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Nanomaterials and Ferroelectric Domain Polarization on the Transmission Electron Microscopy of Wushu Performance Major Students

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Abstract: Nanomaterials and ferroelectric materials are two commonly used materials in today's society, and they have great influence in various fields. This article aims to study the TEM analysis of nanomaterials and ferroelectric domain polarization for Wushu performance students when shooting. This paper proposes to combine the characteristics of the multi-molecular structure of nanomaterials and the compactness of ferroelectric domain films to strengthen the transmission electron microscope, and optimize the imaging effect of the transmission electron microscope through EMCD technology. After improving the transmission electron microscope, this article has done experiments on capturing and manipulating ferroelectric domain nanoparticles with transmission electron microscope and exploring the anti-beating ability of transmission electron microscope. The experimental results show that the anti-smashing ability of the transmission electron microscope after nanomaterials and ferroelectric domain polarization has been greatly improved. The comprehensive damage degree of the transmission electron microscope dropped at a height of 10m is only 0.00007175, and the impact on the shooting effect is only 0.0208%. However, due to its increased density after strengthening, the improved transmission electron microscope is 1 to 1.5 times heavier than the ordinary transmission electron microscope.

1. Introduction

Non-volatile strong media memory is widely used due to its excellent characteristics and is considered to be the most promising storage device. However, in ferromagnetic storage, there are also a series of failure problems that need to be solved urgently, such as fatigue, implantation, and poor retention performance. The failure phenomenon of ferroelectric memory is essentially related to the polarization (domain structure) of the ferroelectric film.

In transmission electron microscopy, it is always a difficult problem to achieve nanometer-scale quantitative magnetic parameter measurement. The invention of Electromagnetic Dichroism (EMCD) realizes a new method of material magnetic measurement using transmission electrons. This is also the new magnetic characteristic of transmission electron microscope after Lorentz technology and electronic holographic technology. However, EMCD technology is still a developing technology, and there are still some problems that need to be solved in the process of use. The improvement and broadening of EMCD technology is of great significance for the characterization of magnetic properties on the nanometer scale in transmission electron microscopy.

Therefore, in order to solve the reliability problem of ferroelectric memory, it is necessary to study the factors that affect the domain structure evolution of ferroelectric thin films and their internal influence mechanism. Interface mismatch strain, dislocations and other microstructures will have an important influence on the domain structure of ferroelectric thin films. Regarding the interface mismatch strain, existing studies have shown that the interface mismatch strain of ferroelectric materials will affect the domain wall, but the internal mechanism of its effect is still unclear, and further research is needed.

In order to study the application of nanomaterials in the field of construction, Rzayev emphasized the ability of molecular bottle brushes as height-adjustable building blocks to create nanostructured materials through molecular templates, solution aggregation and melt self-assembly. He highlighted the latest achievements in the synthesis of discrete nano-objects, micellar structures and periodic nano-materials from brush copolymers, and briefly discussed future opportunities in the field of polymer science [1]. For this article, we can refer to the application of its nanomaterials, which is convenient for its application in transmission electron microscopy, but it lacks the application of ferroelectric domains. For the application of nanomaterials, Lithoxoos G P uses Grand Canonical Monte Carlo (GCMC) simulation combined with ab initio QM calculation to study the adsorption capacity of H_2 in single-walled silicon nanotubes (SWSiNT) assuming an armchair structure model [2]. It has studied the adsorption capacity of H_2 in single-walled silicon nanotubes, but it has little relevance to the subject of this article. The construction of nano-scale components and units as functional in the defined system and material dimensions has recently attracted attention as a nano-architectural method. Due to the large surface area suitable for various surface active applications, two-dimensional nanomaterials are the focus of attention. Khan A H conducted research on energy conversion and storage of two-dimensional nanomaterials [3]. Two-dimensional nanomaterials have developed a new world in the construction industry, but this article mainly applies them to transmission electron microscopy. Ferroelectric perovskites, such as $Pb(Ti,Zr)O_3$ and $BaTiO_3$, are affected by the aging effect, which is caused by the gradual stabilization of the ferroelectric domain structure. Lambeck PV studied the development of this stability in a Mn-doped $BaTiO_3$ single crystal with a special domain structure. He measured the increase of the internal bias field E_i and the change of the lateral 180° domain wall mobility with time and concluded that the considerable stability in the material is due to the volume effect, which means the gradual renewal of polar defects. Orientation Regarding the direction of spontaneous polarization, 180° domain wall pinning and surface layer effects are completely absent [4]. Lambeck P V's research on ferroelectric domain structure is very in-depth, it is worthy of this article for reference, if it can involve transmission electron microscopy, it will be more applicable. The dipole configuration in ferroelectric nanodots depends on the symmetry of their shapes. $BaTiO_3$ ultra-thin nanosheets exhibit a tetragonal vortex domain structure. Liu J reported a new vortex domain structure in $BaTiO_3$ nanodots. The behavior of the new vortex is well controlled by electric field and stress [5]. This new type of vortex can be well controlled in ferroelectric nanometers, but it would be better if it is studied by transmission electron microscopy. Domain walls play an important role in adjusting the performance of ferrous materials. Jinghui uses the Landau-Ginzburg thermodynamic model to study the ferroelectric domain wall around the MPB, which contributes to the large piezoelectric response, including the tetragonal (T) symmetrical 90 °domain wall and 109 ° and 71 ° domains the rhombus (R) of the wall is symmetrical [6]. He strengthened ferroelectric domains through a thermodynamic model, which can be used to strengthen the application of ferroelectric domains in transmission electron microscopy. By capturing the entire unsaturated diffraction pattern in a scanning mode, one can capture brightfield, darkfield, and phase contrast information at the same time, and can analyze the total scattering distribution, thereby realizing true centroid imaging. Tate M W describes a hybrid pixel array detector (electron microscope pixel array detector, or EMPAD) suitable for electron microscopy applications, especially as a general detector for scanning transmission electron microscopes. Scattering is recorded on an absolute scale, so information such as local sample thickness can be directly determined [7]. It describes the hybrid pixel array detector for electron microscopy, but this article focuses on the applications related to transmission electron microscopy. Dravid V P introduced the high-resolution transmission electron microscopy (HRTEM) observation results of the phase interface in the NiO-ZrO 2(CaO) directional solidification eutectic (DSE). Chemical microanalysis using X-ray emission spectroscopy (XES) shows that CaO and ZrO 2 have an obvious distribution relationship [8]. It would be better if TEM can be strengthened based on nanomaterials and ferroelectric domains.

The innovation of this paper is to study the multi-molecular structure of nanomaterials and the denseness of ferroelectric domain films, strengthen the anti-beating ability of transmission electron microscope, and then use EMCD technology to optimize the shooting effect of the transmission electron microscope for martial arts performances, and Through the comparative experiment of falling at different heights, the anti-beating ability is explored.

2. Explore the Method of Combining Nanomaterials and Ferroelectric Materials to Strengthen Transmission Electron Microscopy

2.1. Nano Materials

Due to the small size of nanomaterials [9], nanomaterials have many advantages such as large specific surface area and high surface activity. Therefore, the use of nanomaterials to construct electrochemical sensing interfaces is expected to greatly improve the detection performance of electrochemical sensors for target substances. In order to construct a high-performance electrochemical sensing interface based on nanomaterials, it is necessary to study the preparation methods of nanomaterials, so that nanomaterials can be designed and prepared according to needs. On the other hand, the development of nanotechnology has not only promoted the progress of the synthesis method of nanomaterials, but also updated the types of nanomaterials, enabling the production of new nanomaterials. Therefore, constructing electrochemical sensors based on new nanomaterials and exploring the catalytic behavior of new nanomaterials on the reaction of target substances on the sensing interface is expected to promote the development of electrochemical sensing research. As shown in Figure 1, nanomaterials are used in various fields on the application.

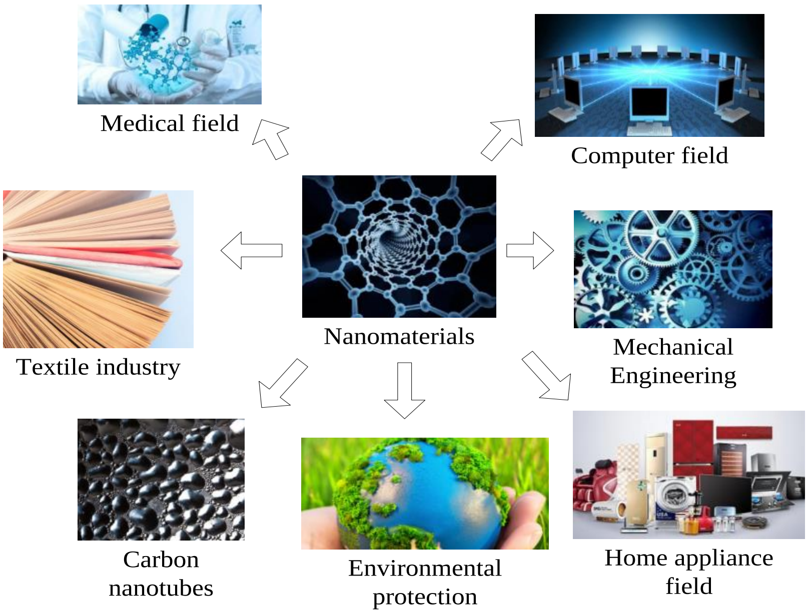


Figure 1. Application of nanomaterials

The preparation of nanomaterials by chemical method is to prepare nanomaterials from the atoms and molecules "bottom-up" by adopting appropriate chemical reactions.

2.2. Ferroelectric Materials

Ferroelectric material [10] refers to the polarization within the material without the action of an external electric field. This polarization is called "spontaneous polarization", and its spontaneous direction can be reversed by an external electric field. Rotating or switching directions, the reversal behavior of the spontaneous polarization of ferroelectrics [11] as an electromagnetic hysteresis loop (Figure 2) shows that this is also a typical ferroelectric material characteristic.

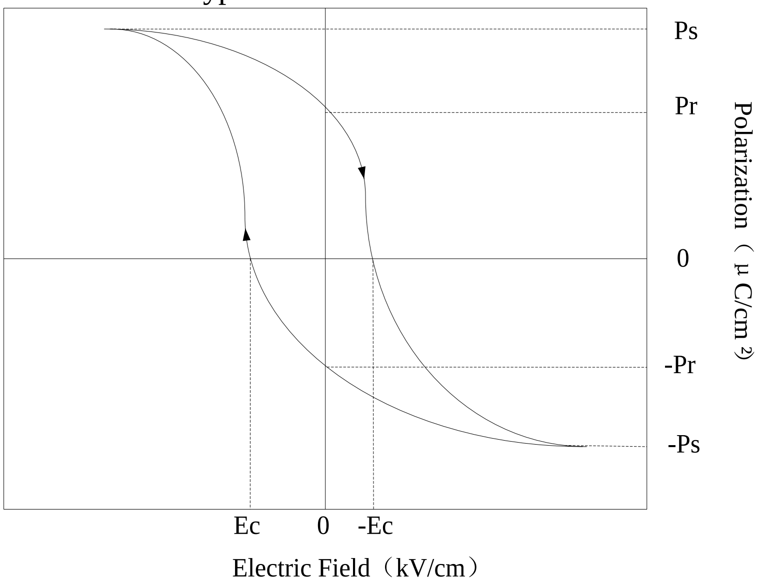


Figure 2. Schematic diagram of hysteresis loop of ferroelectric

Only dielectric materials with a specific crystalline structure have dielectric properties. Among the 32 crystallization point groups, 10 is the pole group, and only the crystals of these 10 pole groups have spontaneous polarization. Polar media lack central symmetry due to spontaneous polarization. The property that mechanical stress or strain can be applied to induce polarization is called piezoelectricity. With the change of ambient temperature, the change of polarization state is called the general characteristic of pyroelectric spontaneously polarized crystal. Ferroelectrics require not only spontaneous polarization within the crystal, but also two or more possible orientations of spontaneous polarization. Ferroelectric materials are divided into ferroelectric materials and ferroelectric thin film materials [12], and one of the most popular materials is calcium. The chemical formula of the compound is ABO3, and the structure is shown in Figure 3. Among them, A and B represent different metal cations, and O is an oxygen ion. The large cation A occupies 8 corners of the cubic unit crystal lattice, the small cation B occupies the center of the cubic unit crystal lattice, and the oxygen ions are distributed in the center. As shown in Figure 4, when the temperature is lower than the Curie temperature, the atoms in the ferroelectric material unit unit will move. The displacements of positive ions and negative ions are different, and the centers of positive and negative charges do not overlap, so the correction result refers to the electric dipole moment per unit volume. In other words, when the Curie temperature is low, the ferroelectric material exhibits a macroscopically strong dielectric property.

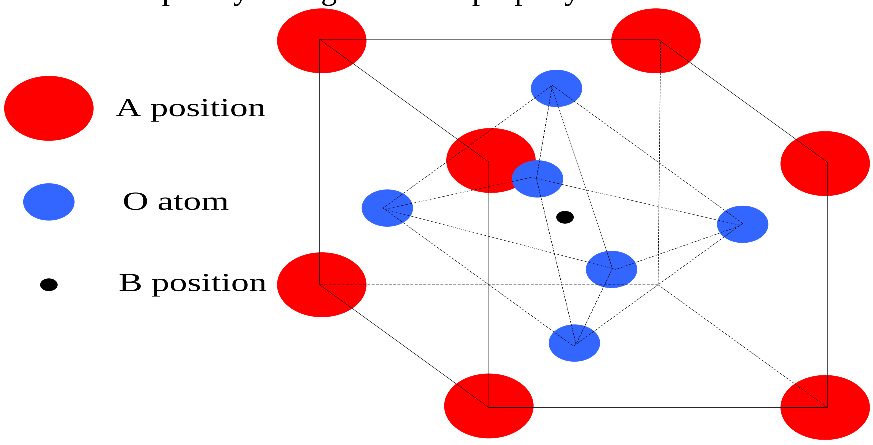


Figure 3. The crystal structure of the paraelectric phase of perovskite

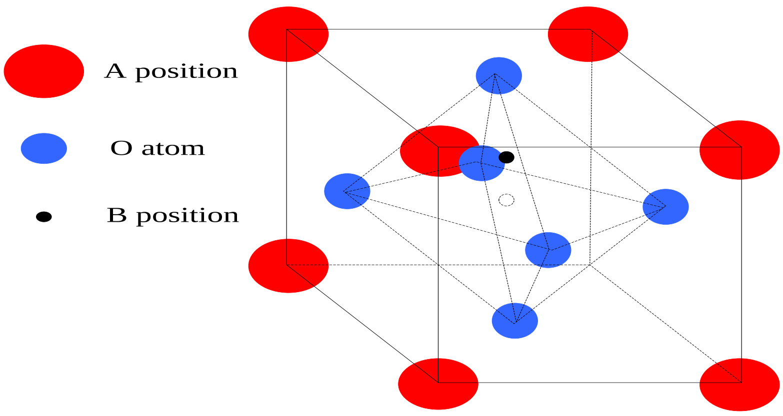


Figure 4. The crystal structure of the ferroelectric phase of perovskite

Ferroelectric film [13] has excellent properties of ferroelectric materials such as ferroelectricity, pyroelectricity, piezoelectricity, electro-optic effect, acousto-optic effect, light and shadow effect, and nonlinear optical effect.

For a long time, ferroelectric materials have received a lot of attention and have been studied in depth. Table 1 lists important historical events in the development history of ferroelectric materials:

Table 1. Important event in the development history of ferroelectric materials

years	event	years	event
1842	Pyroelectricity found in rasid salt	1880	Found in quartz, rosid salt and other ores Current piezoelectricity
1912	Ferroelectric	1921	Found that rosidum salt has ferroelectricity
1935	Found that KH2PO4 has ferroelectricity	1941	Developed BaTiO3 high K (greater than 1200) Capacitor
1994	Discovery of BaTiO3 with ABO3 perovskite structure Ferroelectric	1945	BaTiO3 for piezoelectric sensors
1949	Put forward the phenomenological theory of BaTiO3	1949	It is reported that LiNbO3 and LiTaO3 are ferroelectrics
1951	Propose the concept of anti-ferroelectric	1952	Report that PZT is a ferroelectric
1953	Reported that PbNb2O3 is a ferroelectric	1954	PZT is used for piezoelectric sensors
1955	Reported that BaTiO3 has PTC effect	1955	It was reported that basic niobate is a ferroelectric.
1961	Propose the lattice dynamics of ferroelectric materials Theory, soft model theory	1961	reported that PMN is a relaxor ferroelectric
1964	Developed ferroelectric semiconductor (PTC) devices	1967	reported the optics of ferroelectric ceramics prepared by hot pressing And electro-optical properties
1969	Proposed "ferroelectric" and "ferroelasticity" the term	1971	reported the electro-optical properties of PLZT
1977	Ferroelectric thin film	1980	Use PMN relaxor ferroelectric to develop electricity
1981	Sol-gel technology is used to prepare ferroelectric thin films	1983	reported that PZT and PLZT have photo-stretch
1993	Combination of ferroelectric thin film and silicon technology	1997	Developed relaxor iron for piezoelectric sensor
1998	The electric effect of the developed Yu ferroelectric body Should be as high as 4%	2006	Relaxation ferroelectrics produce a large electro-noise Criticality phenomenon

As a kind of dielectric material, ferroelectric material has other characteristics besides showing ferroelectricity, such as dielectric property [14], piezoelectricity, pyroelectricity, photoelectric effect, acousto-optic effect, optical transition effect [15] Wait. These different characteristics also make ferroelectric materials have a wide range of applications. People's application of ferroelectric materials is shown in Figure 5. From the table, we can see that the application prospects of ferroelectric materials are very attractive. This is also the reason why ferroelectric materials have received more and more attention in recent decades. In these applications, ferroelectric memory uses polarized bistable state for information storage, so it has the advantages of non-volatile, fast reading and writing, fatigue resistance, and radiation resistance. It is considered to be one of the most potential new types of memory. Electrical storage has been commercialized.

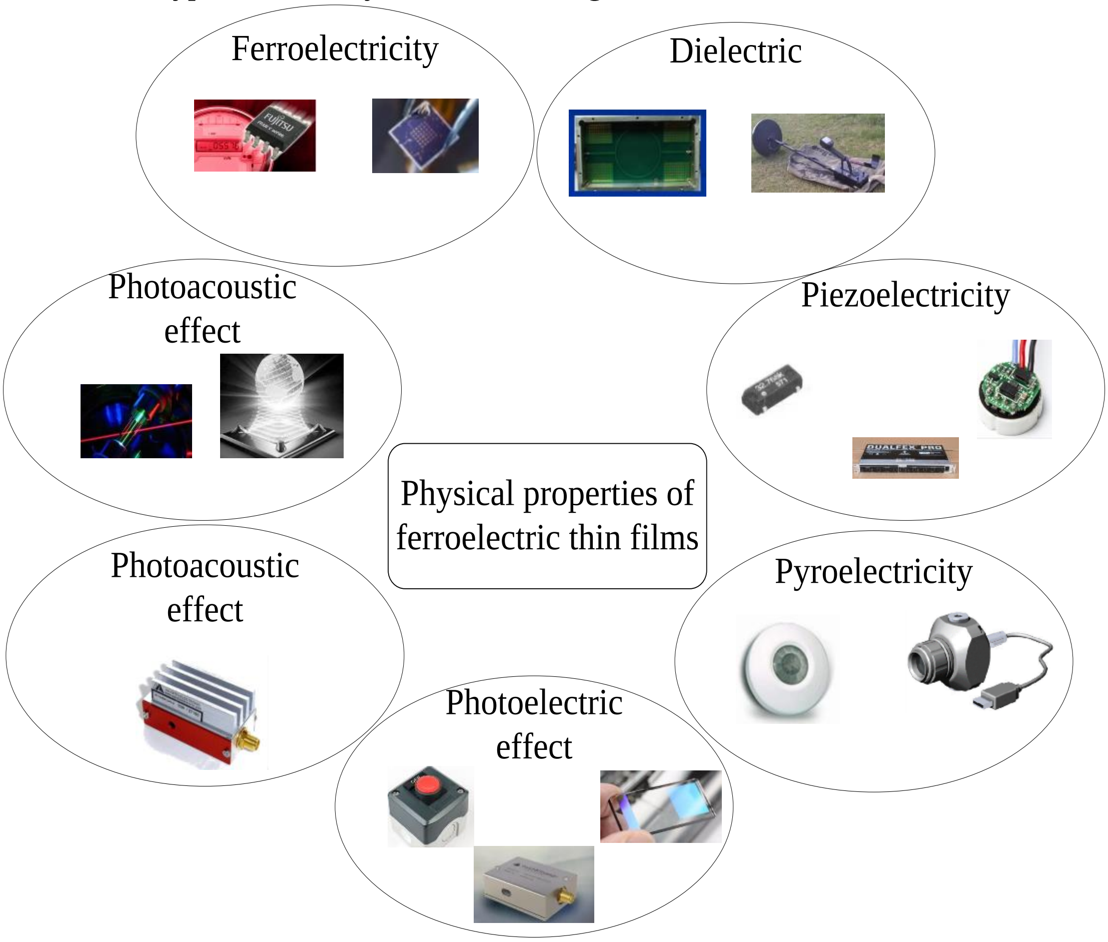


Figure 5. Physical properties and corresponding applications of ferroelectric thin films

Although compared with traditional inorganic ferroelectric materials, organic ferroelectric polymer materials have many advantages, and the development of high-density data storage based on organic ferroelectric thin films has also achieved rapid development. However, FeRAM utilizes ferroelectric films. Polarization reversal realizes the writing and reading of data, so the reading process of information is accompanied by a large number of delete/rewrite operations. As the number of polarization inversions increases, the polarization intensity of the ferroelectric thin film, which is a key information material, will gradually decrease, eventually leading to the failure of the entire ferroelectric memory cell. Therefore, in practical applications, organic ferroelectric thin films still face the challenge of failure caused by functional degradation, which will greatly affect the service life and reliability of devices prepared by using them. The most critical issues leading to the failure of ferroelectric films are fatigue [16] and imprinting [17].

(1) Fatigue

Polarization fatigue refers to the phenomenon in which the residual polarization strength of a ferroelectric material gradually decreases with the increase in the number of polarization reversals during the polarization reversal process, as shown in Figure 6. When the polarization intensity drops to a certain value, equipment failure will occur, which is an important factor limiting the practical commercial application of ferroelectric memory devices. A large number of research results show that the polarization fatigue of ferroelectric thin films is the result of many factors, such as electrode material, thin film thickness, voltage, frequency, external temperature, interface layer and so on. For example, the results of Furukawa [18] et al. showed that the polarization reversal time of the film not only depends on the magnitude of the applied voltage, but also on the type of metal electrode. With the further deepening of research, people gradually realized that only by clarifying the microscopic mechanism that causes the fatigue of ferroelectric thin films, and combining theoretical research with experiments can fundamentally solve the fatigue problem of ferroelectric thin films. For this reason, researchers have put forward some models based on relevant experimental results, trying to theoretically explain the fatigue phenomenon of ferroelectric thin films. At present, the main theories about the fatigue causes of ferroelectric thin films include: oxygen vacancy migration and domain pinning, trap charges injected by electrodes into the thin film, and interface effects between metal electrodes and ferroelectric thin films.

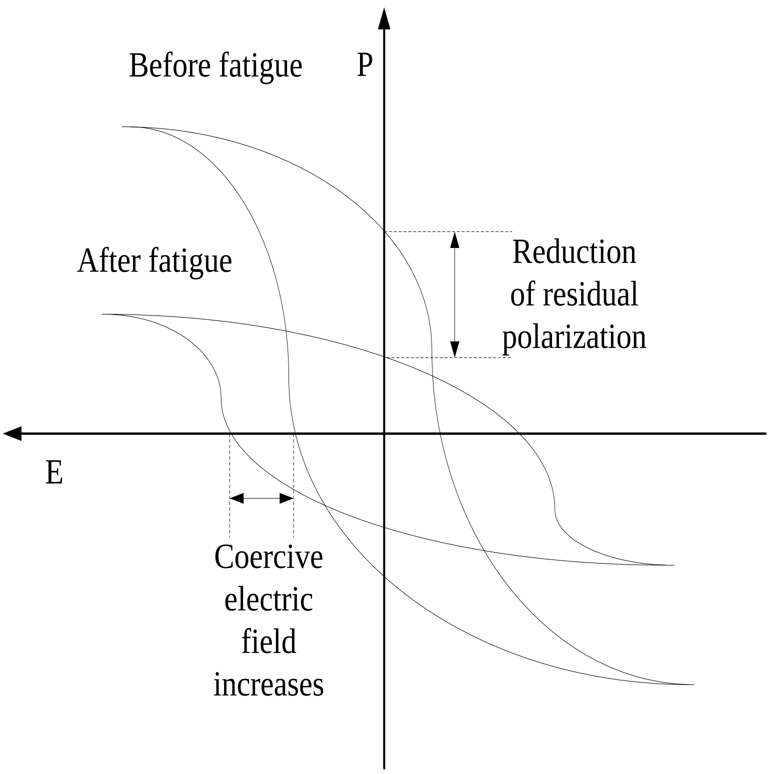


Figure 6. Schematic diagram of polarization fatigue

(2) Imprint

The so-called imprint refers to when the ferroelectric film is in a specific polarization state for a long time, as shown in Figure 7, when it becomes the opposite polarization state under the action of the applied reverse electric field, a higher Voltage. This may be because the charge injected from the electrode forms a built-in electric field between the electrode and the ferroelectric film, thereby preventing the ferroelectric dipole from rotating. The electromagnetic hysteresis loop shows the forced electric field shift and the increase in the reversal time with the decrease of the remanent polarization. Since the imprinting effect can lead to read and write errors of the ferroelectric memory, it is necessary to conduct an in-depth analysis of the causes of the imprinting effect. Lazareva [19] and others believe that the imprinting effect is caused by the shielding effect of the charge injected during the polarization reversal process. Warren [20] and others believe that the imprinting effect comes from the defect dipole in the film. Tang Minghua and others proposed a dual interface layer model to explain the experimental phenomenon, and believed that the imprinting effect was related to the conductivity of the interface layer.

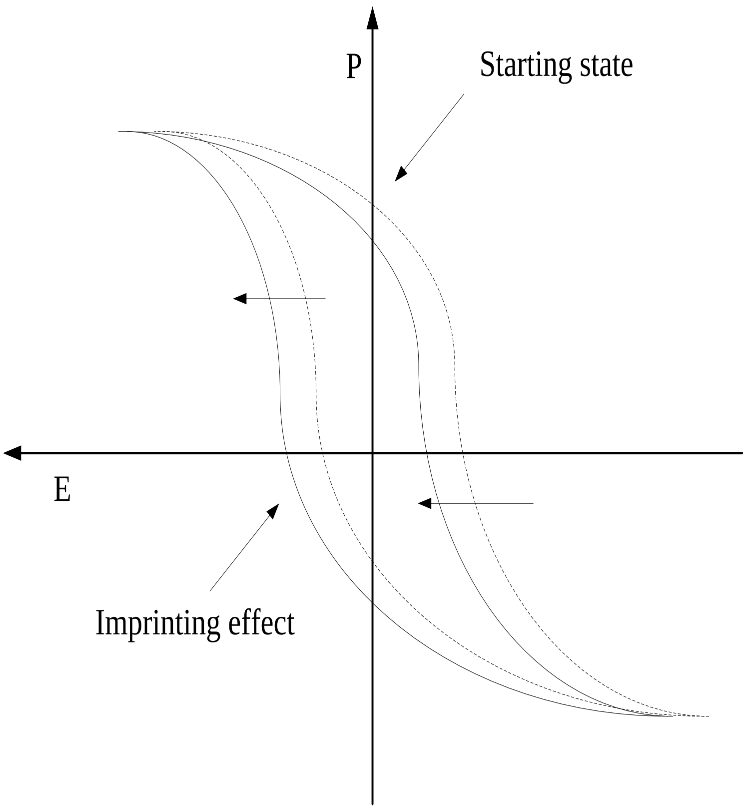


Figure 7. Schematic diagram of imprinting effect

It cannot be denied that high-performance ferroelectric materials are important functional materials with broad development prospects. However, from the current research status, compared with the research related to the properties of inorganic ferroelectric materials, the application and development of high-performance organic ferroelectric thin film materials and the research on the dynamic mechanism of polarization reversal are still in the development stage. It has not reached a satisfactory level, its mechanism is not yet clear, and we still need to continue research and investigation. Therefore, studying the fatigue and imprinting failure problems of organic ferroelectric thin films and seeking solutions are not only of important theoretical significance, but also key issues that must be resolved in the commercialization of organic ferroelectric thin films.

2.3. Transmission Electron Microscope

The microscope is an indispensable research tool for humans to understand the microscope world. According to the invention of the optical microscope (OM), the door to understand micron (10-6m) size objects was opened. However, due to the limitation of light wavelength, the resolution limit of the optical microscope does not exceed 10-7m, which will limit researchers in small within the scope, to clarify the relationship between the microstructure and material properties. Electron microscope (EM) is a tool developed in recent years. It uses nanometer (10-9m) or sub-angstrom (0.1μ, 10-11m) resolution to characterize the microstructure of materials. It can be used to analyze material interfaces, dislocations, vacancies, Defects such as atomic-scale structural configuration. Electron microscopes are mainly used to evaluate the static microstructure characteristics of materials. It is difficult to establish a direct relationship between the microstructure and the physical properties of the material during use. According to this, researchers can apply various physical signals or environmental atmosphere to samples, and observe samples in real time on SEM [21] or TEM [22]. At the same time, it records the evolutionary environment of the microstructure under various physical fields and various conditions, as well as the dynamic changes of various physical and chemical properties. Compared with static research, on-site dynamic research better simulates the actual state of material services, clarifies the corresponding physical mechanism, and provides a scientific basis for the development of new materials, the improvement of material properties, and the extension of their durability. Since the elasticity and plastic deformation of materials are the basic characteristics of materials, on these field research platforms, the development of field mechanical test methods and devices has received great attention. In addition, since most materials are used in high-temperature environments, the development of methods that can study the micro-mechanism of atomic-scale material deformation under high-temperature stress conditions is very important for material optimization and new development. The development of this method and the development of the platform must be based on a TEM with an atomic scale resolution, but due to the size limitation of the internal space of the TEM, the current commercial in situteM sample stage [23] can only provide a single stress field or temperature field. In such a narrow space, realizing the load of the stress field and temperature field without affecting the biaxial tilt function of the TEM sample rod [24], realizing the observation of the evolution of the material microstructure on the atomic scale, is an international bottleneck problem.

(1) EMCD technology

The term EMCD technology [25] comes from the XMCD technology in X-rays. The first difference between the two lies in the use of different detection sources. But there are many similarities in the basic principles, so you can compare and discuss. EMCD technology is based on electron energy loss spectroscopy. XMCD technology is based on X-ray absorption spectroscopy (XAS). EELS and XAS are basically similar in principle. Because the energy range studied by EMCD and XMCD technology corresponds to the ionization transition of inner shell electrons, that is, within the energy absorption or loss range of the previous microstructure (XXANES and ELNES), the following discussion is also limited to this range, the part of the low energy loss peak is not discussed here. The (second-differential) scattering cross section of XANES and ELES can be expressed as follows:

$$\sigma = \sum_{i,f} 4\pi^2 \omega \left| \langle f | \varepsilon \cdot R | i \rangle \right|^2 \delta\left(Q + Q_i - Q_f\right) \quad (1)$$

$$\frac{\partial^2 \sigma}{\partial Q \partial \Omega} = \sum_{i,f} \frac{4y^2}{\alpha_0^2 e^4} \frac{k_f}{k_i} \left| \left\langle f \middle| e \cdot R \middle| i \right\rangle \right|^2 \delta\left(Q + Q_i - Q_f\right) (2)$$

Among them, σ is the scattering cross section, Q is the energy loss, Q_i and Q_f are the electron energy before and after the transition, and <f| and |i> are the wave functions of the initial state and the final state. R is the position vector of the atom, σ is the polarization vector of the X-ray, and e is the momentum transfer after the electron interacts with the substance.

First, the theoretical framework between EMCD technology and diffraction dynamics effects is established. EMCD technology is based on electron energy loss spectroscopy. Under specific diffraction conditions, collect the EELS spectra at the positive and negative positions and perform subtraction to obtain the magnetic circular diversity signal. Therefore, the relationship between EMCD and diffraction kinetics can be established on the basis of EELS, and the second-order differential scattering cross section (DDSCS) describing signal intensity can be expressed as:

$$\frac{\partial^2 \sigma}{\partial \Omega \partial Q} = \frac{4y^2}{\alpha_0^2} \frac{x_f}{x_0} \sum_{sds'd'} \frac{1}{P_u} \sum_u \frac{G_u(e, e', Q)}{e^2 e'^2} q^{i(e-e') \cdot u} \times \sum_{jlj'l'} Y_{sds'd'}^{jlj'l'} T_{jlj'l'}(t) \, (3)$$

Among them, the terms related to the diffraction dynamics effect mainly include two parts, the Bloch wave coefficient and the thickness function, and the specific expression forms are:

$$Y_{sds'd'}^{jlj'l'} = A_0^{(j)^*} A_s^{(j)} B_0^{(l)} B_d^{(l)^*} \times A_0^{(j')} A_{s'}^{(j')^*} B_0^{(l')^*} B_{d'}^{(l')} (4)$$

$$T_{jlj'l'}(t) = q^{i\left[\left(y^{(j)} - y^{(j')}\right) + \left(y^{(l)} - y^{(l')}\right)\right]\frac{t}{2}} \frac{\sin \Delta \frac{t}{2}}{\Delta \frac{t}{2}} (5)$$

C and D are the Bloch wave coefficients obtained by solving the electron diffraction dispersion equation, and t is the thickness of the sample, without considering the absorption effect.

The detection source of EMCD technology is electrons, but electrons exist in the form of blocking waves in the periodic structure of the crystal, and the influence of diffraction dynamics becomes greater. The EMCD signal based on specific diffraction geometry will inevitably be affected by diffraction dynamics factors, such as the thickness of the sample, the incident conditions, and the emission conditions. Therefore, the EMCD signal is sensitive to these factors, and the distribution of the simulated EMCD signal also needs to accurately determine these parameters. It can also be seen that the diffraction dynamics effect makes EMCD technology more complicated than XMCD technology.

The mixed dynamics formation factor (MDFF) is expressed as:

Where |i>, |f> are the wave functions of the initial and final states before and after the electrons in the crystal are excited.

For the mixed kinetic factor, the expression form of left spiral light and right spiral light in XMCD can be rewritten as:

$$G(e, e', Q) = \sum_{i,f} < i \left| q^{ie' \cdot R} \right| f > < f \left| q^{ie' \cdot R} \right| i > \delta\left(Q_f - Q_i - Q\right) (6)$$

$$G(e, e', Q) = \frac{e_x e'_x + e_y e'_y}{2} \left[\mu_+(Q) + \mu_-(Q)\right] + e_z^2 \mu_0(Q) + i \frac{e_x e'_y + e_y e'_x}{2} \left[\mu_+(Q) + \mu_-(Q)\right] (7)$$

Among them, μ_+, μ_-, and μ_0 are equivalent to left-handed circular polarization, right-handed circular polarization, and linearly polarized light parallel to the wave vector in XMCD. The approximation commonly used in XAS is used here:

$$\mu_0 \approx \frac{1}{3}\left(\mu_+ + \mu_- + \mu_0\right) \quad (8)$$

Substituting equations (4), (5), (7) and (8) into equation (3), we get the expression of the intensity distribution of the EELS signal in the momentum space in the EMCD technology:

$$\begin{aligned}\left(\frac{\partial^2\sigma}{\partial Q\partial\Omega}\right)_{\pm} &= \sum_u \left[\mu_+(Q)+\mu_-(Q)+\mu_0(Q)\right]\cdot\frac{2}{3}\sum_{e,e'}\frac{e_x e'_x + e_y e'_y + e_z e'_z}{2e^2 e'^2} e^{i(e-e')\cdot u}\times Rq\left(A_{e,e'}\right)\\ &\pm\sum_u\left[\mu_+(Q)-\mu_-(Q)\right]_u\cdot\sum_{e,e'}\frac{e_x e'_y + e_y e'_x}{2e^2 e'^2} e^{i(e-e')\cdot u}\times \mathrm{Im}\left(A_{e,e'}\right)\end{aligned} \quad (9)$$

The terms related to the diffraction dynamics effect are expressed by $A_{q,q'}$ as:

$$A_{e,e'} = \sum_{sds'd'}\sum_{jlj'l'} Y_{sds'd'}^{jlj'l'} T_{jlj'l'}(t) \quad (10)$$

Among them, u represents the atomic coordinates of different positions of different kinds of elements, $\mu_+(Q)+\mu_-(Q)+\mu_0(Q)$ corresponds to the non-magnetic EELS signal, and $\mu_+(Q)-\mu_-(Q)$ corresponds to EMCD signal. Only the x and y components are included in the momentum transfer. This is because considering that in TEM, Experiments have proved that an external magnetic field of about 2 Tesla is sufficient to deflect the magnetization direction of the magnetic material to the direction of the electron beam.

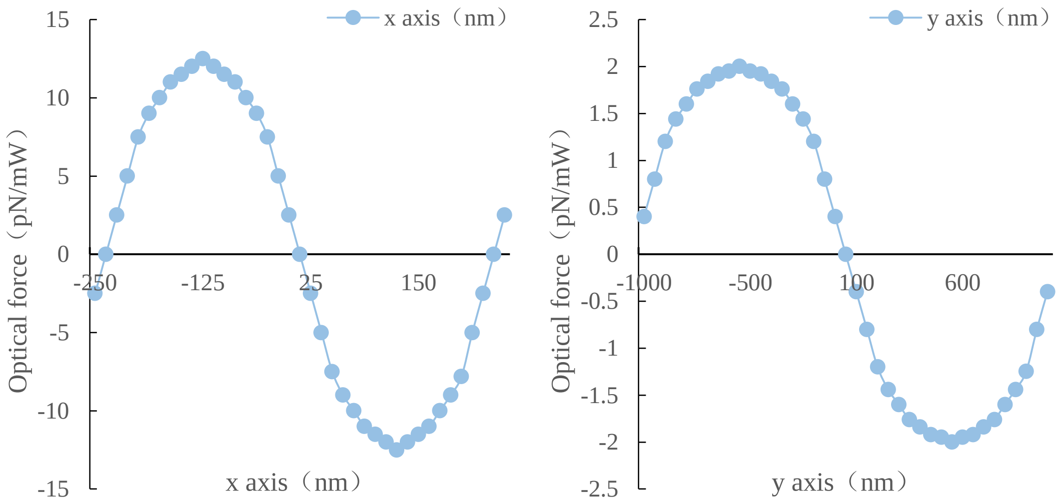
Finally, the sum rule was put forward to establish a quantitative relationship between EMCD signal and material magnetic parameters. LionelCalmels and JanRusz deduced the sum rule of EMCD technology (Equations 11, 12) based on the sum rule in XMCD technology, combined with the expression of the differential scattering cross section of EMCD signal, so that they can be directly obtained from the EMCD spectrum Quantitative magnetic parameter information. It is worth noting that due to the influence of the diffraction dynamics effect on the EMCD signal, this leads to the addition of the parameter K related to the diffraction dynamics effect in the sum rule, so only the orbital magnetic moment and the spin magnetic moment can be obtained. The extraction of atomic magnetic moment depends on the determination of kinetic coefficients, which is also the key to realizing the quantitative magnetic parameter measurement of EMCD technology.

$$\frac{\int_{L_3}(\sigma_2-\sigma_1)hQ - 2\int_{L_2}(\sigma_2-\sigma_1)hQ}{\int_{L_3+L_2}(\sigma_2+\sigma_1)hQ} = K\left(\frac{2}{3}\frac{<G_z>}{N_d}+\frac{7}{3}\frac{<T_z>}{N_d}\right) \quad (11)$$

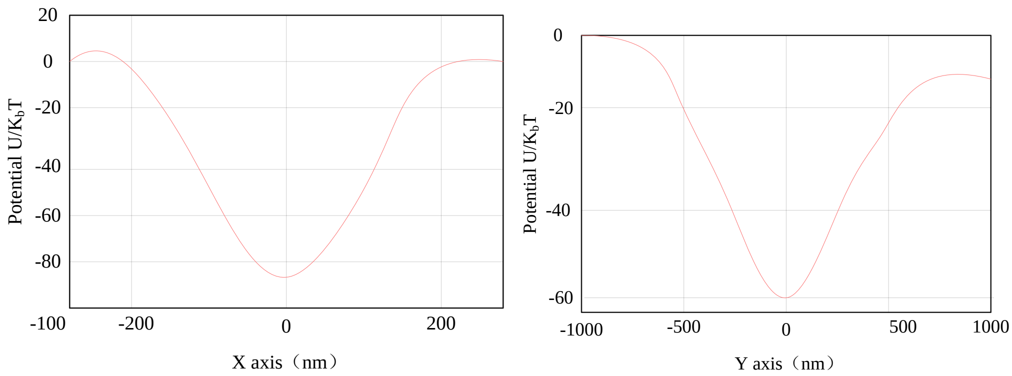
$$\frac{\int_{L_3+L_2}(\sigma_2-\sigma_1)hQ}{\int_{L_3+L_2}(\sigma_2+\sigma_1)hQ} = K\frac{1}{2}\frac{<L_z>}{N_d} \quad (12)$$

3. Transmission Electron Microscopy Experiments on Capturing and Manipulating Ferroelectric Domain Nanoparticles

The constructive interference between two SP focal fields propagating in opposite directions [26] will produce a series of diffraction-limited SP focal spots, which not only helps to enhance the optical gradient force, but also provides the possibility to manipulate multiple nanoparticles at the same time. In addition, the SP focal field propagating in opposite directions will cancel the axial scattering force due to interference, so the motion behavior of the nanoparticles is mainly determined by the gradient force. These advantages have been proved to be useful for capturing ferroelectric domain nanoparticles. Assuming that a ferroelectric domain particle with a radius of 100nm is near the center of the interference focal spot, and the power of the optical field is 200mW, Figure 8 shows the optical power and potential well distribution of the ferroelectric domain nanoparticles along the x-axis and y-axis.



(a) Force distribution along the x-axis *(b) Force distribution along the y-axis*

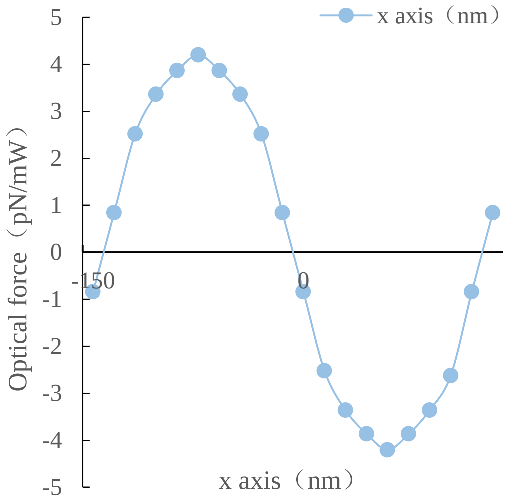


(c) Distribution of potential wells along the x-axis

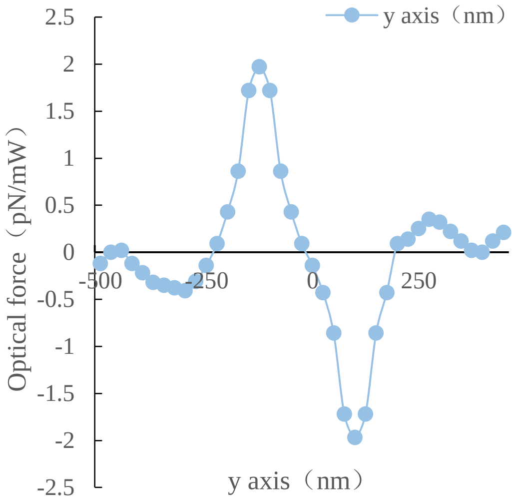
(d) Distribution of potential wells along the y-axis

Figure 8. Two beams of circularly polarized surface plasmon optical tweezers with a wavelength of 1064nm

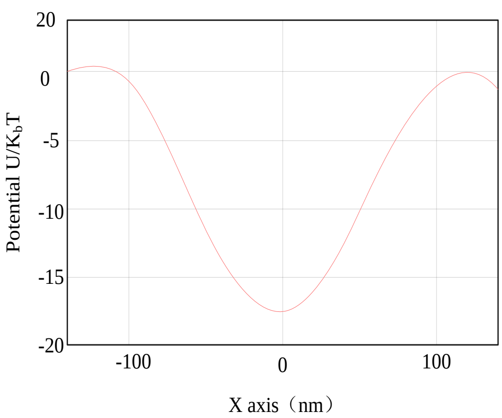
From the above analysis, it can be seen that surface plasmon optical tweezers can achieve stable capture of metal nanoparticles at near-infrared wavelengths. In order to confirm the versatility and versatility of surface plasmon optical tweezers, we will consider the most extreme case that is, capturing ferroelectric domain nanoparticles in a resonance state. For nano-scale ferroelectric domain particles, the surface plasmon resonance wavelength tends to 532nm. In order to prevent the incident wavelength from resonating with the metasurface itself and affecting its focusing characteristics, we should use silver as the material of the metasurface, and the design method is the same as the above-mentioned gold supersurface. It can be seen from Figure 9 that the motion behavior of the resonant ferroelectric domain nanoparticles is not affected by the axial scattering force. From the point of view of mechanical balance: the surface plasmon optical tweezers constructed based on the silver holographic metasurface can stably capture the resonant ferroelectric domain nanoparticles in three-dimensional space.

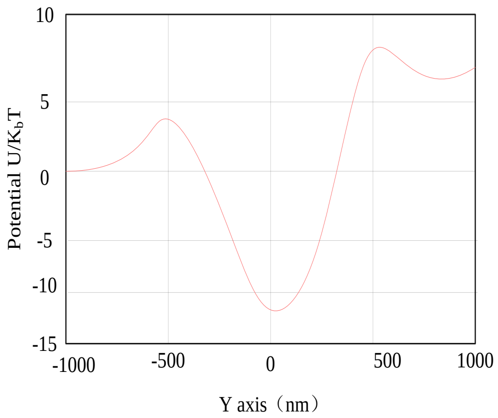


(a) Force distribution along the x-axis



(b) Force distribution along the y-axis





(c) Distribution of potential wells along the x-axis

(d) Distribution of potential wells along the y-axis

Figure 9. Circular polarization at 532nm wavelength based on surface plasmon optical tweezers based on silver holographic metasurface

The high-efficiency focusing of the optical tweezers system makes it possible to maintain a stable mechanical balance even at a relatively low incident light power, which helps to alleviate the photothermal effect that destroys the stability of the particles. By constructing a photo-thermal coupling model, we simulated and calculated that the surface temperature of the ferroelectric domain nanoparticles in the resonance trapping environment is only 318K, which is lower than the critical temperature of bubble formation (647K). Therefore, the surface plasmon optical tweezers on the silver holographic super-surface can avoid the optical thermal effect caused by capturing ferroelectric domain particles, and obtain stable mechanical capture in a three-dimensional space.

In summary, this paper proposes a new type of surface plasmon optical tweezers based on the surface of the holographic element, which can capture and manipulate various types of ferroelectric nanoparticles. The SP focal fields generated by two identical holographic metasurfaces propagate in opposite directions, and the constructive interference will cancel the axial scattering force, so as to realize the three-dimensional stable capture of the resonant ferroelectric domain nanoparticles. More importantly, the high-efficiency focusing of the holographic metasurface enables stable capture of particles at relatively low incident light power, which helps to reduce the photothermal effect that destroys the stable capture of particles. In addition, the nanoparticles can be precisely controlled by adjusting the phase difference of the two illuminating lights. This technology can be easily applied to other metal species and semiconductor nanoparticle capture, thus opening up new ways for optical manipulation and other related fields.

4. Nanomaterials and Ferroelectric Domain Polarization Improved Transmission Electron Microscopy Experiment Analysis of Martial Arts Performance Shooting

Through nanomaterials and ferroelectric domain polarization, transmission electron microscopy has been improved in many ways. Based on the multi-molecular structure of nanomaterials, the material of transmission electron microscopy has been strengthened, and the deneness of ferroelectric domain films has made transmission electron microscopy The material is more resistant to beating. When shooting martial arts performances, there are many images that need to be represented by the vibration effect of the lens, which tests the material of the camera. If the material is too soft, it will cause damage to the equipment. If the material is too strong, it will easily affect the shooting effect. Therefore, this experiment conducted an anti-fall test on the improved fluoroscopy electron microscope, and compared and analyzed the damage degree of the fluoroscopy electron microscope by falling from different heights, as shown in Table 2. There is no modified fluoroscopy experiment result.

Table 2. Damage degree of the unimproved fluoroscopy electron microscope falling from different heights

high	External damage	Internal damage	Comprehensive damage	Impact on shooting
0.5m	0.0001	0.00005	0.00015	0.5%
1m	0.037	0.0024	0.0394	1.39%
3m	0.089	0.0074	0.0964	3.21%
5m	0.124	0.0311	0.1551	7.11%
10m	0.334	0.0694	0.4028	10.09%

It can be seen from the experiment that in the process of rising height, the damage of the fluoroscopy electron microscope has also increased. Falling at 10m will cause the fluoroscopy electron microscope to be damaged by 0.4028, and it will also affect 10.09% of the shooting effect, but the improved perspective the electron microscope is shown in Table 3.

Table 3. Damage degree of the modified fluoroscopy electron microscope from different heights

high	External damage	Internal damage	Comprehensive damage	Impact on shooting
0.5m	0.000005	0.0000001	0.0000051	0.0032%
1m	0.000007	0.00000013	0.00000713	0.0045%
3m	0.000018	0.00000027	0.00001827	0.0084%
5m	0.000039	0.00000044	0.00003944	0.0132%
10m	0.000071	0.00000075	0.00007175	0.0208%

It can be seen from the table that the damage degree of the transmission electron microscope after being strengthened by nanomaterials and ferroelectric domain polarization film from different heights is much lower than that of the unmodified one. The comprehensive damage at 10m is only 0.007175, which is relatively low. Compared with the unimproved 0.4028, it has a qualitative leap, and the impact on the shooting effect is only 0.208%, which is basically negligible.

However, the enhanced fluoroscopy electron microscope is more expensive to manufacture, and its density is relatively large due to it’s too rigidity. The improved fluoroscopy electron microscope will be 1~1.5 times heavier than the ordinary fluoroscopy electron microscope.

5. Conclusion

This article mainly studies the influence of nanomaterials and ferroelectric domain polarization on the fluoroscopy electron microscope in the shooting of martial arts performances. By understanding the characteristics of nanomaterials and ferroelectric materials, and then using EMCD technology to explore the capture and manipulation of ferroelectric domains by transmission electron microscopy the ability of nanoparticles is ultimately based on the multi-molecular structure of nanomaterials and the compactness of ferroelectric domain films to strengthen the anti-beating ability of the fluoroscope. Experiments show that the improved fluoroscopy electron microscope has great changes in the drop experiment at different heights. The improved fluoroscopy electron microscope has a comprehensive damage degree of only 0.00007175 when dropped at 10m, and the impact on the shooting of martial arts performances is only 0.0208%, which is almost acceptable. Ignorable, but due to the strengthening of nanomaterials and ferroelectric domain films, the density of the see-through electron microscope is higher than that of ordinary ones, and it is 1~1.5 times heavier.

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Data Availability

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

Conflict of Interest

The author states that this article has no conflict of interest.

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