Hybrid Photonic Integration: An Enabling Technology for Terabit/s Communications and Teratronics

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Silicon photonics offers tremendous potential for large-scale photonic-electronic integration by enabling foundry-based fabless processing and co-integration of photonic and electronic circuitry. Silicon as an optical material, however, falls short of properties that are indispensable for high-performance devices: The indirect bandgap of crystalline silicon prevents efficient light emission, and bulk silicon does not feature any second-order optical nonlinearity due to crystal symmetry, making high-speed electro-optic modulators and power-efficient phase shifters challenging.

These deficiencies can be overcome by hybrid photonic integration concepts, which combine silicon photonic circuitry with other material systems that provide complementary optical properties. We will give an overview on our research in the areas of silicon-organic hybrid (SOH) integration and photonic multi-chip integration. SOH integration combines conventional silicon-on-insulator (SOI) waveguides with functional organic cladding materials and is particularly well suited for high-speed electro-optic phase modulators and power-efficient phase shifters. Photonic multi-chip integration relies on photonic wire bonding as a chip-to-chip interconnect technology and enables heterogeneous photonic systems that are assembled from known-good dies of different material systems. The review of fundamental technological concepts will be complemented by the discussion of selected application demonstrations: Hybrid photonic systems are key to power-efficient transmission of terabit/s data streams and will represent the technology base of future teratronic systems, which enable generation and processing of electromagnetic waveforms with terahertz bandwidths or carrier frequencies.