ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Transforming Electric Vehicle Energy Harvesting: A Comprehensive Review of Composite Materials

Sanjay Yadav, KLEF VADDESWARAM GUNTUR 522302

Abstract

The field of energy harvesting is experiencing rapid expansion, driven by the ambition to power various devices, including electric vehicles, through harnessing energy from their surrounding environments. Among the various materials considered for these applications, composite materials have emerged as highly promising candidates. They possess unique combinations of mechanical and electrical properties, making them particularly well-suited for energy harvesting purposes. However, to fully unlock the potential of composite materials in powering electric vehicles, further research and development are essential. This review article critically examines the utilization of composite materials for energy harvesting in the context of electric vehicles. It thoroughly analyzes key aspects such as mechanical characteristics, electrical conductivity, thermal stability, and cost-effectiveness.

1. Introduction

The utilization of composite materials for energy harvesting in electric vehicles is witnessing a notable rise [1]. Energy harvesting involves the conversion of ambient energy into electric power, reducing the reliance on the vehicle's battery and enhancing overall energy efficiency [2]. Composite materials possess distinctive mechanical and electrical characteristics that make them well-suited for energy conversion, leading to an increased adoption in energy harvesting systems. This comprehensive review article aims to present a thorough survey of composite materials for energy harvesting in electric vehicles. The article will commence with an overview of composite materials used for energy harvesting in electric vehicles, encompassing the various types of composites utilized, a summary of existing research, and a state-of-the-art review[3]. It will further delve into the characteristics of composite materials relevant to energy harvesting, including mechanical properties, electrical conductivity, thermal stability, and cost-effectiveness. The review will explore the diverse applications of composite materials in energy harvesting systems, covering piezoelectric, electromagnetic, and thermoelectric energy harvesting technologies.

2. Background and State of the Art

2.1. Overview of Energy Harvesting in Electric Vehicles

Energy harvesting in electric vehicles is a growing field that aims to optimize the energy efficiency of these vehicles by converting ambient energy into usable electrical energy. This technique plays a crucial

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

role in reducing the dependence on the vehicle's battery and improving its overall energy efficiency. The demand for energy-efficient vehicles has been increasing in recent years, driving the interest in energy-harvesting systems for electric vehicles. Various energy conversion principles can be used for energy harvesting in electric vehicles, including piezoelectric, electromagnetic, and thermoelectric energy conversion. Piezoelectric energy harvesting involves the conversion of mechanical energy into electrical energy through the use of piezoelectric materials. Electromagnetic energy harvesting involves the conversion of magnetic energy into electrical energy through the use of electromagnetic induction . Thermoelectric energy harvesting involves the conversion of thermal energy into electrical energy through the use of thermoelectric materials. Each energy conversion principle has its advantages and limitations. For example, piezoelectric energy harvesting is highly efficient. It can be used in a wide range of applications. However, it is limited because it requires significant mechanical energy to generate a small amount of electrical energy. Electromagnetic energy harvesting is highly efficient and can be used to generate electrical energy from a variety of sources, but it requires a strong magnetic field to work effectively.

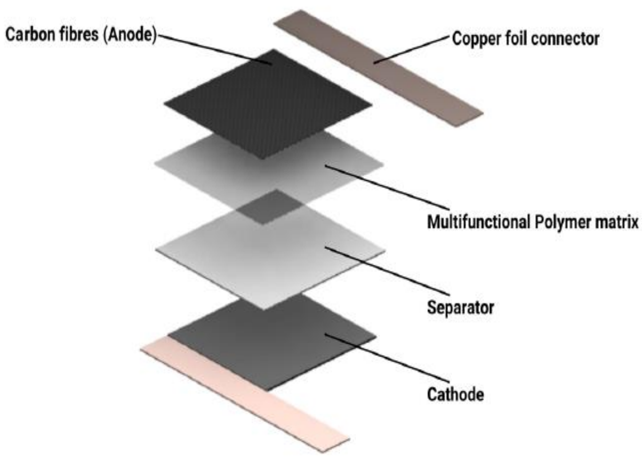

Figure 1. Structural composite battery.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021**

Table 1. Comparison of Composite Materials for Energy Harvesting.

Composite Material	Advantages	Applications
Polymer-based composites	• Inexpensive • Easy to work with • Flexible • Can be designed and optimized for specific properties	• Used in electric vehicles • Piezoelectric composites • Triboelectric nanogenerators
Metal-based composites	• High electrical conductivity • Strong and durable • Can be designed and optimized for specific properties	• Used in electromagnetic energy harvesting • Aerospace • Automotive • Sporting goods
Bio-waste-based hybrid composites	• Significant piezoelectric properties • Can generate power from various human movements	• Energy harvesting through development of piezoelectric hybrids
Cement-based composites	• Can convert temperature differences into electrical energy. • Can be used in various structures	• Thermoelectric-based cement composites • Piezo catalysis for environmental remediation

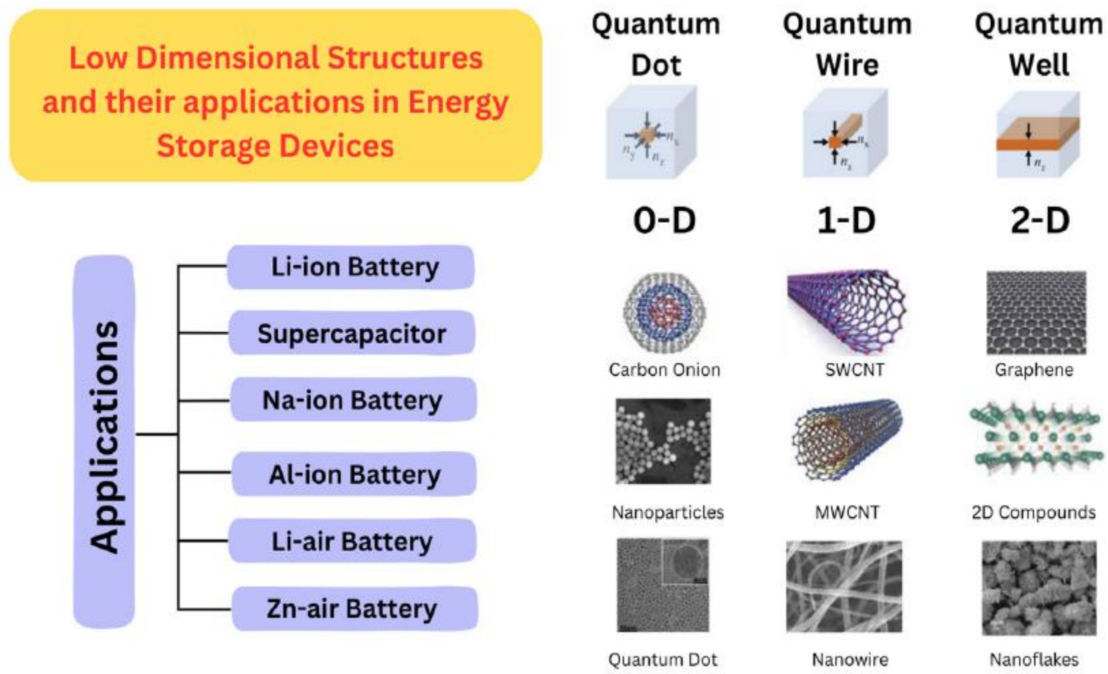

Figure 2. Low dimensional structures and their applications in energy storage devices.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021**

Table 2. Comparison of Energy Harvesting Techniques.

Technique	Principle	Advantages	Disadvantages	Applications
Piezoelectric	Converts mechanical energy into electrical energy using piezoelectric materials	Improved mechanical properties (flexibility, resistance to mechanical stress) provided by polymers in composites, enhanced electrical conductivity provided by piezoelectric ceramics	Relatively small energy generated compared to other techniques	Low-power applications, such as powering sensors
Electromagnetic	Converts electromagnetic energy into electrical energy using electromagnetic generators	High electrical conductivity provided by metal matrix composites, high thermal stability	Requires a strong electromagnetic field to generate electrical energy	Applications with strong electromagnetic fields, energy harvesting systems in electric vehicles
Thermoelectric	Converts thermal energy into electrical energy using thermoelectric materials	Generates electrical potential when subjected to temperature gradient, improved mechanical properties and electrical conductivity provided by polymers in composites	Amount of energy generated is relatively insignificant compared to other techniques	Energy harvesting in electric vehicles

6. Conclusions

Composite materials have garnered significant attention for their potential in energy harvesting applications within the electric vehicle industry. They bring a host of advantages over traditional materials, including enhanced mechanical properties, improved electrical conductivity, greater thermal stability, and cost-effectiveness. The development and utilization of composite materials for energy harvesting in electric vehicles have become a burgeoning field of research, with numerous recent studies exploring various composite materials and their diverse applications. This review underscores the versatile potential of composite materials in energy harvesting for electric vehicles, encompassing piezoelectric, electromagnetic, and thermoelectric energy harvesting methods. Each of these applications boasts unique strengths and limitations, warranting further research to optimize their performance and efficiency. Importantly, the review also highlights that the path to developing and implementing composite materials for energy harvesting in electric vehicles is not without its challenges..

References

1. Gibson, R.F. A review of recent research on mechanics of multifunctional composite materials and structures. Compos. Struct.**2010**, 92, 2793–2810. [CrossRef]
2. Nechibvute, A.; Chawanda, A.; Luhanga, P. Piezoelectric Energy Harvesting Devices: An Alternative Energy Source for WirelessSensors. Smart Mater. Res. **2012**, 2012, 853481. [CrossRef] Bowen, C.R.; Arafa, M.H. Energy harvesting technologies for tire pressure monitoring systems. Adv. Energy Mater. **2015**,5, 1401787. [CrossRef]
3. Mori, T.; Priya, S. Materials for energy harvesting: At the forefront of a new wave. MRS Bull. **2018**, 43, 176–180. [CrossRef]