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微纳技术与精密机械

电活性聚合物薄膜柔性结构的动态特性分析与实验

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摘要： 针对用电活性聚合物(EAP)薄膜制造柔性智能器件提出的理论模型和性能要求,采用一种铁电高分子聚合物薄膜制作了柔性结构器件,建立了它的动力学方程、振动行为模型及其机电性能描述。研究了预张力-抗弯刚度、驱动电压、器件几何参数对柔性薄膜器件性能的影响。提出了柔性薄膜器件在预张力和抗弯刚度共同作用下的振动行为模型及其特征化描述,用数值模拟和有限元仿真研究了杨氏模量及预张力-刚度比对柔性薄膜结构振动行为的影响,基于有限元模型与激光多普勒技术模拟和实测了EAP薄膜柔性结构的模态振型。此外,基于压电激励-激光拾振方法研究了驱动电压及器件几何尺寸对EAP薄膜柔性结构动态响应特性的影响。实验结果验证了激光多普勒技术用于EAP薄膜智能器件测试的有效性,揭示了EAP薄膜柔性结构器件的工作机理及动态性能,1 V驱动电压可产生精密位移21.6 nm。本文为研究EAP薄膜器件提供了理论基础和实验依据。

关键词： 电活性聚合物 薄膜器件 动态特性 柔性结构 激光多普勒技术

Dynamic characteristic analysis and experiments of flexible structure based on electroactive polymer film

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Abstract: According to the theory model and property requirements proposed by Electroactive Polymer (EAP) film-based flexible and intelligent devices, a flexible structure device was fabricated using a ferroelectric polymeric film, the corresponding kinetic equation,vibration behavior model, and electromechanical property description for the flexible device were established, and the influence of pretension-bending rigidity, driving voltage and geometric parameters on the properties of the flexible device was investigated. The vibration behavior model and characteristic description for the flexible film device under the coupling effects of pretension-bending rigidity were presented, the influence of Young's modulus and pretension-rigidity ratio on the vibration behavior of flexible film device was illustrated through combing numerical analysis with finite element simulation, and then the mode shape of the EAP film-based flexible structure was simulated and measured by using the Finite Element Model (FEM) and laser Doppler technique. Furthermore, dynamic response characteristics of EAP film-based flexible structure versus the driving voltage and geometric parameters were indicated by a combined approach of piezoelectric excitation and laser vibrometer measurement. The research results demonstrate the validity of laser Doppler technique employed in the property test on the EAP film-based flexible and intelligent film devices, illustrate its the working mechanism and dynamic properties. and show the precision displacement to be 21.6 nm under a driving voltage of 1 V. This work can provide theoretic foundation and experimental supports for EAP-based flexible devices.

Keywords: electroactive polymer film device dynamic characteristic flexible structure laser Doppler technique

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