applied sciences

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Editorial

Smart Materials for Control of Structural Dynamics

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Problems related to controlling the dynamics of machines and devices have been a major engineering challenge for many decades. However, developments in the field of smart materials engineering have recently enabled these materials to be used in ways that can influence the dynamic behaviour of objects. Various analytical, numerical, and experimental techniques have been used so far to understand the properties of smart materials. Therefore, it would be beneficial to gather the latest achievements in structural dynamics control using smart materials in one place.

Smart materials and devices present some challenges for structural control, such as complexity and uncertainty, due to nonlinearities, hysteresis, degradation, or coupling effects. Compatibility and integration also need to be considered when selecting, fabricating, and installing smart materials and devices. Additionally, advanced control algorithms, strategies, and architectures are required for control and coordination of the interaction and communication of multiple smart materials and devices within a structure or a network of structures. Lastly, certain care should be provided to security and privacy to protect the data and information generated by smart materials and devices from potential cyberattacks, hacking, or unexpected interference. The last-mentioned actions are here treated as a direction for future challenges in the field.

Despite the challenges, smart materials and devices offer numerous opportunities and trends for structural control. This includes innovation and development through interdisciplinary research and collaboration, as well as engaging students, educators, and the public in learning about the science and engineering of smart materials and devices. Additionally, guidelines, protocols, and standards can be established for the design, analysis, implementation, and evaluation of smart materials and devices for structural control. Furthermore, new products, services, and business models can be created based on the value proposition and competitive advantage of smart materials and devices for structural control.

Smart materials and devices have a variety of applications in structural control, depending on their functionality. Piezoelectric materials, for example, generate an electric charge when subjected to mechanical stress or mechanical forces when subjected to an electric field. For these reasons, they can be used as sensors, actuators, or energy harvesters. Shape memory alloys change their shape and stiffness when heated or cooled and can be used as actuators, dampers, connectors, or self-healing components. Magneto-strictive materials can also change their shape and stiffness when exposed to a magnetic field and can be used as sensors, actuators, or energy harvesters. Electro-rheological and magneto-rheological fluids modify their viscosity when subjected to an electric or magnetic field and can be used as dampers, valves, or clutches. Finally, fibre optic sensors measure strain, temperature, or displacement using light signals and are often employed for monitoring, damage detection, or feedback control.

Smart materials and devices can offer numerous advantages for structural control [1–5], such as improved performance, reliability, and safety; enhanced functionality and adapt-

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Citation: Palacz, M.; Krawczuk, M. Smart Materials for Control of Structural Dynamics. *Appl. Sci.* **2024**, *14*, 2078. https://doi.org/10.3390/app14052078

Received: 23 February 2024
Revised: 26 February 2024
Accepted: 26 February 2024
Published: 1 March 2024

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ability; reduced weight, size, and cost; and increased sustainability and resilience [6–8]. These materials can reduce vibrations, noise, deflections, stresses, and fatigue while increasing stiffness, damping, and stability. Moreover, they can enable self-sensing, self-actuating, self-healing, or self-optimizing capabilities while adjusting to changing conditions, loads, or requirements. Additionally, they can replace conventional sensors, actuators, or dampers while minimizing the need for external power sources, wiring, or maintenance. Furthermore, they can harvest energy from ambient sources such as wind or rain while mitigating the effects of natural disasters like earthquakes or floods.

It is our pleasure to present you a set of the latest achievements gathered in this Special Issue covering the latest and most interesting research results from both the scientific and industrial societies. The aim of this issue is to provide the reader with a better understanding of the control of the dynamic behaviour of structural elements by dedicated smart materials applications. This area of expertise may utilize analytical models, different numerical methods, and experimental approaches. We believe that experiences from research communities representing a wide area of engineering needs can satisfy a wide scientific audience.

Conflicts of Interest: The authors declare no conflict of interest.

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