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摘要: 研究了化学镀Ni-P涂敷后光纤布拉格光栅(ENFBG)的均匀轴向拉力响应特性。利用其轴对称特性,分析了光栅的应力及应变状态;采用有限元方法数值分析了光栅应变,并实验验证了数值分析结果。数值分析表明:处于纤芯处的光栅被均匀拉伸,剪应变远小于正应变,可忽略;正应变与轴向拉力成正比,ENFBG中心波长的变化正比于均匀轴向拉力变化;但由于化学镀层与光纤力学特性的差异,镀层对FBG轴向均匀拉力响应起去敏作用。当化学镀层厚度为7.25 μm 时,ENFBG的均匀轴向拉力实测灵敏度为12.45 $\mu\text{m}/\text{MPa}$,相关系数为0.999 6,理论计算值为12.744 $\mu\text{m}/\text{MPa}$,但随着镀层厚度的增加,灵敏度呈下降趋势。镀层在为FBG提供良好保护的同时,ENFBG中心波长对于轴向拉力保持线性响应。实验显示ENFBG是性能良好的轴向拉力传感器。

关键词: 光纤光学 化学镀Ni-P布拉格光纤光栅 均匀轴向拉力传感 灵敏度

Uniform axial tension effect of electroless plating Ni-P coated fiber Bragg grating

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Abstract: To research the uniform axial tension effect of an Electroless plating Ni-P coated Fiber Bragg Grating (ENFBG), the stress and strain properties of the ENFBG were analyzed based on its axial symmetry. The finite element method was used for theoretical calculations, then it was verified by following experiments. Theoretical calculation shows that under uniform axial tension, the core of the ENFBG is drawn uniformly, the shearing strain is far less than normal strain and can be omitted. The normal strain is proportional to the axial tension, and the change of center wavelength of ENFBG is proportional to that of the tension too. However, because of the difference of mechanic parameters between electroless plating Ni-P coating and optical fiber, the metal coating reduces the uniform axial tension sensitivity of the FBG. In sensor experiment, when the thickness of the coating is 7.25 μm , the sensitivity is 12.45 $\mu\text{m}/\text{MPa}$, R -square is 0.999 6, and the theoretical calculation value is 12.744 $\mu\text{m}/\text{MPa}$. Moreover, the sensitivity is decreased with the increase of the thickness of metal coating. The ENFBG is an excellent uniform axial tension sensor, because its center wavelength shows high linearity to uniform axial tension and its metal coating can provide good protection.

Keywords: fiber optics electroless plating Ni-P coated fiber Bragg grating uniform axial tension sensor sensitivity

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