Comparative neutron irradiation effects on structural (B/Ge) and rare-earth (Er/Yb) doped silica fibers: Photoluminescence and application specific performance analysis

By

Are you this author?

Saidin, N (Saidin, Norazlina) [1] ; Baba, T (Baba, Tamana) [1] ; Muzafar, NA (Muzafar, Nurul Addeeni) [1] ; Farid, RZBRA (Farid, Raja Zarith Batrisyia Raja Ahmad) [1] ; Shaharuddin, SSA (Shaharuddin, Siti Shafiqah Ahmad) [2] ; Sing, LK (Sing, Lim Kok) [3] ; Karim, JA (Karim, Julia Abdul) [4] ; Hasbullah, NF (Hasbullah, Nurul Fadzlin) [1]

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Abstract

The resilience of optical fibers in radiation-rich environments is increasingly critical for applications in space communications, nuclear facilities, and high-power photonics. While extensive studies have been conducted on either structurally doped fibers or rare-earth doped fibers, comparative insights across these two fundamental classes remain limited. This work systematically investigates the effects of neutron irradiation on Boron- and Germanium-doped fibers (structural dopants) alongside Erbium- and Ytterbium-doped fibers (rare-earth dopants). Photoluminescence (PL) spectroscopy was employed as a universal diagnostic probe to evaluate radiationinduced modifications in optical properties, while application-specific performance metrics were separately analyzed: reflectivity and Bragg wavelength shifts for Boron and Germanium, and the output power and amplified spontaneous emission (ASE) for Erbium and Ytterbium. The results reveal distinct radiation responses: Boron-doped fibers exhibit strong PL quenching and pronounced Bragg wavelength shifts, highlighting their potential as sensitive radiation dosimeters; Germanium-doped fibers display moderate PL variation and minimal wavelength shifts, underscoring their spectral stability; Erbium-doped fibers suffer severe ASE degradation (>40 dB loss), reflecting poor radiation tolerance; while Ytterbium-doped fibers retain emission stability with modest losses (15-20 dB), demonstrating structural resilience. By unifying the analysis of structural and rareearth dopants, this study bridges a critical gap in fiber radiation research and provides a comprehensive framework for tailoring dopant selection according to both optical response and application-specific performance in harsh environments.

Keywords

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Author Information

Corresponding Address: Saidin, Norazlina (corresponding author)

Int Islamic Univ Malaysia, Dept Elect & Comp Engn, Kulliyyah Engn, Kuala Lumpur 53100, Malaysia

E-mail Addresses :

norazlina@iium.edu.my

Addresses :

[1] Int Islamic Univ Malaysia, Dept Elect & Comp Engn, Kulliyyah Engn, Kuala Lumpur 53100, Malaysia

[2] Int Islamic Univ Malaysia, Dept Phys, Kulliyyah Sci, Kuantan 25200, Malaysia

[3] Univ Malaya, Photon Res Ctr, Kuala Lumpur 50603, Malaysia

[4] Agensi Nuklear Malaysia, Reactor Technol Ctr, Reactor Instrumentat & Control Engn, Kajang 43000, Selangor, Malaysia

E-mail Addresses :
norazlina@iium.edu.my

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