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Editorial

Functional Nanomaterial-Based Flexible Electronics

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With the rapid development of society, the growing interest in flexible electronics has led to remarkable progress in recent advances in the manufacture of flexible electronics. It is worth noting that flexible electronic products have a very broad application field, covering not only traditional electronic device, but also ecological/bioelectronic devices. such as flexible energy storages, flexible displays, wearable electronics, flexible solar cells, and healthcare monitoring devices [1–3].

In recent years, nanoscale fabrication using functional nanomaterials has been an effective strategy used to enhance the electrical and mechanical performance of flexible electronics. Specifically, functional materials suitable for flexible electronic devices not only need to have basic functions such as signal sensing, energy generation, and energy storage but also need to have outstanding mechanical stability to meet the needs of practical applications [4]. Through the study of existing natural structures, a functional and innovative structure design was carried out to promote development in the field of intelligence [5]. For example, it is well known that high adhesion and water resistance are important indicators for the development of high-performance wearable and skin-attachable electronics. By learning from octopus suckers, other researchers innovatively designed an artificial patch with an octopus-like pattern. Their results showed that the structure has high adhesion ability under both wet and dry conditions on various surfaces [6]. This functionalized structural design can facilitate the development of wearable and skin-attached sensors.

As a power source, energy storage is an indispensable and important component in flexible electronics [7]. In order to meet the practical application requirements of flexible electronic devices, energy storage devices as their important components need to possess flexibility, compressibility, and stretchability [8]. Inspired by the self-healing properties of human skin, this functional design with self-healing can improve the self-healing ability of flexible devices when damaged, thereby increasing their service life. For example, Huang's group successfully prepared a new type of polyelectrolyte through the design of double-crosslinked hydrogels, which can realize self-healing function [9]. The electrolytes were assembled into energy storage devices and tested for performance. The results exhibited that the repaired samples still show outstanding mechanical properties compared to the original samples.

In many flexible electronic devices, a environmental sensing capability can be used to monitor atmospheric conditions as a common function. It is mainly derived from ubiquitous natural signals [10,11], such as humidity, light, pH, etc. It is worth noting that functional integration with various powerful functions, including energy storage, self-powering, mechanical deformation, sensing, etc., is quite necessary for the development of high-performance flexible electronics. Inspired by the natural phenomenon of triboelectric electrification, triboelectric nanogenerators can not only realize the multifunctional integration of flexible electronic systems but also complete independent operation, such as the integrated design of self-powered and multifunctional multimodal sensor systems [12].

With the continuous development of intelligent electronic products, it has brought great changes to human life style. However, it has also contributed to the growing problem of e-waste and environmental pollution. In order to solve the above problems, some

Citation: Mo, R. Functional Nanomaterial-Based Flexible Electronics. *Coatings* **2022**, *12*, 809. https://doi.org/10.3390/coatings12060809

Received: 30 May 2022
Accepted: 8 June 2022
Published: 10 June 2022

researchers have stimulated great research interest in biodegradable and biocompatible electronic products in recent years [13]. In addition to environmental pollution issues, biodegradable electronic devices can significantly reduce the risk of secondary surgical infection for device removal in clinical applications, mainly due to the fact that the device can be absorbed or dissolved by the body. It is necessary for flexible electronic devices to carry out material design and functional integration from the perspective of nature, beyond nature, and towards nature in the emerging intelligent field, which will promote the development of next-generation flexible electronic products.

The development of materials science has promoted research high-performance flexible electronic devices. To build high-performance flexible electronic devices, carbon based nanomaterials can be used as next-generation electronic materials due to their excellent properties, including high carrier mobility, excellent mechanical flexibility, high current-carrying capacity, and low-cost production. In recent years, carbon nanotubes and graphene, as typical carbon-based nanomaterials, have been widely used in the field of bioelectronics due to their unique optical and electrical properties, and excellent mechanical properties [14,15]. Carbon nanotubes and graphene, as representatives of one-dimensional and two-dimensional carbon-based nanomaterials, not only have similar physical structures but also, more importantly, have excellent mechanical properties [16]. Such excellent properties are conducive to the construction of high-performance flexible and stretchable bioelectronics.

In addition, carbon-based nanomaterials are characterized by high stability and low biofouling and high reproducibility of direct growth, so this material can be used in bioelectronics [17,18]. It is worth noting that the ultrathin shape of carbon-based nanomaterials can eliminate the mechanical mismatch between organs or tissues and electronic devices, which can facilitate the development of bioelectronics [19,20]. Among them, skin-like electronics, as a type of flexible electronics, have attracted extensive research interest due to their wide range of applications, such as medical implantation, health monitoring, and sensor integration. A variety of new carbon-based functional nanomaterials have been applied in skin-like electronic products.

Overall, this Special Issue aims to provide a forum for researchers to share latest research results and to promote further research into flexible electronic devices.

Funding: This work was supported by Shanghai Pujiang Program (A type) (grant no. 20PJ1402500), Natural Science Foundation of Shanghai (grant no. 22ZR1416600) and the Fundamental Research Funds for the Central Universities.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data are available from the corresponding author upon request.

Conflicts of Interest: The author declares no conflict of interest.

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