

**Invited paper**

**Integrated 100-Gb/s PDM-QPSK modulator using a hybrid assembly  
technique with silica-based PLCs and LiNbO<sub>3</sub> phase modulators**

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**Abstract**

*We demonstrate a PDM-QPSK modulator operating at 100-Gb/s. Two QPSK modulators and a polarization beam combiner are integrated using a hybrid assembly technique with silica PLCs and LiNbO<sub>3</sub> phase modulators.*

**Extended Abstract**

We demonstrate a polarization-division-multiplexing quadrature-phase-shift-keying (PDM-QPSK) modulator operating at 100-Gb/s. For the integration of two QPSK modulators and a PDM circuit with a large electro-optic bandwidth and a low insertion loss, we used a hybrid assembly technique with silica-based planar lightwave circuits (PLCs) and an array of LiNbO<sub>3</sub> (LN) phase modulators. The PDM circuit, which is implemented in a PLC, includes a waveguide polarization beam combiner (PBC), in which we controlled the relative phase between the orthogonal polarization modes by controlling the width of the waveguide core. The PBC operates in a broad spectral range with a polarization extinction ratio of more than 23 dB and a low optical loss of 0.3 dB. The four sub Mach-Zehnder modulators in the two QPSK modulators, each of which consists of two PLC Y-branch couplers and two LN phase modulators, operate with uniform characteristics, such as the electro-optic 3-dB bandwidths of around 27 GHz. The PDM-QPSK modulator as a whole has a low static insertion loss of 4.8 dB and a low inter-channel crosstalk of around -25 dB. The back-to-back operation at 100-Gb/s (25 Gbaud) was also successful. To our knowledge, this is the first integrated PDM-QPSK modulator reported so far.

**Hiroshi Yamazaki**

Hiroshi Yamazaki received a bachelor degree in integrated human studies and a master degree in human and environmental studies from Kyoto University, Kyoto, Japan, in 2003 and 2005, respectively. He joined NTT Photonics Laboratories in 2005, where he has been engaged in research on silica-based planar lightwave circuits (PLCs).

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