

## Research Article

# The Application of Nanoparticle Ceramic Materials in the Design of Modern Handicrafts

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With the development of society, people's purchasing power is gradually increasing, and more and more people choose to buy handicrafts. The popularity of handicrafts has also promoted the development of production technology and production materials, and high-quality handicrafts are most favored by consumers. As an enduring material, ceramics are also under continuous development. This article is aimed at studying nanoceramic materials and gaining a detailed understanding of the classification, structure, and manufacturing process of nanoceramic materials. In the experimental stage of this article, through the analysis of whether nanoceramic materials and technology are used in modern crafts, it is verified whether nanoceramic materials contribute to the advancement of modern craft design and the growth of product sales. This article shows through experimental research that the application of nanoceramic materials to handicrafts can not only increase its sales by more than 30% but also increase its sales unit price by 36%.

## 1. Introduction

People need materials in order to make products. In product design, material is the most basic thing to ensure the function and shape of the product. Regarding the definition of matter, it generally refers to the raw materials used by human beings as objects, which are the basis for the existence of all natural and artificial objects. Since the beginning of the Neolithic age, humans made stone tools consciously, so the design and materials were closely integrated. Design is an engraving activity with dual functions of material and spirit, physiology, and psychology. Material is the basic condition for realizing design. More than a century later, the development classics of product design reflect strong nationalization and various languages and cultural contents, with rich spiritual and cultural connotations. There are many types and quantities of materials suitable for modern product design. People have used ceramics as raw materials for a long time. Silicon has long been one of the most basic raw materials for making ceramic materials. With the continuous innovation of society, most of the new ceramic

materials and ceramic products are mainly composed of pure oxides, carbides, and nitrides. In the era of modern industrial production, ceramics still bear an important role and mission in modern product design by virtue of its unique color, texture, and inherent quality. Handicraft refers to the art of handicraft with a unique style. It is different from the arts and crafts that mass produce standardized daily use handicrafts by means of large-scale industrial mechanization. Handicrafts refer to products made purely by hand or with the help of tools.

Decorative art is a bridge connecting human spiritual civilization and material civilization. Ceramic art is a formal feature. It not only embodies the value of beauty in appearance but also embodies the craftsmanship and production technology of people to create beauty. At the same time, the combination of craftsmanship and decoration needs to be manipulated through artistic techniques to get its exquisite artistic effect. More and more people are pursuing ceramic art. Our ideal lies in its changes. We use the beauty created by ceramic art to embellish people's daily life environment, improve people's lives, and further

enhance people's artistic vision. Ceramic art is designed to meet the material and spiritual requirements of the people in their work and life. Indeed, as a product of traditional Chinese culture, ceramics have undergone continuous development, change, and innovation of decorative patterns in the early lacquered pottery era. The materials and technology of ceramics and the continuous update and progress of craftsmen reflect the diligence and wisdom of the Chinese people. It has become China's far-reaching cultural heritage. Of course, we should look at the mainstream of Chinese traditional culture and the fundamental source of national culture. The continuation of this traditional culture and the continuity of the evolution of totems depend on the study of decorative images that are close to the reliability of human life and art. All in all, the application of ceramics in the design of modern industrial products shows its unparalleled charm and appeal. Modern ceramic decoration design is inseparable from the trend of the times, modern craft materials, technology, and aesthetic preferences. We must keep pace with the times, grasp the requirements of the times, grasp the market and technical information of modern ceramic art and crafts, and strive to create more and more updated ceramic products. The design of modern art and crafts needs to combine the completion of ceramic art with art and then make new features of pottery.

With the continuous development of society, ceramic materials and their production technology are also constantly evolving. Simonenko et al. stated that nanocrystalline (19 nm) silicon carbide powder is made by combining the sol-gel treatment of the finely dispersed and chemically reactive  $\text{SiO}_2\text{-C}$  system with the carbothermic synthesis under vacuum medium temperature ( $1400^\circ\text{C}$ ). Porous ceramic materials can be produced by hot pressing methods [1]. In addition to porous ceramic materials, Scribot et al. have shown through experiments that using red mud and broken glass soda as raw materials, heat treatment at  $600\text{-}800^\circ\text{C}$  for 1 hour can also successfully synthesize new foamed geopolymer materials [2]. In the research on the production of ceramic materials, Kairakbaev et al. used the Mossbauer effect to establish the distribution of iron ions during the firing of acid-resistant ceramic materials using production waste as raw materials. Studies have shown that by calculating the area of the double peaks of the spectrum, the iron compounds on the surface of the studied sample are mainly represented by hematite. In this case, the acid resistance of the sample is reduced [3]. At the same time, in the further development of ceramic materials, Baranova and Valiakhmetov have shown through continuous practice results that through the minimum preparation of raw materials used, a corundum material with high thermal stability can be obtained. The corundum material can be used to produce the parts of the molybdenum heater insulator in the voltage stabilizer furnace for the stabilizer casting blade made of high-temperature alloy [4]. Through the continuous advancement of ceramic manufacturing technology, the development of nanoceramic materials is getting faster and faster. Yin et al. prepared  $\text{Al}_2\text{O}_3$ -based micro-nano-composite ceramic tool materials by hot pressing. The tribological behavior and wear mechanism on metals (stainless steel, chromium

steel) and cemented carbide ( $\text{Si}_3\text{N}_4$ ) were studied. Yin et al.'s research shows that when it rubs with stainless steel, the friction coefficient is the smallest and the wear rate is the largest [5]. With the continuous development of nanoceramic production technology, the use of nanoceramics in various fields is also becoming wider and wider. In medicine, Liu et al. said that the nanoceramic coating on the surface of titanium-based metal implants is a potential clinical choice in orthopedic surgery. Stem cells have been found to have osteogenic ability, and it is necessary to study the effect of functionalized nanoceramic coatings on stem cell differentiation and proliferation in vivo [6]. In the application and research of ceramic crafts, Ivkovi et al. studied Belgrade ceramic craftsmanship and craftsman's archaeology through ceramic petrography and chemical analysis, as well as the production technology of these porcelains, including ceramic bodies, slips, and glazes. And use the chaîne opératoire conceptual framework to explain the results [7]. Although ceramic manufacturing technology and manufacturing processes are beginning to be used in more and more fields, the cost of production and use of ceramic materials is much higher than that of other materials, and ceramic materials require high technical levels of production, especially nanoceramics. It needs to use the latest production equipment for production, the production cycle is long, and the cost is high.

The innovation of this article is to incorporate modern nanoparticle ceramic technology into the design of modern handicrafts and to apply advanced nanoceramics to the design of contemporary handicrafts, so that contemporary handicrafts can fully demonstrate the beauty of the fusion of modern technology and modern design. I mainly researched the characteristics and production technology of nanoparticle ceramics to find the most suitable ceramic materials for contemporary handicraft design, so as to better promote the design and promotion of modern industrial products. Because of its high strength, high hardness, corrosion resistance, high temperature resistance, and other characteristics, ceramic materials have become the development center of new materials and received extensive attention, and the application field is also expanding.

## 2. The Application of Nanoparticle Ceramic Materials in the Design of Modern Handicrafts

*2.1. Ceramic Materials.* Ceramic materials are one of the most common materials in daily life and play an important role that most materials cannot replace in people's daily work and life. Because of its fragile surface, the ceramics that people produce early have the shortcomings of fragility and low flexibility. With the large-scale application of nanoceramic technology in ceramic production, we hope to produce ceramic materials with higher strength, better flexibility, and wider applicability, such as ceramics that can be used for metal preparation [8, 9]. Nanoceramics are a new type of ceramic material that appeared around 1970. The development of nanotechnology means that the microstructure, grain boundaries, and particles of ceramic materials have

changed. All of these are to improve the compression resistance, foldability, and plasticity of the material. Ceramic engineering has overcome many shortcomings, which have important effects on electrical, thermal, magnetic, optical, and other mechanical properties. Nanoceramic materials have gradually become engineering materials that can replace traditional industries [10].

**2.1.1. Preparation of Nanoceramics.** Different from traditional ceramic sintering, in the process of nanoceramic sintering, cutting countermeasures must be studied in order to control particles [11]. The special sintering method of nanoceramics can control the size of nanoceramic particles, so as not to have a serious impact on the inherent characteristics of nanoceramics after growth [12]. As shown in Figure 1, there are mainly four methods.

### 2.1.2. The Structural Foundation and Basic Performance of Ceramics

**(1) Ceramic Material Bonding Bond.** Chemical bonding is divided into strong bonding and weak bonding. Among them, strong bond refers to metal bond, covalent bond, and ionic bond, and weak bond generally refers to hydrogen bond and van der Waals bond [13]. Most people think that covalent bonds and ionic bonds are the most important structural combination of ceramic materials. However, after detailed investigation and research, they will find that the bonding properties of ceramic materials vary widely, and there are usually many intermediate types of ceramics. Usually people can judge the degree of ion binding by using electronegativity [14]. The ratio of ion bonding in the ceramic structure composed of two elements  $a$  and  $b$  can be calculated from the formula given in

$$M = 1 - \exp \left[ -\frac{(X_a - X_b)}{4} \right]. \quad (1)$$

In the formula,  $M$  is the ratio of ion binding components and  $X_a$  and  $X_b$  are the electronegativity of element  $a$  and element  $b$ , respectively. In the formula, if the difference between  $X_a$  and  $X_b$  is greater,  $M$  is greater. That is, the ratio of ion binding becomes larger. Conversely, the smaller the difference between  $X_a$  and  $X_b$ , the smaller  $M$  is. In other words, the proportion of covalent bonds becomes larger [15]. When  $X_a = X_b$ , the measured ceramic materials are all covalent bonds, and there are no ionic bonds. In general, the ion bonding ratio of oxides is higher than the ion bonding ratio of carbides, and the ion bonding ratio of nitrides is higher.

**(2) Pauling's Rule.** The most basic characteristic of Pauling's rule is to use positive ion coordination polyhedrons as the basic structural unit instead of the common lattice structure as the basic structural unit. Therefore, when studying its complex structure, the unit presented by it has its own uniqueness [16]. This rule plays a very important role in understanding the structure of ionic crystals, and it also

plays a great reference for crystals with covalent bonds and ions. However, this rule is not suitable for crystals with a single structure [17]. There are 5 rules in total, which are imported as described in Figure 2.

The first rule: the positive ion is in the center, surrounded by many negative ions to form a polyhedron. The algebra of the radius of the positive and negative ions determines the distance between the positive and negative ions. In actual practice, most of the time ions are described as spheres with a fixed volume.  $A^+$  and  $A^-$  represent the radius of positive and negative ions, respectively, and the coordination number of positive ions can be represented by the value of  $A^+/A^-$ . Put positive ions into a gap smaller than its volume to form a stable structure. In particular when the size of the positive ion is consistent with the size of the gap, the formed structure is very stable. Conversely, if the size of the gap is larger than the size of the cation, the structure formed will become unstable [18]. Table 1 shows the relationship between  $A^+/A^-$  and the coordination number.

The second rule: electricity tariff rules. This rule firstly plays a decisive role in the distribution of the number of vertices and polyhedrons and secondly determines whether the result of studying a certain crystal is stable. This rule shows that there is also a certain algebraic relationship in the crystal structure; specifically, there is a certain relationship between the values of positive and negative ions [19]. In other words, the algebraic sum of the electrostatic bonding strength of the positive ions in the vicinity of the negative ions to the negative ions is equal to the value of the negative ions, and the deviation is less than 1/4. The formula for electricity tariff rules is as follows:

$$E^- = \sum_n S_n = \sum_n \frac{E^+}{W}. \quad (2)$$

The third rule: the rule of cotop, face, and edge of polyhedron. The rule is to measure the structural stability of the crystal from the connection mode of the polyhedron. Pauling's law proposes that whether the ionic crystal structure is stable is subject to the collection of polyhedrons. In other words, the structural stability of coplanar crystals is weaker than that of different polyhedral crystals connected at the edge of a common edge [20]. This is due to the presence of high valence positive ions in gaps with low coordination numbers. The intensity of electrostatic coupling can be allocated to adjacent coordinated negative ions, but it cannot completely shield the electric field emitted by positive ions. If the number of common edges between anion polyhedrons increases, the distance between cations becomes shorter. At this time, the repulsive force that is not completely shielded between the cations becomes larger [21]. In particular, when a plurality of such polyhedrons is coplanarly connected, the stability of the crystal structure may decrease. Therefore, the polyhedrons of a crystal with a stable structure are not the same edge or the same plane but are formed at the same angle.

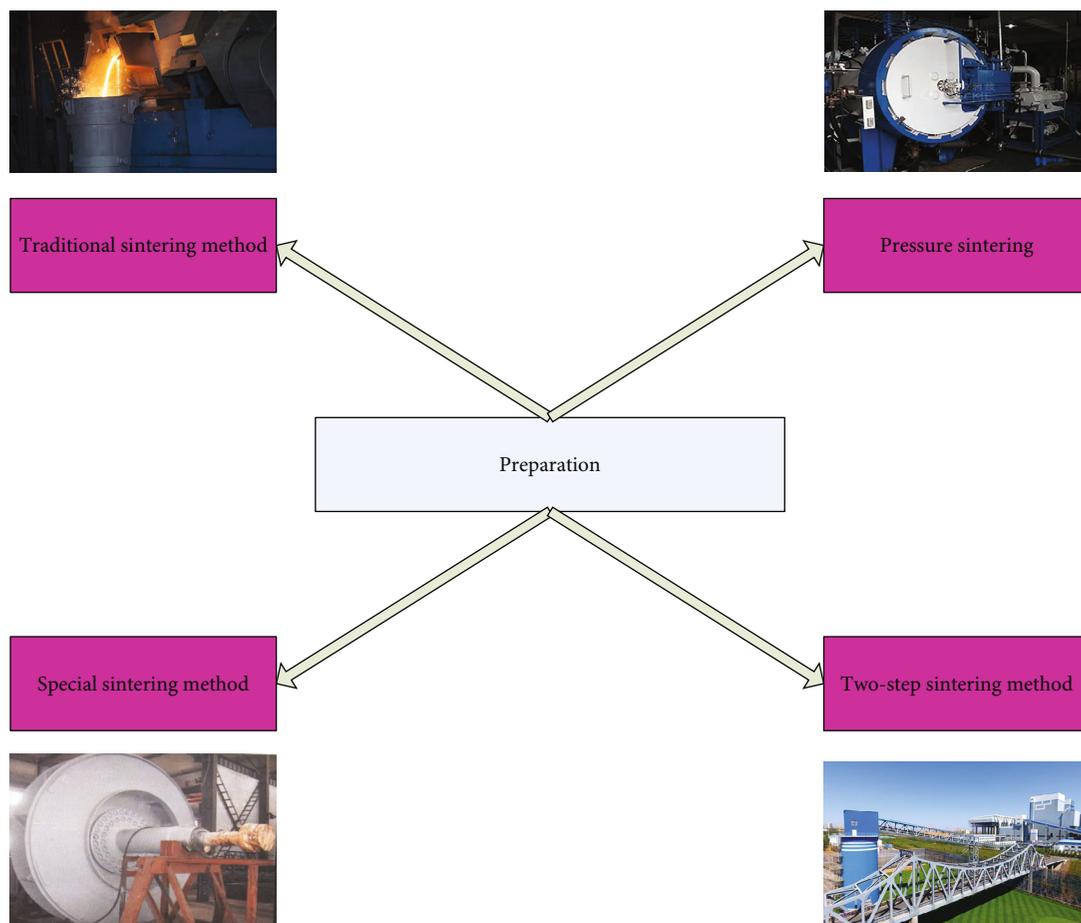


FIGURE 1: Four manufacturing methods of nanoparticle ceramic materials.

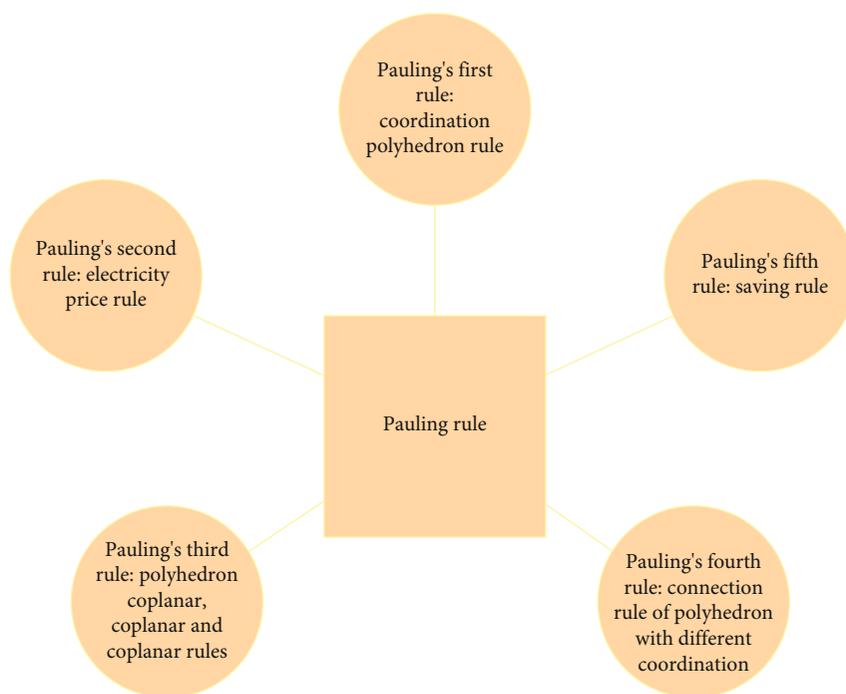


FIGURE 2: Pauling rule.

TABLE 1: Relationship between  $A^+/A^-$  and the coordination number.

$A^+$ to $A^-$ radius ratio	Coordination number	Coordination polyhedron
0.000~0.155	2	Dumbbell shape
0.155~0.255	3	Plane triangle
0.255~0.414	4	Tetrahedron
0.414~0.732	6	Octahedron
0.732~1.000	8	Cube
1.000	12	Tetrahedron

The fourth rule: this rule shows that if there are multiple different cations in the same ionic crystal structure, polyhedrons with high atomic valence and low coordination are likely to fail to connect to each other [22]. For example, in  $\text{BaTiO}_3$ , the titanium oxide octahedrons are not connected on the same plane or common edge but connected only at the upper corners. Fortsulight is divided into tetrahedron ( $\text{SiO}_4$ ) and octahedron ( $\text{MgO}_6$ ) two coordination polyhedrons, but the  $\text{Si}^{4+}$  coordination number is low and the electricity cost is high, so it is connected by tetrahedron ( $\text{SiO}_4$ ) and separated by octahedron ( $\text{MgO}_6$ ) [23].

The fifth rule: saving rules. This rule shows that in the same ionic crystal, there is a tendency to minimize the number of different structural units. In other words, cations of the same type must be in the same coordination environment [24]. The basis of this rule is the symmetry and periodicity of the crystal structure. The basic units that make up the crystal are of different types and large numbers, and when each basic unit forms its own regularity and periodicity, they will interfere. As a result, a stable crystal structure cannot be formed.

(3) *Typical Crystal Structure.* Ceramic structures are generally more complex, but generally speaking, the following typical structures are inseparable. This can be considered the most densely filled voids in which positive ions are filled into negative ions [25–27]. The following briefly introduces several typical ceramic structures. The first introduction is the perovskite-type structure, and its structure is shown in Figure 3.

The perovskite-type composite compound has the general formula  $\text{WTY}_3$ , and the coordination number is  $W : T : Y = 12 : 6 : 6$ . The radii  $Q_W$ ,  $Q_T$ , and  $Q_Y$  of  $W$ ,  $T$ , and  $Y$  ions have the following relationship:

$$Q_W + Q_Y = \sqrt{2}(Q_Y + Q_T). \quad (3)$$

The above equation is the condition for the spheres of radii  $Q_W$ ,  $Q_T$ , and  $Q_Y$  to contact. But in fact, there is a certain radius difference between the  $W$ -site ions and the oxygen ions, and the  $T$ -site ions may not contact the oxygen ions constituting the octahedron [28]. Therefore, the

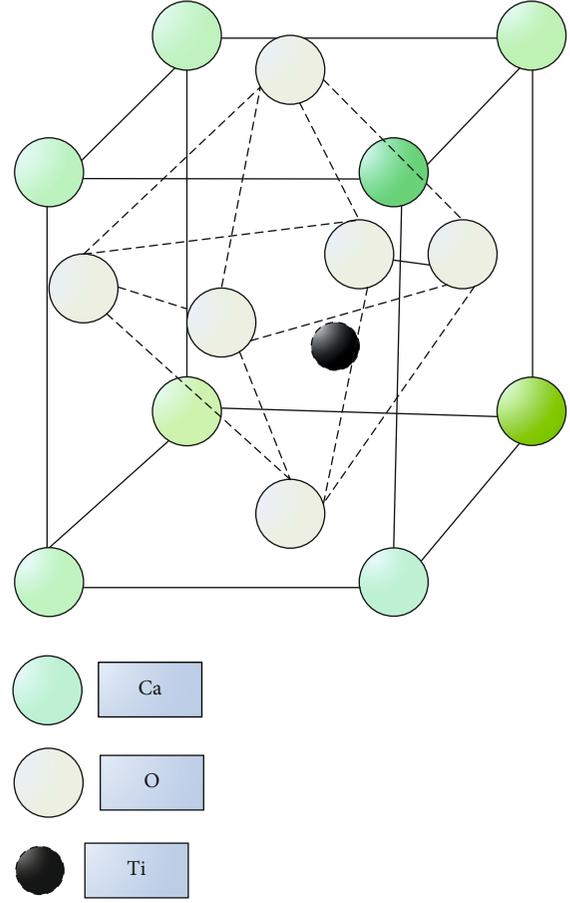


FIGURE 3: Perovskite crystal structure.

tolerance of the radius can be expressed by the tolerance coefficient  $e$ , which can be expressed by the following relational formula:

$$Q_W + Q_Y = \sqrt{2}e(Q_T + Q_Y). \quad (4)$$

The value of  $e$  ranges from 0.77 to 1.10. In the case of  $e = 0.77$  to 1.10, the structure of the WTY<sub>3</sub> compound is a perovskite type. When the value of  $e$  is not within this range, it will change to another crystal structure. In the case of  $e < 0.77$ , it is a ferro-titanium-type structure. In the case of  $e > 1.10$ , there is a calcite or calcite structure.

(4) *Basic Properties of Ceramic Materials.* Dielectric constant is the main parameter reflecting the dielectric properties or polarization properties of piezoelectric smart materials under the action of electrostatic field  $\epsilon$ . Piezoelectric components for different purposes have different requirements for the dielectric constant of piezoelectric smart materials. When the shape and size of piezoelectric smart materials are certain, the dielectric constant  $\epsilon$  is determined by measuring the inherent capacitance (CP) of piezoelectric smart materials. In many materials, the specific permittivity is an indispensable characteristic parameter, reflecting the ability of the charge storage material. This is closely related to the

polarization of the material. The relationship between the polarization parameter and the specific permittivity  $R$  can be obtained from cloud computing and Mossotti's equation:

$$\frac{R_I - 1}{R_I + 1} = \frac{1}{3R_0} \sum jN_j \alpha_j. \quad (5)$$

The above formula reflects the relationship between the polarizability and the specific permittivity, combining the macroscopic quantity and the microscopic quantity.

The quality factor is a parameter for measuring the electric field, especially the internal dielectric loss of the medium in the AC electric field. The quality coefficient  $Qu$  is generally expressed as follows:

$$\frac{1}{\tan \delta} = Qu = \frac{\omega_r^2}{2\pi FY}. \quad (6)$$

It can be concluded from formula (6) that the  $Qu * F$  value is a physical quantity reflecting material loss and an important parameter to explain the quality of ceramic microwave dielectric properties. The  $Qu * F$  value of ceramic materials can be increased by selecting suitable raw materials and improving the preparation and sintering process. Only an excellent preparation method can ensure that the dielectric loss of the ceramic is small.

(5) *Performance Requirements of Ceramic Packaging Materials.* This package mainly plays the role of transporting and supporting chips and electronic components, connecting electronic circuits, sending signals, and protecting heat dissipation. Therefore, as shown in Table 2, ceramic packaging materials mainly have electrical and mechanical requirements.

For packaging materials, the most important requirements for electrical properties are dielectric loss and insulation resistance. The dielectric loss can be expressed by the tangent value of the phase angle of the polarization current of the delayed material voltage, which is the following relational formula:

$$\tan A = Wcr. \quad (7)$$

In the formula,  $A$  is the loss angle,  $W$  is the signal frequency, and  $c$  and  $r$  are the circuit distribution parameters. Over time, the signal sent to the material will disappear in the form of heat, so especially in high-frequency applications, it is necessary to reduce the dielectric loss. The signal transmission speed  $v$  can be expressed by equation (8):

$$v = \frac{s}{\sqrt{\epsilon\epsilon}}. \quad (8)$$

## 2.2. Alumina Composite Ceramic Materials

2.2.1. *The Structure, Performance, and Application of  $Al_2O_3$  Ceramics.* At present,  $Al_2O_3$  ceramics are one of the largest

TABLE 2: Properties of ceramic packaging materials.

Nature	Specific requirements
Electrical properties	Low dielectric loss High insulation voltage
Mechanical properties	High mechanical strength Easy to achieve multiple layers Flat and smooth surface
Other properties	Easy to metallize Resistant to oil and chemical corrosion

production and widely used ceramic materials in the world. Not only is it widely used in the most cutting-edge technical fields such as national defense and aerospace but also due to its heat resistance, corrosion resistance, wear resistance, and other characteristics, part of the material made of it can completely replace part of the metal material. Through effective dispersion and recombination, nanoceramic composites make heterogeneous nanoparticles uniformly dispersed and retained in the ceramic matrix structure, which greatly improves the toughness and wear resistance and high-temperature mechanical properties. Nanoceramic materials can not only bend freely without cracks like metal materials at low temperature but also carry out mechanical cutting like metal materials and even make ceramic springs. These excellent mechanical properties of nanoceramic materials make them widely used in cutting tools, bearings, automobile engine parts, and so on. Figure 4 shows the schematic diagram of the microstructure of the  $Al_2O_3$  ceramic-sintered body.

$Al_2O_3$  ceramic materials have excellent physical properties and chemical stability (high mechanical strength, wear resistance, high temperature resistance, corrosion resistance, high hardness, excellent insulation properties, low dielectric loss, etc.). At the same time,  $Al_2O_3$  ceramics are widely used in machinery, aerospace, electronic instruments, electric power, and chemical industries.

2.3. *Nanoceramic Materials.* At present, the preparation of nanoceramics is still relatively small, but through the efforts of a large number of researchers, a variety of oxide nanoceramics have been successfully prepared, and a perfect sintering theory has been formed, which provides theoretical and experimental support for the preparation of  $BiFeO_3$  nanoceramics. Compared with the traditional solid-phase reaction method and rapid liquid-phase sintering method, it has the advantages of high product particle purity, convenient operation, simple synthesis conditions, and easy control. The sintering theory and research progress of nanoceramics are introduced as follows.

2.3.1. *Introduction to the Sintering Theory of Nanoceramics.* At the microstructure level, sintering refers to the process of powder solid phase material transfer, accompanied by particle growth and densification. Sintering generally includes volatilization-condensation, surface diffusion, grain boundary diffusion, bulk diffusion, plastic deformation, and

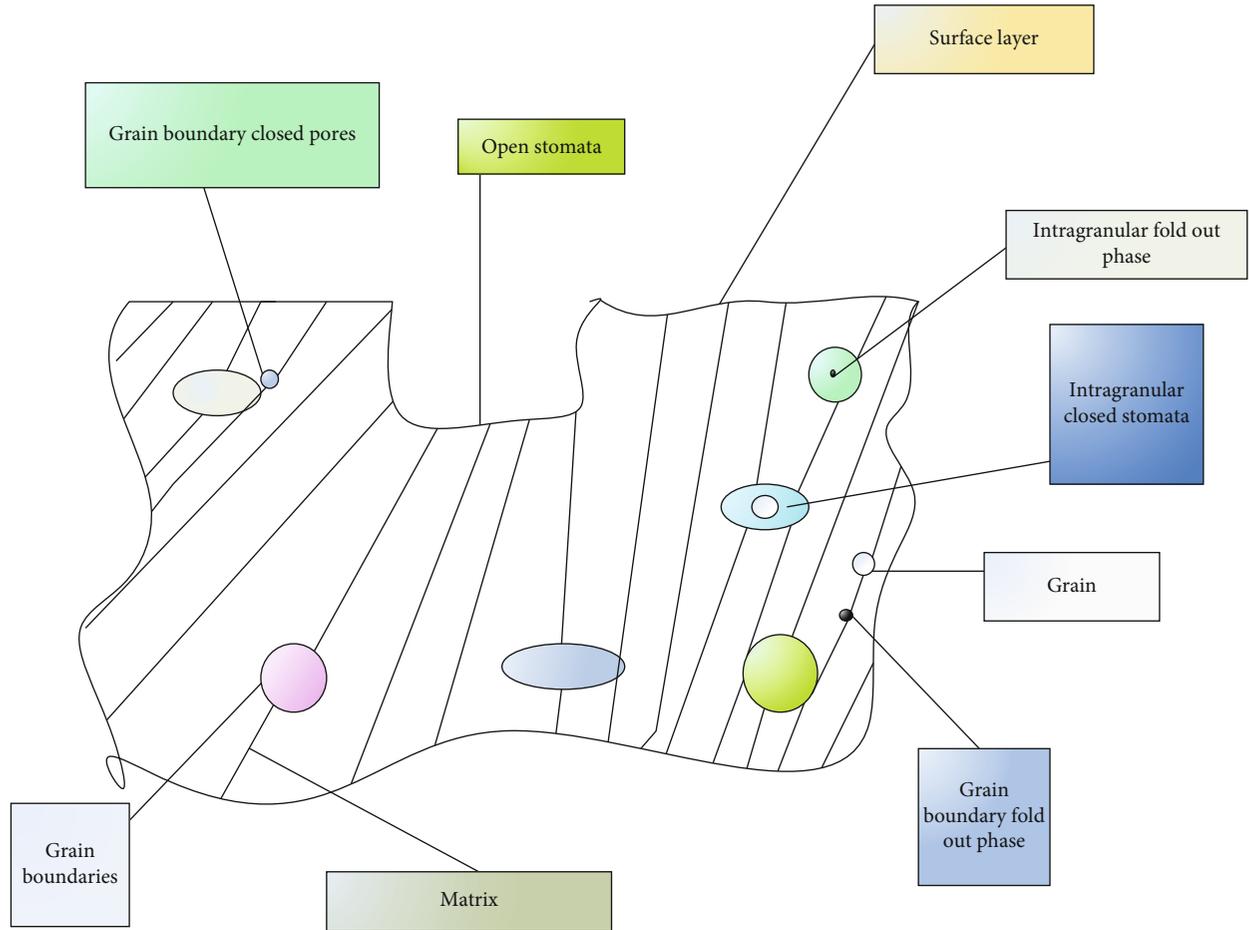


FIGURE 4: Schematic diagram of the microstructure of the  $Al_2O_3$  ceramic-sintered body.

other processes. In the process of densification, only particle diffusion, volume diffusion, and plastic deformation play a role. In the process of sintering without external stress and in the densification of ceramics, only particle diffusion and volume diffusion play a role. Taking the effect of particle diffusion as an example, the rate of change of all particle diffusion can be expressed as follows:

$$\frac{Ac}{Ax} |WQ = B_{WQ} \frac{\alpha_{WQ}}{(2\pi m * r * t)^{1/2}} * \frac{\Omega N_{flat} E_{WQ}}{KY} * \sum B. \quad (9)$$

Among them,  $m$  is the gas constant,  $t$  is the absolute temperature, and  $\Omega$  is the volume of the unit powder. The absolute shrinkage is expressed as the sum of grain boundary diffusion and bulk diffusion, which can be expressed as

$$\frac{DV}{VDt} |D = B \frac{DV}{VDt} |WQ + \frac{DV}{VDt} V = M * R * \sum b. \quad (10)$$

In the formula,  $C$  is a constant related to temperature and  $A$  is the area of grain boundaries. The change of grain

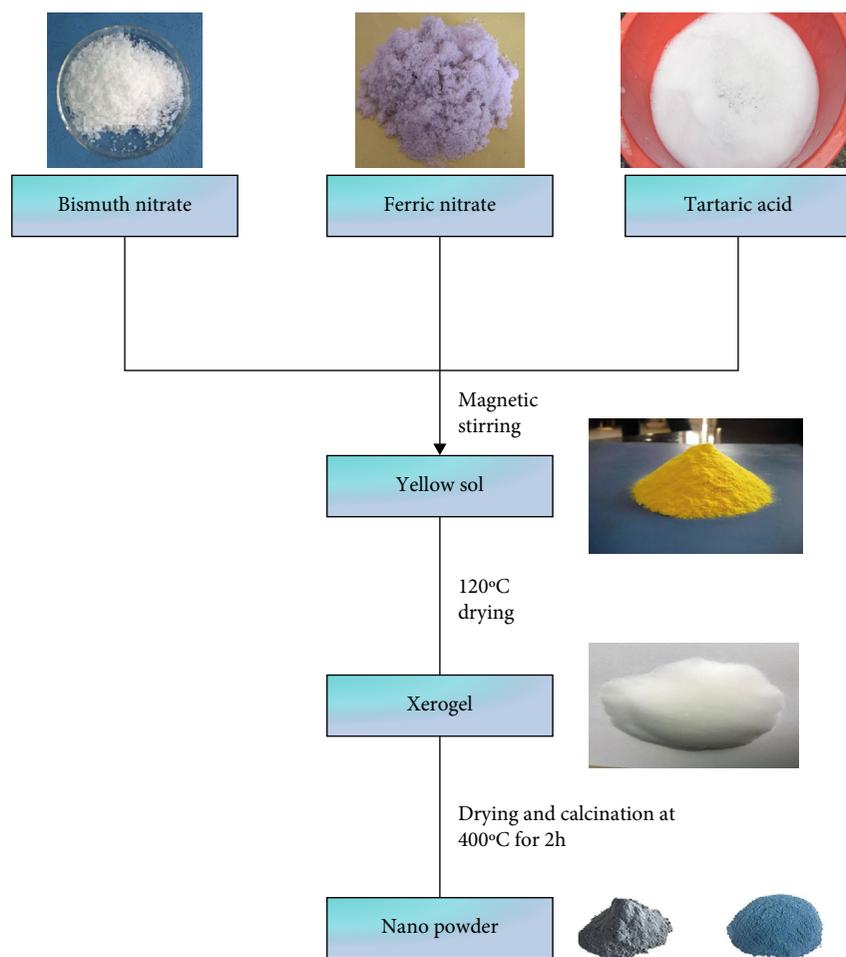
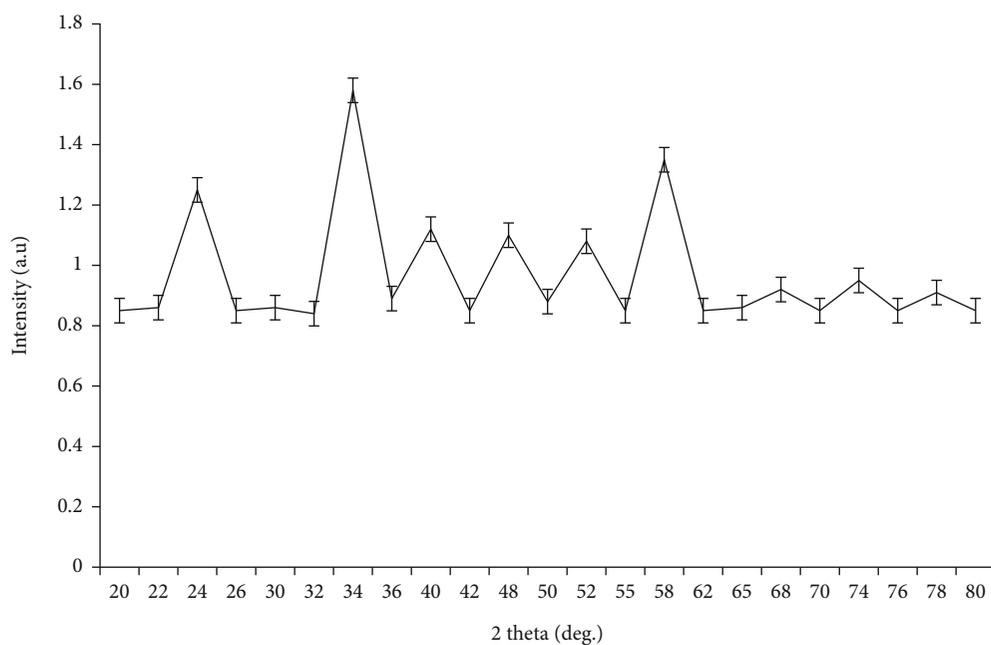
TABLE 3: The main raw materials used in the experiment.

Drug name	Chemical formula	Molecular weight	Specification
Ferric nitrate	$Fe(NO_3)_3$	404	500 g
Bismuth nitrate	$Bi(NO_3)_3$	485.07	500 g
Tetrabutyl titanate	$C_{16}H_{36}O_4Ti$	223	500 ml
Ethylene glycol	$(CH^2OH)_2$	123.22	100 g
Absolute ethanol	$C_2H_6O$	46.07	500 ml
Nitric acid	$HNO_3$	60.05	500 ml

size in the process of grain growth can be expressed by the following formula:

$$\frac{E_R}{E_T} = (L_{B-A} * I_{B-A} + L_W * I_W + L_Q * I_Q)B. \quad (11)$$

### 2.3.2. Preparation Principle of $BiFeO_3$ -Based Nanoceramics

FIGURE 5: Preparation flowchart of BiFeO<sub>3</sub> nanopowder.FIGURE 6: XRD pattern of BiFeO<sub>3</sub> nanopowder.

(1) Experimental materials and experimental equipment, as shown in Table 3

(2) Performance characterization

First, the resistance analysis of the ceramics is carried out, and the surface of the ceramic samples is ground and polished and electrodes are covered. Among them, the relationship between the imaginary part of the impedance and the corresponding frequency is

$$X'' = r \left[ \frac{\omega rc}{1 + (\omega rc)^2} \right]. \quad (12)$$

The relationship between the imaginary part of the electric modulus and the frequency is

$$T'' = \frac{\epsilon_0}{c} \left[ \frac{\omega rc}{1 + (\omega rc)^2} \right]. \quad (13)$$

Among them,  $\omega$  is the angular frequency  $= 2\pi F$  and  $\epsilon_0 = 8.854 * 10^{-14} \text{ F} \cdot \text{cm}^{-1}$  is the dielectric constant in vacuum. The maximum value of the semicircle is the peak value of the Debye peak, and the frequency corresponding to the peak value is

$$\omega_{\text{MAX}} = 2\pi F = (rc)^{-1}. \quad (14)$$

The maximum resistance value  $r$  and the minimum capacitance value  $c$  are extracted by the relaxation peaks of  $X'' - F$  and  $T'' - F$ . From formula (12), the following can be obtained:

$$\begin{aligned} X''_{\text{MAX}} &= \frac{r}{2}, \\ T''_{\text{MAX}} &= \frac{\epsilon_0}{2c}. \end{aligned} \quad (15)$$

When extracting the contribution of defects to Debye relaxation, the extracted system grain boundary and grain conductance can be fitted by fitting, and the relationship between conductance and temperature obeys the Arrhenius formula:

$$\alpha = \alpha_0 \exp \left( -\frac{Wa}{Ki} \right), \quad (16)$$

where  $\alpha$  is the conductivity,  $K$  is the Boltzmann constant,  $i$  is the absolute temperature, and  $Wa$  is the activation energy.

$$\ln(\alpha) = \ln(\alpha_0) - \frac{Wa}{Ki}. \quad (17)$$

The activation energy obtained by fitting can distinguish the dominant defect types of the system. When

TABLE 4: Experimental raw material manufacturers and purity.

Raw material	Material formula	Production address	Purity
Alumina (a1)	Al <sub>2</sub> O <sub>3</sub>	Imported from Japan	>99.90%
Alumina (a2)	Al <sub>2</sub> O <sub>3</sub>	Imported from Japan	>99.90%
Alumina (a3)	Al <sub>2</sub> O <sub>3</sub>	Imported from Japan	>99.90%
Alumina (a4)	Al <sub>2</sub> O <sub>3</sub>	Imported from Japan	>99.90%
Alumina (a5)	Al <sub>2</sub> O <sub>3</sub>	Imported from Japan	>99.90%
Alumina (a6)	Al <sub>2</sub> O <sub>3</sub>	Domestic	>99.90%
Alumina (a7)	Al <sub>2</sub> O <sub>3</sub>	Domestic	>99.90%
Alumina (a8)	Al <sub>2</sub> O <sub>3</sub>	Domestic	>99.90%
Alumina (a9)	Al <sub>2</sub> O <sub>3</sub>	Domestic	>99.90%
Lanthanum oxide	La <sub>2</sub> O	Domestic	>99.90%
Yttrium oxide	Y <sub>2</sub> O <sub>3</sub>	Domestic	>99.90%

extracting the contribution of the defect type to the dielectric relaxation, by fitting the relationship between the relaxation time  $T$  and the reciprocal of the absolute temperature:

$$T = T_0 \exp \left( -\frac{We}{Ki} \right), \quad (18)$$

the relaxation time can be calculated from the frequency corresponding to the peak in the  $X'' - F$  spectrum:

$$T = \frac{1}{2\pi F_{\text{max}}}. \quad (19)$$

(3) Ceramic preparation process

BiFeO<sub>3</sub> and a series of materials derived from it belong to single-phase perovskite oxide-type multiferroic materials, with ferroelectric, piezoelectric, dielectric, electrooptical, ferromagnetic, photovoltaic, and magnetoelectric coupling, photocatalysis, etc. at the same time above room temperature effect. It has important application prospects in many new smart devices. The mixed nitrate solution is prepared according to the stoichiometric ratio of 1:1 of Fe(NO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O and Bi(NO<sub>3</sub>)<sub>3</sub>·5H<sub>2</sub>O or Fe<sub>2</sub>O<sub>3</sub> and Bi<sub>2</sub>O<sub>3</sub>. Glycine is added as fuel, 5~10ml of oxalic acid is added for dehydration, and the resulting solution is put into a microwave oven and heated with 800 W power. After evaporating the water, it is heated for 10~20 seconds. The mixture undergoes a rapid combustion reaction to obtain loose nanoparticle powder products. The obtained granular

TABLE 5: Name, model, and manufacturer of experimental equipment.

Experimental equipment name	Device model	Equipment manufacturer
Density tester	DE-120 M	Hongtuo Instrument Co., Ltd.
Microwave network analyzer	4284A	Agilent Corporation
X-ray diffraction analyzer	X'pert Pro MPD	Netherlands PANalytical
Electronic Vernier caliper	0-150	Chengdu Chuanliang Tools Co., Ltd.
Hydraulic jack machine	QYL-32	Shanghai Hunan Jack Manufacturing Factory
Precision electronic balance	JA-5003	Shanghai Sunny Scientific Instrument Co., Ltd.
Flowing powder production line and continuous ball mill		
Flow-type frit production line and continuous frit kiln		
Rotary hydraulic brick press and dry glazing process		

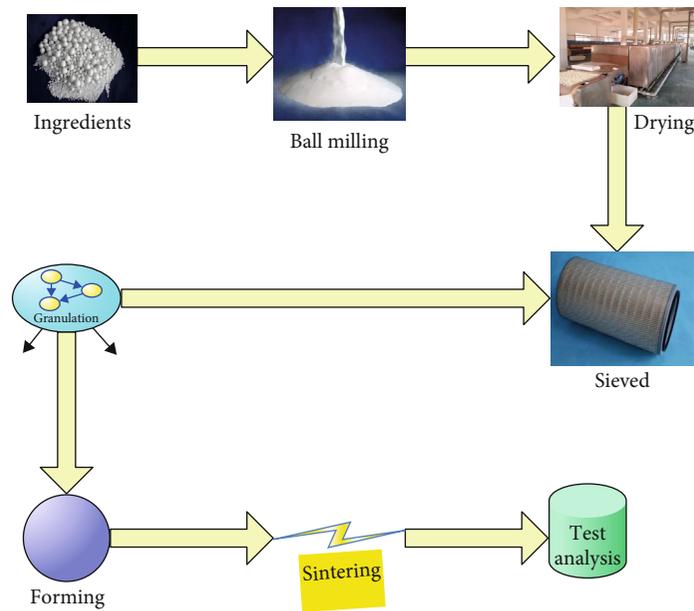


FIGURE 7: Flowchart of ceramic preparation.

powder is pressed into small pieces by a tablet press to obtain a block sample. Then, the bulk sample was sintered in a muffle furnace and quenched to room temperature to obtain the product with uniform-size  $\text{BiFeO}_3$  prepared by this method having high purity, uniform particle size, and adjustable particle size.  $\text{BiFeO}_3$  adopts a sol-gel method to prepare nanopowder, and the preparation process is shown in Figure 5.

After the dry gel is ground and sieved, it is placed in a muffle furnace and calcined at  $400^\circ\text{C}$  for 2 hours to completely drain the organic matter and nitrate in the dry gel and at the same time obtain pure  $\text{BiFeO}_3$  nanopowder. The XRD of the nanopowder is shown in Figure 6.

The preparation process of nanoceramics mainly includes the preparation, molding, and sintering of nanopowder. The methods are as follows: (1) settlement method, (2) in situ solidification method, and (3) sintering or hot pressing method.

It can be seen from Figure 6 that there is no obvious second phase in the nanopowder. According to the Scherrer formula,

$$Q = \frac{wy}{E \cos \vartheta}, \quad (20)$$

where  $Q$  is the grain size,  $w$  is the Scherrer constant with a value of 0.89,  $E$  is the half-height width of the diffraction peak of the measured sample,  $\theta$  is the diffraction angle,  $y$  is the X-ray wavelength, and its value is 0.154056 nm for the known nanopowder. The grain size is 15.95 nm.

### 3. Experimental Design and Result Analysis

3.1. Preparation of Nanoceramics in the Application of Handicrafts. The preparation methods of nanomaterials can be divided into physical method, chemical method,

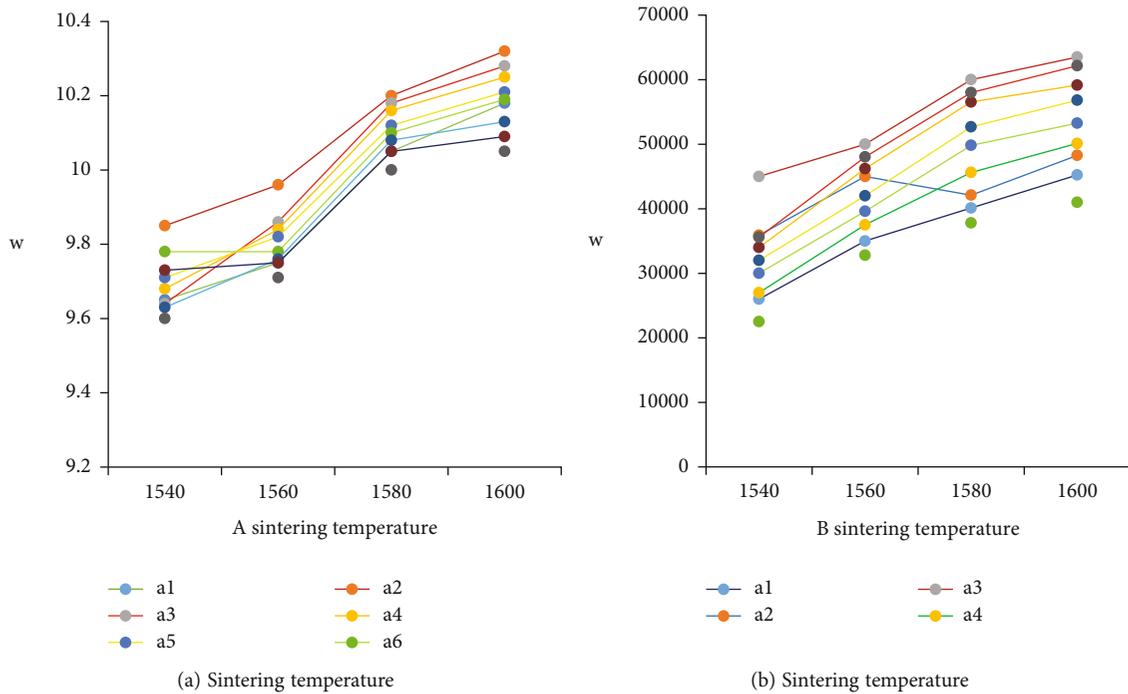


FIGURE 8: Al<sub>2</sub>O<sub>3</sub> ceramic dielectric performance test results.

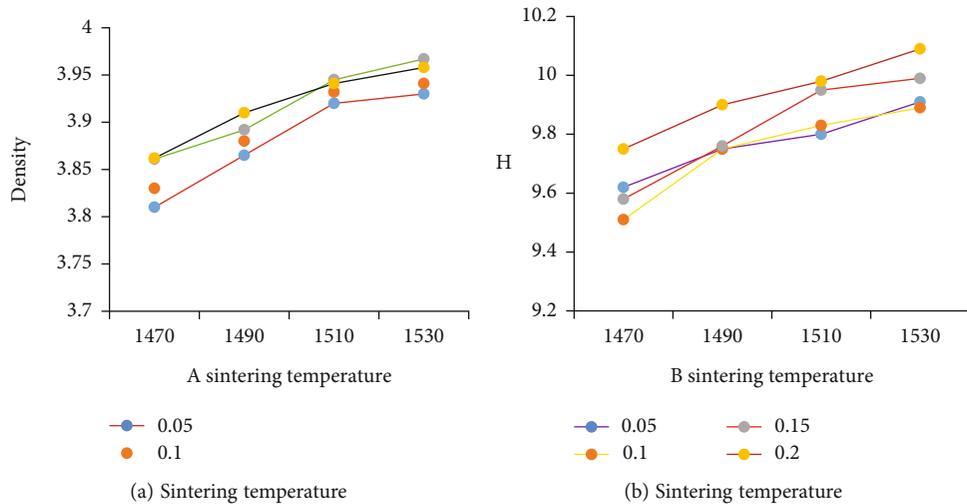


FIGURE 9: The density and dielectric constant of Al<sub>2</sub>O<sub>3</sub> ceramics change with the sintering temperature.

and other methods. Physical methods include crushing method, deposition method, sputtering method, etc. Chemical methods include sol-gel method, precipitation method, evaporation solvent pyrolysis method, oxidation-reduction method, solvothermal method, etc.

LAO<sub>3</sub> and Y<sub>2</sub>O<sub>3</sub> have better performance on the absorption and emission peaks of transparent ceramics, while BiFeO<sub>3</sub> is not suitable for application in this field. The main raw materials used in this experiment are high-purity Al<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, and Y<sub>2</sub>O<sub>3</sub> with different particle sizes from different manufacturers. The name, molecular formula, manufacturer, and purity are shown in Table 4.

After calculating and weighing the raw materials, use the solid-phase sintering method to prepare Al<sub>2</sub>O<sub>3</sub> ceramics, test the sintered samples, and perform performance analysis. Table 5 shows the main equipment and test equipment used in the entire preparation and testing process.

This article uses the most commonly used solid-phase sintering method in industrial production to prepare 99 alumina ceramics. The ceramic preparation process is shown in Figure 7.

The advantages of the solid-phase reaction sintering method for preparing ceramic samples are as follows: the experimental conditions are easy to control, the preparation process is relatively simple, the cost is relatively low, and the

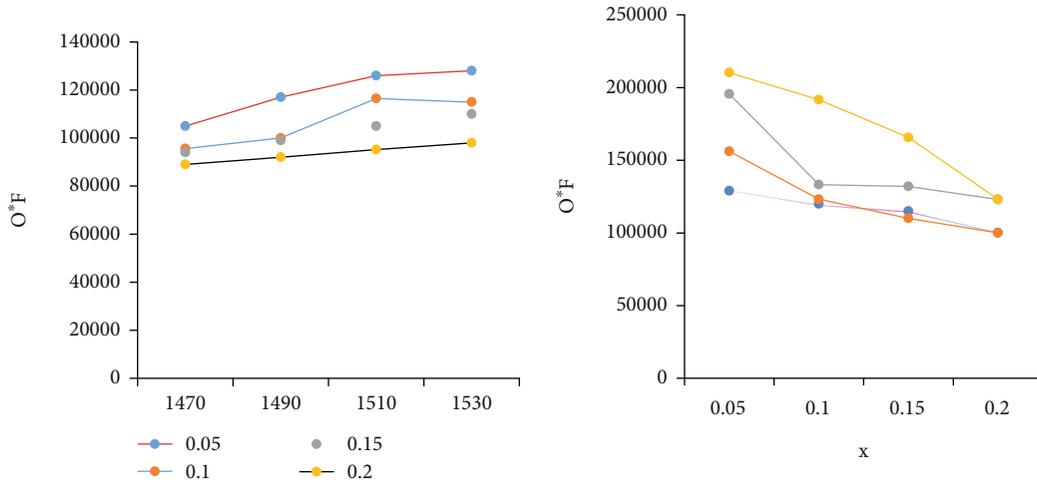


FIGURE 10: Variation curve of the ceramic  $O * F$  constant value with sintering temperature.

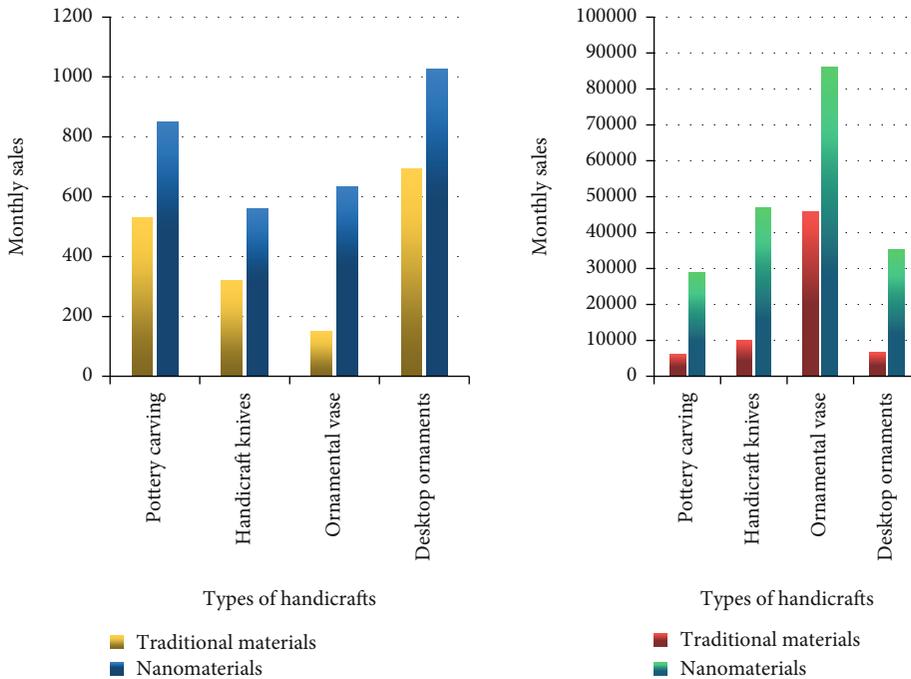


FIGURE 11: Sales volume and sales comparison chart of handicrafts with different materials.

chemical composition of the raw materials of this method is uniform, easy to popularize, and suitable for large-scale industrial production; the disadvantage is that the calcination temperature is high and energy consumption is high. It is easy to introduce impurities during the grinding process, and the process parameters are more complicated.

**3.2. Preparation Results of Nanoceramics in the Application of Handicrafts.** In this section, the solid-phase reaction sintering method commonly used in industrial production is used to prepare pure  $Al_2O_3$  ceramics. The raw materials involved are nine kinds of high-purity  $Al_2O_3$  powders with different particle sizes from different manufacturers, num-

bered a1~a9. Using a vector network analyzer, the microwave dielectric properties of the sintered ceramic samples were tested. The test result is shown in Figure 8.

It can be seen from Figure 8 that as the sintering temperature increases, the relative permittivity and  $Q \times f$  value of  $Al_2O_3$  ceramics numbered a1 to a9 increase. This shows that as the sintering temperature increases, the pores in the ceramic are gradually discharged, the grain size becomes larger, the ceramic compactness becomes better, and the relative permittivity and  $Q \times f$  value are closely related to the density and grain size of the ceramic material. It can be seen from Figure 8(b) that the  $Q \times f$  value of a3  $Al_2O_3$  ceramics is much higher than that of the other 8  $Al_2O_3$

ceramics. Compared with other  $\text{Al}_2\text{O}_3$  ceramics, it exhibits extremely excellent microwave dielectric properties.

The density test was performed on the ceramic samples after sintering. Figure 9 shows a graph of the density and dielectric constant of  $\text{Al}_2\text{O}_3$  ceramics as the sintering temperature changes.

As shown in Figure 9, it can be seen that the ceramic becomes dense with the increase in the sintering temperature, and its density increases with the increase in temperature. At the same time, with the increase in MgO doping amount, the density of ceramic samples increased first and then decreased. At  $1530^\circ\text{C}$ , when doped with 0.15% MgO, the density of  $\text{Al}_2\text{O}_3$  ceramics reached the maximum  $3.961\text{ g/cm}^3$ .

Then, use the vector network analyzer to test the microwave performance of the sintered ceramic samples. As shown in Figure 10, the ceramic  $O * F$  constant value changes with the sintering temperature:

It can be seen from Figure 10 that as the sintering temperature increases, the ceramic density gradually increases, the relative dielectric constant also increases, and the  $Q \times f$  value of MgO-doped  $\text{Al}_2\text{O}_3$  ceramics increases. Since the relative permittivity of MgO is 9.7, the relative permittivity of pure  $\text{Al}_2\text{O}_3$  ceramics is relatively close, and the amount of MgO doped is small, it has little effect on the relative permittivity of MgO-doped  $\text{Al}_2\text{O}_3$  ceramics.

*3.3. The Application of Nanoparticle Ceramic Materials in the Design of Modern Handicrafts.* Through the investigation and analysis of the sales volume of some modern handicrafts made with nanoceramic materials and the sales volume of traditional handicrafts, Figure 11 is obtained.

From the data in Figure 11, it can be concluded that not only has the sales volume of handicrafts using nanoceramic materials increased greatly but also the average sales volume is more than 35% higher than that of handicrafts made of ordinary materials, and the selling price is due to the use of new materials. The new production process has also increased the price of a single product. According to a comprehensive analysis, the average selling price of crafts using nanoceramic materials is at least 40% higher than that of traditional crafts.

## 4. Discussion

This article is devoted to the research of nanoceramic materials and applies them to modern handicrafts. This article discusses the production process, manufacturing technique, and manufacturing materials of nanoceramic materials. While discussing, we will also apply it to our modern handicrafts in the experimental stage and then conduct research and analysis on the sales volume and sales of modern handicrafts, so as to better explore the use of nanoparticle ceramics in modern handicrafts. In addition, this article mainly conducts sufficient research on the different forging methods of nanoceramics and conducts experiments on nanoceramics in terms of dielectric loss and temperature resistance. The experimental results in this article also show that nanoceramic materials have a wear resistance, high temperature resistance, corrosion resistance, hardness, insula-

tion performance, dielectric loss rate, and other aspects superior to ordinary ceramic materials.

The analysis of the experimental cases in this article shows that the performance of nanoceramic materials is much better than that of other materials, and its use in modern handicrafts has also been favored by most consumers. Modern handicraft design and production manufacturers can make full use of the existing nanoceramic technology and integrate it into the design of handicrafts. Of course, enterprises can also choose good production materials and production techniques according to their own conditions to help them develop better.

In this paper, the production of nanoceramics is firstly studied, and the raw materials that are more suitable for the production of nanoceramics are obtained through experiments, and then, the nanoceramic materials after the improvement of production are studied, and the nanoceramic materials that are more suitable for use in daily life are selected. Finally, through the research on the sales and price of handicrafts using nanoceramic materials in daily life, the survey results show that not only can modern handicrafts using nanoceramic materials occupy a 30% advantage in sales but also it is better than traditional crafts.

## 5. Conclusions

Through the analysis of this case, the following conclusions can be drawn: modern handicrafts designed and manufactured using nanoceramic materials can not only increase the sales and selling prices of modern handicrafts by more than 30% but also increase the use value and ornamental value of the products. There has also been a qualitative leap in collection value. As one of the three main materials, ceramic materials are world-renowned as unique craft buildings. Modern handicraft design is an important carrier reflecting its culture. Excellent handicraft design should not only reflect the uniqueness and superiority of product information but also use cultural connotation to highlight the taste, grade, and value of the design. While modern handicraft design reflects contemporary culture, it is also the demand for modern design innovation in terms of the expression strategy of design creativity, the shaping of the brand image, and the ecological design concept of materials. For example, in this case, the merchants who use nanoceramic materials to design and produce modern handicrafts, because of the use of nanoceramic technology, make their product sales, and sales prices have a great leap. It can be seen that the average selling price of handicrafts using nanoceramic materials is at least 40% higher than that of traditional handicrafts.

## Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

## Conflicts of Interest

The authors state that this article has no conflict of interest.

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