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Technique of selective and tunable wavelength conversion employing quasi-phase matched lithium niobate devices with dual pump configuration

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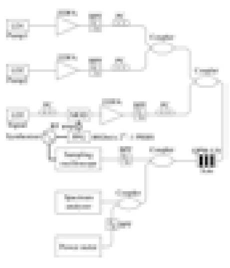
All-optical and tunable wavelength converters (WCs) can offer many attractive functions such as optical channel routing, optical add-drop multiplexing, optical label processing and dynamic light-path establishment for constructing transparent and scalable wavelength-division multiplexed (WDM) networks or future optical packet switched systems. The potential of such WCs has already been revealed in a number of system experiments. To date, a selective and tunable WC (STWC) has been realized by employing the cascaded second-order nonlinear effect of sum frequency mixing (SFM) and difference frequency mixing (DFM) in a quasi-phase-matched (QPM) lithium niobate (LN) device. In this technique, a signal light and two pump lights 1 and 2, which have angular frequencies ωs, $\omega_p 1$ and $\omega_p 2$, respectively are launched on the device with a QPM frequency of ω_{QPM}; to satisfy the QPM condition, $\omega_p 1$ is set to $2\omega_{QPM}-\omega s$; SFM between the signal light and the pump light 1 then produces a sum-frequency component at $2\omega_{QPM}$; a wavelength-converted output finally appears at $2\omega_{QPM}-\omega_p 2$ through DFM between the $2\omega_{QPM}$ component and the pump light 2. Generally, the wavelength conversion efficiency of the QPM-LN devices or the output power of the wavelength-converted signal light increases dramatically as the length of the LN crystal becomes longer. In such a dual-pumped wavelength conversion scheme, however, the available signal bandwidth is strictly limited by the QPM bandwidth of the device. In other words, the crystal length of the QPM-LN device has to be optimally determined so that the QPM bandwidth corresponds to or is slightly broader than the bandwidth of the original signals to be wavelength-converted. In this paper, we review a technique of the QPM-LN-based STWC from an arbitrary wavelength to another arbitrary one. Through wavelength conversion experiments using short optical pulses for the QPM-LN devices having different crystal length, we investigate the bandwidth limitation in the dual pump configuration. We show that the minimum pulse width to be wavelength-converted without waveform distortion is proportional to the length of the LN crystal, and also reveal that that ratio is 1.6ps/cm. By utilizing this critical value as a performance metric, we demonstrate highly efficient selective and tunable wavelength conversion of 40-Gbit/s data signals using a QPM-LN waveguide device with an optimum crystal length of 5cm. This device is quite attractive for channel-by-channel wavelength conversion in 40-Gbit/s dense WDM (DWDM) systems thanks to many excellent features such as wide range of wavelength tunability, high conversion efficiency, modulation format free, adequate signal bandwidth and selectivity of 100-GHz-spaced DWDM channels.



Biography

Yutaka Fukuchi was born in Tochigi, Japan, on April 29, 1975. He received the BS and MS degrees in electronics engineering from Tokyo University of Science, Chiba, Japan, in 1998 and 2000, respectively and the PhD degree in electronics engineering from the University of Tokyo, Tokyo, Japan, in 2003. In 2003, he joined the Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science, Tokyo, Japan as an Assistant Professor. From 2003 to 2005, he was also a Co-operative Research Fellow in Research Center for Advanced Science and Technology, the University of Tokyo, Tokyo, Japan. Then, he became a Junior Associate Professor of Tokyo University of Science in 2006. Since 2009, he has been an Associate Professor at this university. From 2013 to 2014, he was a Visiting Research Fellow with the High-Speed Optical Communications Group, Department of Photonics Engineering, Technical University of Denmark, Lyngby, Denmark. He has published over 120 papers in major international journals and conferences. His research interests are optical communications, quantum optics, nonlinear optics and their applications. He is a member of the Institute of Electrical and Electronics Engineers (IEEE), the Optical Society of America (OSA) and the Institute of Electronics, Information and Communication Engineers (IEICE).

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