High-Sn content GeSn Light Emitters for Silicon Photonics

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Recently it has been shown that alloying Ge with Sn enables the fabrication of fundamental direct bandgap group IV semiconductors as well as optically-pumped GeSn lasers grown on Si(001) [1]. This achievement might pave the route towards efficient and monolithically integrated group-IV lasers for electronic-photonic integrated circuits (EPICs) that could solve the emerging power consumption crisis in CMOS technology by enabling optical on-chip and chip-to-chip data transfer. Changing from electrons to photons for the data transfer would lead to a tremendous reduction in energy consumption of ICs [2].

Here we present GeSn light emitting diodes (LEDs) using CVD-grown GeSn alloys [3] with Sn concentrations above 10 at.%. Layer characterization by photoluminescence (PL) exhibits excellent optical quality for layer thicknesses up to 1 µm. For the fabrication of vertical *p*-*i*-*n* structures, *p*-GeSn/*i*-GeSn/*n*-GeSn heterostructures are grown on a p^+-doped Ge virtual substrate. The peaks of room temperature electroluminescence (EL) spectra (Fig. 1) emerge at energies below 0.5 eV (~2.5 µm), stemming from electron-hole recombination at the Γ-point. At 4 K the EL peak intensity increases by a factor of two compared room temperature. Integrated intensities as function of temperature (not shown) indicate a small separation in energy between the Γ- and L-valley, softening the excitation requirements for lasing compared to fundamental indirect group IV semiconductors [4]. This demonstration of electrically excited luminescence in $Ge_{1-x}Sn_x$ alloys with x > 10 at.% represents a major step towards electrically driven direct bandgap group IV lasers.

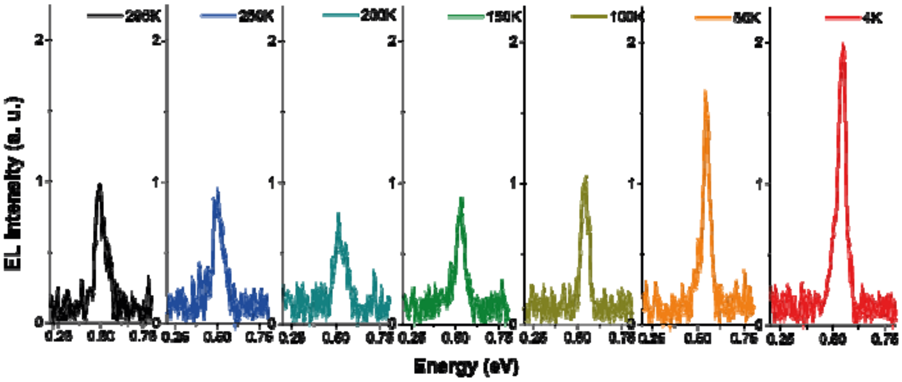

Fig. 1. Temperature-dependent electroluminescence spectra of a $Ge_{0.89}Sn_{0.11}$ *p-i-n* diode with NiGeSn metal contacts, at current densities of 1.27 kA/cm^2. The evolution of the intensity with temperature is typical for quasi-direct semiconductors.

1. S. Wirths, R. Geiger *et al.*, "Lasing in direct-bandgap GeSn alloy grown on Si", *Nature Photonics* (2015) *doi:10.1038/nphoton.2014.321*
2. D. A. B. Miller, *Optics Lett.* **14**, 146 (1989).
3. S. Wirths *et. al.*, *ECS J. Solid State Sci. Technol*. **2**, N99 (2013).
4. B. Dutt *et al.*, *IEEE J. Selected Topics Quantum Electronics* **19**, 1502706 (2013).