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Radiation tolerant fiber Bragg gratings: review of FBG sensing

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Abstract

Fiber Bragg Gratings (FBGs) have emerged as versatile optical sensors capable of precisely monitoring environmental parameters such as temperature and strain, making them invaluable in harsh radiation environments like space, nuclear facilities, marine systems, and high-energy physics applications. This review critically examines the performance of FBGs under radiation exposure, emphasizing their adaptability and challenges in extreme environments. The radiation-induced Bragg wavelength shift, resulting from refractive index changes and defect formation, presents a significant measurement error influenced by factors such as grating inscription techniques, fiber composition, and irradiation conditions. Germanium-doped fibers exhibit higher radiation sensitivity, whereas nitrogen- and fluorine-doped alternatives demonstrate improved stability. Innovative approaches, including femtosecond laser inscription, regenerated FBGs, and distributed feedback gratings, enhance radiation tolerance and broaden FBG applications. Radiation-tolerant fibers and advanced fabrication techniques further optimize sensor performance. The review also explores future trends and challenges, including the development of more robust sensing technologies and improving radiation resistance to enable reliable operation in extreme environments. With ongoing advancements, FBGs remain integral to meeting the sensing needs of next-generation applications in aerospace, marine, and other demanding fields. © The Author(s) 2025.

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