Silicon photonics has been a rapidly growing subfield of integrated optics in the last decade and is currently considered a mature technology. The main thrust behind the growth is compatibility with matured and low-cost microelectronic integrated circuits fabrication process. In recent years, several active and passive photonic devices have been demonstrated on silicon. Optical delay lines are among important silicon photonic devices, which are essential for a variety of photonic system applications including optical beam-forming for controlling phased-array antennas, optical communication and networking and optical coherence tomography.

In this thesis, several types of delay lines based on apodized gratings are proposed and demonstrated. Simulation and experimental results suggests that these novel devices can provide high optical delay and tunability at very high bit rate. Further, they have less optical insertion loss compared to current state-of-the-art devices based on photonic crystals and microring resonators.

While most of research focus of silicon photonic has been in in near-infrared wavelengths, extending the operating wavelength range into in the 3" 5" or mid-wave infrared regime is a more recent field of research. A key challenge has been that the standard silicon-on-insulator waveguides are not suitable for mid-infrared, since the material loss of the buried oxide layer becomes substantially high. Here, the silicon-on-sapphire waveguide technology, which can extend silicon's operating wavelength range up to 4.4", is investigated. Further silicon-on-nitride waveguides, boasting a wide transparent range of 1.2" 6.7", are demonstrated and characterized at both mid-infrared (3.39") and near-infrared (1.55") wavelengths.