resistant coatings are diffusion coatings and overlay coatings. Below I will give you a detailed introduction to these two types of coatings.

1.1 Diffusion coating

Diffusion coating is a coating that changes the composition and properties of the substrate by forming a chemical reaction on its surface. This coating is commonly used to improve the high temperature resistance, corrosion resistance and oxidation resistance of the substrate. Common coatings are: First, aluminum coating. Aluminum coatings are often used to improve the high temperature resistance and oxidation resistance of the substrate. At high temperatures, aluminum reacts with oxygen on the surface of the substrate to form an alumina layer, which provides a protective barrier.

Second, carbide coating. Carbide coatings are often used to improve the hardness and wear resistance of the substrate. They can be formed on the substrate surface by methods such as chemical vapor deposition (CVD) or physical vapor deposition (PVD). Third, silicide coating. Silicide coatings are often used to improve the high temperature resistance and corrosion resistance of the substrate. Silicide coatings can be formed by hot dipping, chemical vapor deposition or physical vapor deposition.

1.2 Cover the coating

Overlay coating is a coating that directly coats a material with good high temperature resistance on the surface of the substrate. This coating is mainly used to provide a protective barrier to prevent the substrate from being exposed to high temperatures. Here are some common types of covering coatings: First, ceramic coatings. Ceramic coatings are usually composed of ceramic materials such as oxides, carbides or nitrides. They have excellent high temperature resistance and corrosion resistance and can be used to protect the substrate from high temperature gases, liquids or solids. Second, the metal coating. Metal coatings are usually composed of superalloys such as nickel, chromium and cobalt. These coatings can provide good high temperature resistance and oxidation resistance and are used to protect the substrate from high temperature gases or liquids. Third, composite coating. Composite coatings are coatings composed of a variety of materials that combine the advantages of different materials. For example, composite coatings can be composed of ceramic particles and metallic substrates to provide better high-temperature resistance and mechanical properties.

2. Preparation method and characterization of high temperature resistant coating

2.1 The main preparation method and its advantages and disadvantages

2.1.1 Plasma spraying and supersonic flame spraying

Plasma spraying and supersonic flame spraying are two kinds of thermal spraying technology, both of which can be used to prepare high temperature resistant coatings. The main principle of these technologies is to heat powder or wire material to a molten state and then spray it onto the surface of the substrate through a high-speed gas stream to form a coating. Plasma spraying is a high-energy density spraying technology, and its spraying temperature can reach more than 10,000 degrees Celsius. It uses a plasma arc as a heat source to heat powder or wire material to a molten state and then ejects it onto the surface of the substrate through a high-speed gas stream. Plasma spraying can produce high temperature resistant coatings with excellent properties, such as high hardness, high wear resistance and oxidation resistance. Supersonic flame spraying is a high-speed spraying technology with a spraying speed of more than 1000 m/s. It uses the combination of high-temperature gas and high-speed gas flow to heat powder or wire material to a molten state and then spray it onto the surface of the substrate through the high-speed gas flow. High temperature resistant coatings with high bonding strength and densification can be prepared by supersonic flame spraying for various materials and workpieces.

2.1.2 Vapor deposition technology

Vapor deposition technology is a method of deposition of high temperature resistant coating on the surface of substrate by gaseous chemical reaction. The main principle of this technology is to make the gas undergo a chemical reaction through high temperature heating or ultraviolet irradiation, and then deposit a high temperature resistant coating on the surface of the substrate. Vapor deposition technology can prepare high temperature resistant coatings with excellent properties, such as high hardness, high wear resistance and oxidation resistance. The advantages of this technology are high coating quality, fast deposition speed, and wide application range, but the disadvantages are high equipment cost, high deposition temperature, and the need for precise control of reaction conditions.

2.1.3 Laser cladding method

Laser cladding is a method of using a high energy laser beam to melt alloy powder onto the surface of the substrate to form a high temperature resistant coating. The main principle of this technology is that the alloy powder is heated to a molten state instantaneously by a high energy laser beam, and then quickly cooled to form a high temperature resistant coating. Laser cladding can prepare high-temperature coatings with excellent properties, such as high hardness, high wear resistance and oxidation resistance. The advantages of this technology are fast cladding speed, high coating quality and wide application range, but the disadvantages are high equipment cost and the need to accurately control the laser beam energy and scanning speed.

2.2 Performance characterization method of high-temperature coating

High temperature resistant coating is a special material, which can protect the substrate from high temperature oxidation, thermal corrosion and improve its service life and reliability. The following is a detailed analysis of the performance characterization of high-temperature coatings:

2.2.1 Characterization of the composition and organizational structure of the coating

High temperature resistant coatings are usually composed of a variety of elements and compounds, such as ceramics, metals, alloys, etc. These materials have different atomic structures and types of chemical bonds, so their physical and chemical properties are also different. By characterizing the composition and structure of the coating, we can understand the role and mutual influence of each component in the coating, as well as the crystal structure, phase composition, particle size and distribution of the coating.

Commonly used characterization methods include: chemical analysis, X-ray diffraction, transmission electron microscopy, spectral analysis and so on. Through these methods, the elemental composition, phase structure and microstructure of the coating can be understood, and the thermal stability, oxidation resistance and thermal shock resistance of the coating can be predicted.

2.2.2 Characterization of high-temperature oxidation resistance and thermal shock resistance of the coating

High temperature oxidation resistance and thermal shock resistance are one of the most important properties of high temperature resistant coatings. At high temperatures, the coating reacts with oxygen, water vapor and other media to produce oxides, hydration, etc., resulting in the coating performance decline or even fall off. Thermal shock resistance refers to the ability of the coating to withstand temperature changes without cracking, peeling and other phenomena.

To characterize the high-temperature oxidation resistance and thermal shock resistance of the coating, the following methods are usually used:

(1) High temperature oxidation test: the coating is placed in a high temperature environment, oxygen or air is injected, and its quality changes and surface topography changes are observed, and its oxidation kinetics curve is measured.

(2) thermal shock resistance test: the coating is heated to high temperature, and then quickly cooled to room temperature, and the surface morphology, cracks and other changes are observed after several cycles.

(3) thermal fatigue test: the coating is heated to a certain temperature, and after holding for a certain time, it is quickly cooled to room temperature, so repeated several times, and the changes in its surface morphology and structure are observed.

2.2.3 Particle erosion resistance (erosion) performance characterization

In high temperature environment, particle erosion is one of the main causes of coating damage. When the coating surface is impacted or rubbed by high-speed air flow, it will produce tiny particles and debris, which will further aggravate the wear and damage of the coating. Therefore, it is very important to characterize the particle erosion resistance of high temperature resistant coatings.

Commonly used characterization methods for particle erosion resistance include:

(1) Particle impact test: The use of high-speed airflow or ejector to impact the particles on the surface of the coating, to observe the surface morphology, quality changes, etc.

(2) Wear resistance test: apply a certain load on the surface of the coating mill ball, at a certain speed for reciprocating movement or rotation, to determine its wear rate.

(3) Peel test: apply a certain amount of tension on the surface of the coating to make it peel, and determine its peel strength and peel rate.

Conclusion:

In summary, the preparation methods and characterization methods of high temperature resistant coatings are analyzed and discussed in detail. Through this study, we can better understand the preparation process, performance characteristics and evaluation methods of high temperature resistant coatings, and provide theoretical support and guidance for the preparation and application of high temperature resistant coatings.

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