Non-Confidential Description - PSU No. 3529
“Light Emitting Diodes and Laser Diodes on Silicon”

Keywords:
Photonics, optical gain, electron concentration, on-chip lasers, germanium gain medium, microelectronics, LEDs

Links:
Inventor Website - 1
Inventor Website - 2
US Patent 8,222,657

Inventors:
Jian Xu, Somasundaram Ashok

Background
A key target in the roadmap of silicon photonics is the development of high-performance, current-injected on-chip lasers that can be monolithically fabricated on silicon. This ultimate integration of silicon photonic circuitry and advanced silicon microelectronics may unlock the true power of tomorrow’s computers and networks because of vast data capacity, transmission distance, and insensitivity to electromagnetic interference and cross-talk. Such on-chip lasers should operate at the silica optical fiber communication wavelength ($\lambda = 1.55\,\mu m$). It is also highly desirable that the processing of these miniaturized coherent light sources is compatible with complementary metal–oxide–semiconductor (CMOS) technology in order to make full use of its billion-dollar industrial tools and facilities.

Invention Description
The disclosed invention is a novel approach to creating optical gain in Ge or SiGe that can fulfill the following requirements, all of which are currently unmet by existing technologies: (1) exhibit direct band transition to eliminate dependence on phonon density in the material; (2) exhibit high radiation efficiency even at low or intermediate injection levels; (3) feature low impurity doping for reduced density of nonradiative recombination centers and low Auger recombination rate; and (4) avoid tunnel injection of carriers where carrier injection efficiency is lowered by carrier trapping and de-trapping cycles. The core strategy of the present invention involves inducing high concentrations of electrons in the thin channel regions of lightly-doped or intrinsic bulk or epitaxial layers of Ge or SiGe via surface carrier accumulation/inversion in a metal-oxide(insulator)-semiconductor (MOS) configuration, and interface carrier accumulation by transfer doping across a heterojunction.

Advantages/Applications
- Electrons accumulating at the interface in effect form a 2-dimensional electron gas (2-DEG) with attendant “lift” in the energy level of this quantum well above the conduction band minimum
- Greatly reduces problems of impurity-related recombination losses