**DOI: 10.23977/mpcr.2024.040106**
**ISSN 2616-1702 Vol. 4 Num. 1**

# *Response of an anisotropic conductive film to shear forces and temperature stress in a miniature package*

**Junwei He, Hui Li*, Chunyu Wu, Yitao Liu**

*Faculty of Engineering, Huanghe Science and Technology University, Zhengzhou, 450063, China*
**Corresponding author: 200609181@hhstu.edu.cn*

***Keywords:*** Microencapsulation, anisotropic conductive adhesive film, shear force, temperature stress, performance changes

***Abstract:*** This study investigates the response of anisotropic conductive adhesive films in microencapsulation to shear force and temperature stress. Through experiments and analysis, the changes in the performance of conductive adhesive films during microencapsulation processes are revealed. The research results indicate that conductive adhesive films are sensitive to both shear force and temperature stress, highlighting their significance for the optimization and improvement of microencapsulation processes.

## 1. Introduction

Microencapsulation technology plays a crucial role in modern electronic devices, and anisotropic conductive adhesive films, as an important packaging material, play a vital role in this process. However, during microencapsulation processes, the performance changes of conductive adhesive films have an impact on the reliability and stability of devices. This paper aims to delve into the response mechanism of anisotropic conductive adhesive films to shear force and temperature stress, providing a scientific basis for optimizing microencapsulation processes.

## 2. Shear Force Response of Conductive Adhesive Films

### 2.1. Impact of Shear Force on the Performance of Conductive Adhesive Films

Conductive adhesive films are significantly influenced by shear force during microencapsulation, leading to profound changes in their performance. Under the action of shear force, the conductivity, mechanical strength, and overall stability of conductive adhesive films undergo significant alterations.

One of the primary impacts of shear force is the rearrangement of the internal molecular structure of conductive adhesive films. This rearrangement may result in the disruption and recombination of electron transfer channels, directly affecting the stability of conductivity. Changes in the molecular structure may also trigger adjustments to the microstructure of the conductive adhesive film surface, influencing its response to the external environment.

In our experimental process, we systematically tested the performance of conductive adhesive films under different shear force conditions. The results indicate that with increasing shear force, the conductivity of the adhesive film shows a decreasing trend, while the mechanical strength improves.

This phenomenon is explained by the structural changes induced by shear force within the conductive adhesive film, leading to the disruption and recombination of electron transfer channels.

In summary, the impact of shear force on the performance of conductive adhesive films is complex and significant. Understanding this influence helps better control the performance of conductive adhesive films during microencapsulation, providing crucial theoretical support for the stable operation of electronic devices.

## 2.2. Experimental Methods and Results Analysis

To comprehensively understand the impact of shear force on the performance of conductive adhesive films, we employed a series of systematic experimental methods and conducted detailed result analysis. This helped reveal the mechanism of performance changes in conductive adhesive films under the influence of shear force.

We initially applied different intensities of shear force to conductive adhesive films using advanced mechanical testing instruments. By adjusting experimental conditions, we were able to simulate various shear force scenarios during microencapsulation. Subsequently, we recorded changes in the conductivity and mechanical characteristics of conductive adhesive films under the influence of shear force.[1-2]

During the experimental process, high-resolution instruments such as electron microscopes were used to observe the surface and internal microstructures of conductive adhesive films in detail. This aided in gaining insights into the structural changes induced by shear force in conductive adhesive films and explaining their impact on performance.

The experimental results showed significant differences in the performance of conductive adhesive films under various shear force conditions. Further result analysis revealed the fracture and rearrangement of the internal microstructure of conductive adhesive films caused by shear force. This structural change directly affected the formation and transmission of conductive channels, explaining the observed decrease in conductivity and increase in mechanical strength.

Through experimental methods and result analysis, we gained an in-depth understanding of the mechanism of shear force on the performance of conductive adhesive films. This provides an experimental foundation and theoretical support for optimizing the performance of conductive adhesive films in microencapsulation processes. [3]

## 2.3. Discussion on the Shear Force Response Mechanism

When subjected to shear force, the response mechanism of conductive adhesive films involves various complex physical and chemical processes. This discussion aims to deepen our understanding of the performance changes in conductive adhesive films caused by shear force and reveal the underlying mechanisms.

Firstly, shear force may lead to the fracture and recombination of molecular chains within conductive adhesive films. Under the influence of shear force, the interactions between molecular chains are disturbed, potentially causing the rupture of certain chain segments and the recombination of others. This change in molecular chain results in the ordered rearrangement of the internal structure of conductive adhesive films, affecting their conductivity stability.

Secondly, shear force may also induce changes in the microstructure of the conductive adhesive film surface. This includes alterations in surface morphology and the possible emergence of microdefects. The microstructure of the conductive adhesive film surface has a significant impact on its interaction with the surrounding environment, especially in microencapsulation. Surface changes induced by shear force may affect the adaptability of the conductive adhesive film, making it more stable in complex working environments.

In this discussion, we conducted an in-depth study of the physical and chemical changes induced by shear force in conductive adhesive films and analyzed the impact of these changes on conductivity. This helps reveal the details of the shear force response mechanism, providing a scientific basis for the optimization of microencapsulation processes. A profound understanding of the behavior of conductive adhesive films under the action of shear force is of great significance for controlling their performance and improving the efficiency of microencapsulation processes.

## 3. Temperature Stress Response of Conductive Adhesive Films

### 3.1. Performance Changes Induced by Temperature Stress

Temperature stress is a crucial factor causing performance changes in conductive adhesive films during microencapsulation. With increasing temperature, conductive adhesive films undergo complex performance changes, involving both conductivity and mechanical properties. [4]

Firstly, under elevated temperatures, the internal molecular motion of conductive adhesive films intensifies. This intensification may lead to a weakening of interactions between molecules, thereby increasing the activity of conductive channels. At higher temperatures, molecules are more likely to be in a higher energy state, facilitating electron transfer. Therefore, conductive adhesive films under temperature stress may exhibit an enhancement in conductivity.

Secondly, temperature variations may also cause fluctuations in the overall mechanical properties of conductive adhesive films. High temperatures can lead to the expansion of the internal molecular structure of conductive adhesive films, affecting their mechanical strength. Experimental results show that, although conductivity benefits from temperature stress, there is some loss in mechanical strength. This may be due to uneven expansion of the internal structure of conductive adhesive films induced by temperature stress, resulting in localized strength reduction.

#### 3.1.1. Impact of Temperature Rise on Conductive Channels

In experiments, we conducted detailed tests on the conductivity of conductive adhesive films under different temperature conditions. The results indicate that with an increase in temperature, conductivity shows a gradually strengthening trend. This could be related to the higher energy state of molecules at high temperatures, encouraging more active conductive channels and thus enhancing conductivity.

#### 3.1.2. Influence of Temperature Stress on Mechanical Properties

Simultaneously, we also focused on the impact of temperature stress on the mechanical properties of conductive adhesive films. Experimental results revealed that the expansion of the internal structure of conductive adhesive films caused by high temperatures negatively affected mechanical performance. The degradation in mechanical performance might be due to uneven expansion induced by temperature stress, making conductive adhesive films more prone to deformation under mechanical stress. [5]

In summary, the influence of temperature stress on the performance of conductive adhesive films involves an increase in the activity of conductive channels and a loss in mechanical properties. This provides a profound understanding for optimizing the performance of conductive adhesive films in microencapsulation processes and emphasizes the challenges in maintaining mechanical stability at high temperatures. [6]

### 3.2. Experimental Design and Results Analysis

To comprehensively understand the impact of temperature stress on the performance of conductive adhesive films, we designed a series of targeted experiments and, through in-depth result analysis, revealed the internal changes induced by temperature stress. In the experimental design, we used advanced temperature control devices to precisely regulate the temperature stress experienced by conductive adhesive films. By controlling temperature conditions during the encapsulation process, we simulated different temperature stress scenarios to systematically study the performance changes of conductive adhesive films.

#### 3.2.1. Experimental Steps

Firstly, we selected a series of representative temperature conditions covering the temperature range that conductive adhesive films might encounter during microencapsulation. By conducting encapsulation experiments under these conditions, we obtained performance data of conductive adhesive films under different temperature stress conditions. Secondly, we utilized high-precision temperature measurement instruments to monitor the temperature environment in which conductive adhesive films were placed. This helped ensure the accuracy and controllability of experimental conditions.

#### 3.2.2. Results Analysis

Experimental results showed a significant enhancement in the conductivity of conductive adhesive films with increasing temperature. The explanation for this phenomenon lies in temperature stress prompting the rearrangement of the internal molecular structure of conductive adhesive films, facilitating the formation and transmission of conductive channels. At high temperatures, molecules become more active, leading to the more effective formation of electron transfer channels.

However, accompanying the improvement in conductivity is a decrease in mechanical performance. Through in-depth analysis of experimental data, we found that temperature stress induced changes in the internal structure of conductive adhesive films, including weakened interactions between molecules and lattice structure diffusion. This may lead to a loss in mechanical performance, making conductive adhesive films more susceptible to deformation under mechanical stress.

#### 3.2.3. Significance and Challenges of the Results

This experimental design and results analysis provide strong support for understanding the impact of temperature stress on the performance of conductive adhesive films. The enhancement in conductivity offers new optimization strategies for microencapsulation processes, but simultaneously, the decrease in mechanical performance suggests challenges that may be faced in practical applications. In the design of microencapsulation, it is necessary to comprehensively consider the performance of conductive adhesive films under different temperature conditions to ensure the overall reliability of devices. This research outcome is expected to provide practical guidance for temperature management in microencapsulation processes.

### 3.3. In-Depth Study of the Temperature Stress Response Mechanism

An in-depth study of the impact mechanism of temperature stress on the performance of conductive adhesive films aims to achieve a more comprehensive and profound understanding of the behavior of conductive adhesive films under different temperature conditions. This research aims to reveal how temperature stress fundamentally regulates the performance of conductive adhesive films by influencing aspects such as molecular structure, crystal morphology, and charge transfer characteristics.

### 3.3.1. Changes in Molecular Structure

Firstly, we focus on the influence of temperature stress on the molecular structure of conductive adhesive films. With the increase in temperature, the higher internal energy of molecules may cause changes in interactions between molecules. This may include the stretching, twisting, and breaking and recombination of molecular chains. Through high-resolution analysis techniques, we can observe microstructural changes in the molecular structure of conductive adhesive films, helping understand the impact of temperature stress on conductivity.

### 3.3.2. Adjustment of Crystal Morphology

Secondly, we study the adjustment of crystal morphology in conductive adhesive films induced by temperature stress. Temperature variations may lead to the diffusion or contraction of the crystal structure of conductive adhesive films. This adjustment in crystal morphology may affect the electron transmission paths within conductive adhesive films. Through experiments and simulations, we delve into the regularities of changes in the crystal structure of conductive adhesive films induced by temperature stress, providing strong support for understanding the temperature dependence of their conductivity.

### 3.3.3. Formation Mechanism of Conductive Channels

Finally, we focus on the influence of temperature stress on the formation mechanism of conductive channels. At high temperatures, the high-energy state of molecules may make conductive channels more active, thereby enhancing conductivity. We explore the dynamics of conductive channel formation and how temperature stress plays a regulatory role in this process.

By delving into these three aspects, we are able to more comprehensively understand the fundamental impact of temperature stress on the performance of conductive adhesive films. This contributes to providing theoretical support for the temperature control of microencapsulation processes and offers new insights for designing conductive adhesive films with superior performance. This research provides a profound scientific basis for the temperature stress management of conductive adhesive films in electronic devices.

## 4. Comprehensive Analysis of Conductive Adhesive Film Performance

### 4.1. Synergistic Effects of Shear Force and Temperature Stress

Conductive adhesive films in microencapsulation are simultaneously influenced by shear force and temperature stress, and there exists a complex synergistic interaction between them, making the impact on the performance of conductive adhesive films more comprehensive and profound.

### 4.1.1. Mutual Enhancement of Shear Force and Temperature Stress

Firstly, shear force and temperature stress may mutually enhance each other, leading to greater changes in the internal structure of conductive adhesive films. Under the action of shear force, molecular structures may undergo rearrangement, and the molecular motion induced by temperature stress may intensify this rearrangement trend. This mutual enhancement effect may result in more complex changes in the internal structure of conductive adhesive films.

### 4.1.2. Formation of Complex Conductive Channels

Under conditions of mutual enhancement of shear force and temperature stress, we observe the formation of more complex conductive channels. The complexity of conductive channels may stem from the diversity of molecular structures and interactions. This makes the electron transmission paths within conductive adhesive films richer, while also increasing the uncertainty of conductive channel formation.

### 4.1.3. Nonlinear Performance Changes

Through experiments, we found that the synergistic effects of shear force and temperature stress may lead to nonlinear changes in the performance of conductive adhesive films. Under certain conditions, the changes in conductivity and mechanical performance are not a simple additive relationship but exhibit a more complex mutual influence. This emphasizes the challenges in the comprehensive control of shear force and temperature stress in microencapsulation processes.

### 4.1.4. Experimental Results and Optimization Needs

Experimental results indicate that the synergistic effects of shear force and temperature stress require more careful control and optimization of microencapsulation processes. In practical applications, it is necessary to precisely adjust the intensity and direction of shear force and temperature stress based on the specific material and process conditions of conductive adhesive films to achieve optimal performance.

In summary, the synergistic effects of shear force and temperature stress make the performance changes of conductive adhesive films more complex. A deep understanding of this synergistic effect is crucial for optimizing microencapsulation processes and improving the performance of conductive adhesive films. This research provides practical guidance for the microencapsulation field, contributing to the realization of more stable and reliable electronic devices.

## 4.2. Optimization of Conductive Adhesive Film Performance in Microencapsulation Processes

To achieve optimal performance of conductive adhesive films in microencapsulation processes, we propose a series of effective optimization strategies involving adjustments to process parameters and improvements in material properties.

### 4.2.1. Precise Control of Shear Force and Temperature Stress

Firstly, we recommend the precise control of the magnitude and direction of shear force and temperature stress during the encapsulation process. By accurately controlling these two key factors, the internal structure of conductive adhesive films can be adjusted to optimize their conductivity and mechanical strength. This requires advanced encapsulation equipment and real-time monitoring systems to ensure the accurate control of process parameters.

### 4.2.2. Introduction of Reinforcements or Modifiers

Secondly, the resistance of conductive adhesive films to shear force and temperature stress can be improved by introducing new reinforcements or modifiers into the conductive adhesive film material. The introduction of reinforcements can strengthen the molecular structure of conductive adhesive films, enhancing their mechanical performance. The use of modifiers can adjust the thermal stability of conductive adhesive films, reducing their sensitivity to temperature stress.

#### 4.2.3. Experimental Verification and Performance Enhancement

In experiments, we verified the effectiveness of these optimization strategies. By implementing precise control of shear force and temperature stress in microencapsulation processes and introducing reinforcements and modifiers, we successfully improved the conductivity and mechanical strength of conductive adhesive films. Experimental results demonstrate the practicality of these optimization strategies and provide new insights for microencapsulation processes.

#### 4.2.4. Flexibility in Adjusting Process Parameters

It is noteworthy that these optimization strategies not only enhance the performance of conductive adhesive films but also increase the flexibility in adjusting process parameters in microencapsulation. By flexibly adjusting the magnitude and direction of shear force and temperature stress and selecting suitable reinforcements and modifiers, the performance of conductive adhesive films can be finely tuned according to the requirements of different application scenarios, enabling a wider range of applications. In conclusion, through precise control of process parameters and material composition, the optimization of conductive adhesive film performance in microencapsulation processes is feasible. These optimization strategies provide valuable experience and guidance for the further development of microencapsulation technology.

### 4.3. Considerations in Practical Applications

In practical applications, the performance of conductive adhesive films is influenced by various factors. In addition to optimizing microencapsulation processes, we must consider the long-term stability and reliability of conductive adhesive films under specific environmental conditions to ensure good performance in various real-world scenarios.

#### 4.3.1. Performance within the Operating Temperature Range

Firstly, focusing on the performance of conductive adhesive films within the operating temperature range is crucial. In experiments, we simulated the performance of conductive adhesive films under different operating temperature conditions, including conductivity, mechanical strength, and other indicators. This helps determine the stability of conductive adhesive films at specific operating temperatures, providing a reliable foundation for practical applications.

#### 4.3.2. Tolerance to External Environmental Factors

Secondly, we studied the tolerance of conductive adhesive films to external environmental factors, including humidity and chemical substances. By testing conductive adhesive films under conditions simulating real working environments, we can evaluate their stability in humid or corrosive environments. This is crucial for selecting suitable conductive adhesive films in application scenarios with humidity or corrosive substances.

#### 4.3.3. Comprehensive Consideration of Performance in Complex Environments

Experimental results indicate that conductive adhesive films may face more complex and diverse environmental influences in practical applications. Therefore, when designing electronic devices, it is necessary to comprehensively consider various performances of conductive adhesive films to ensure their reliable operation in different application scenarios. We note that there may be mutual influences between different environmental factors, such as the synergistic effect of humidity and temperature. This emphasizes the importance of comprehensive consideration of conductive adhesive film performance in practical applications.

### 4.3.4. Practical Significance in Real-World Applications

This comprehensive consideration of various factors affecting conductive adhesive films in practical applications provides practical significance for the design and selection of electronic devices. Faced with diverse application scenarios, we need to balance various factors such as conductivity, mechanical strength, and environmental tolerance of conductive adhesive films to ensure the long-term reliability and stability of electronic devices.

In conclusion, considerations in practical applications extend beyond the performance of conductive adhesive films themselves and require a comprehensive evaluation of various external environmental factors to ensure the stable operation of electronic devices under different conditions. This provides a more comprehensive reference for the design and application of electronic devices.

## 5. Conclusion

This study systematically investigated the response of anisotropic conductive films to shear forces and temperature stresses. The experiments proved that the conductive film showed significant sensitivity during microencapsulation. The deep understanding of the influence mechanism of shear force and temperature stress provides a useful guidance for the improvement of the micro-packaging process. This research is expected to provide new ideas and directions for further development and innovation in the field of electronic device packaging.

## Acknowledgement

National Project of Innovation and Entrepreneurship Training Program for College Students in Henan Province (202311834050).

## References

*[1] Yan Ping, Cai Daomin, Li Minglei. Broadband, high-linear and micro-package amplifier study based on E-PHEMT technology [J]. China's new technologies and new products. 2016(16):1-3.*

*[2] Yu Shuping. Study on temperature stress during the construction process of large diameter ultra-deep circular shaft lining [J]. hydraulic electrogenerating. 2023(12):7.*

*[3] Deng Baiwang. Simulation and analysis of temperature stress of concrete structure under three-dimensional constraints [J]. Water conservancy and hydropower express report. 2023,44(S2):66-70.*

*[4] Zhou Ying. Advances in the study of an anisotropic conductive adhesive [J]. Guangdong Chemical Industry. 2021, 48(13):105+110.*

*[5] Li Minglei. Non-destructive test fixture development for RF BGA housing [J]. Scientific and technological innovation and application. 2022,12(15):120-122+126.*

*[6] Yang Yu. Review of the patented techniques of anisotropic conductive adhesive films [J]. Scientific and technological innovation. 2018(25):20-21.*