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Suppressing 1.06μm spontaneous emission of neodymium ions using a novel tellurite all-solid photonic bandgap fiber

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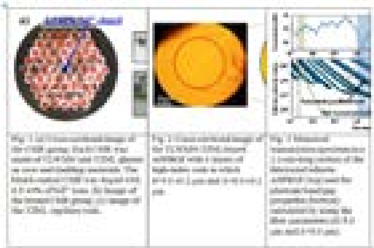
In recent years, the development of high capacity and broad transmission optical systems and devices for global telecommunication networks is rapidly increasing due to the explosive spread of telecommunication devices such as smartphones and computers. Along with the development of broadband optical systems, the demand for optical amplifiers at many different wavelengths in the telecommunication range are also growing. Although Erbium-doped fiber amplifiers (EDFA) are widely used as gain media for wavelength division multiplexing (WDM) systems, their gain bandwidths are as narrow as 30nm from 1530 to 1560nm. In a nearby wavelength range, optical fiber amplifiers operating near 1.3μm in the telecommunication band where conventional single-mode fibers have low-loss and low dispersion are very attractive. Among several active rare-earth ions that have been investigated for optical fiber amplifiers operating near the 1.3μm spectral region, Nd^{3+} is a potential candidate for compact and highly efficient optical fiber amplifiers even with a short fiber length of a few centimeters due to its ${}^4F_{3/2}\rightarrow{}^4I_{13/2}$ transition. However, the use of the 1.3μm emission in a practical Nd^{3+}-doped fiber has faced with several problems. One of its major problems is the presence of competing amplified spontaneous emission (ASE) at 1.06μm due to the ${}^4F_{3/2}\rightarrow{}^4I_{11/2}$ transition whose branching ratio is about 5 times larger than that at 1.3μm. In order to realize a practical optical amplifier device at 1.3μm, the ASE at 1.06μm must be filtered out. In this work, we propose a tellurite all-solid photonic bandgap fiber (ASPBGF) to filter out the competing emission at 1.06μm which is most prominent in the emission spectrum of the Nd^{3+} ion. A novel Nd^{3+}-doped tellurite ASPBGF is fabricated by using our developed tellurite glasses which have high compatibility of thermal properties and their refractive index difference is 0.096 at 1320nm. The fiber is designed with 4 layers of high-index rods to have low confinement loss. The measured transmission spectrum of a 2.2cm long section of the fabricated fiber exhibits high transmission bands near 0.75 and 1.33μm (about -20dB and -19dB) and a low transmission band in the vicinity of 1.06μm which is about -27dB. By using our fabricated Nd^{3+}-doped tellurite ASPBGF, it is demonstrated for the first time that the 1.06μm emission peak due to the ${}^4F_{3/2}\rightarrow{}^4I_{11/2}$ transition of Nd^{3+} ions is greatly suppressed about 12 times as compared to that obtained by using a bulk samples with the same doping concentration.



Biography

Tong Hoang Tuan was born in Ho Chi Minh City, Vietnam, in 1985. He received his MS degree in Applied Physics from the University of Science, Ho Chi Minh City, Vietnam in 2010 and PhD degrees in Future Industry-Oriented Basic Science & Material Engineering from Toyota Technological Institute, Nagoya, Japan in 2015. Since then, he joined the Laboratory of Optical Functional Materials, Toyota Technological Institute, as a post-doctoral fellow. His special technical skills are involved in glass material development, fiber characterization and fabrication using highly nonlinear materials. In 2017, he received the KAKENHI research fund supported by Japan Society for the Promotion of Science (JSPS). His current research interests include the fabrication and characterization of chalcogenide and tellurite buffer-embed hybrid microstructure optical fibers for broadband mid-infrared supercontinuum generation, fiber optical parametric amplification and frequency comb generation, the dynamic photonic bandgap control of novel all-solid photonic bandgap fibers for ultrafast optical modulation, the hollow-core photonic crystal fibers and the infrared optical image transport in novel tellurite optical fibers with transversely disordered refractive index profile..

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