Optical communication systems had successfully met the increasing demands for higher communication speeds through the utilization of all degrees of freedom of the light propagating in a single mode fiber (SMF). However, the Shannon limit restricts further improvements of the capacity in the SMFs. Space-division multiplexing (SDM) offers a way for further increasing the capacity of optical fibers through the utilization of the spatial domain. However, for it to be successfully implemented, many integral parts of the optical communication must be tuned or modified to work effectively with the multimode fibers, including few mode amplifiers, and mode converters. In this work, we first develop the few mode semiconductor optical amplifier (FMSOA) that provides an equalized-gain for E11, E12, E21, and E22 modes. The fabricated InGaAsP MQW FMSOA shows that the modes are confined to the ridge waveguide, overlapping the quantum wells with approximately the same amount, leading to equalized gain for each of the four waveguide modes. Second, we develop an all-optical mode and wavelength converter (AOMWC) using the inter-modal four wave mixing (FWM) process in an FMSOA. At the nonlinear regime of an FMSOA, the interaction of waves with different wavelengths and modes creates gain and index gratings. These gratings provide a very efficient inter-modal FWM process. The high mode selectivity and the efficient FWM make the FMSOA an appealing AOMWC for integrated all-optical signal processors. Lastly, an asymmetric supermode converter is demonstrated by encircling the exceptional point in a non-Hermitian system. Encircling the exceptional point leads to a direction-dependent coalesce of the eigenvalues and merge of the eigenvectors. The supermode converter is designed by manipulating the gain and the propagation constant along the length of a directional coupler. Independent of the input, the output of the coupler merge to a unique single eigenstate at each end of the coupler.

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The public is welcome to attend.