

Three-Dimensional Silicon-Germanium Nanostructures for CMOS Compatible Light Emitters

David J. Lockwood*

Institute for Microstructural Sciences, National Research Council, Ottawa, Ontario K1A 0R6, Canada

In this lecture we review the present status of light emitters based on silicon-germanium nanostructures. In order to be commercially valuable, these light emitters should be efficient, fast, and operational at room temperature, and, perhaps most importantly, be compatible with existing CMOS technology. Another important requirement is in the emission wavelength, which should match an optical waveguide low-loss spectral region, e.g., 1.3–1.6 μm . Amongst various different approaches [1], epitaxially-grown Si/SiGe quantum wells and quantum dot/quantum well complexes produce efficient photoluminescence and electroluminescence in the required spectral range [2]. Until recently, the two major roadblocks for practical applications of these devices have been strong thermal quenching of the luminescence quantum efficiency and a long carrier radiative lifetime.

Three-dimensional SiGe nanostructures grown on Si using molecular beam epitaxy exhibit photoluminescence in the useful spectral range of 1.3–1.6 μm [3]. At a higher level of photo-excitation, thermal quenching of the photoluminescence intensity is suppressed and the previously accepted type II energy band alignment at the Si/SiGe cluster hetero-interface no longer controls radiative carrier recombination. Instead, a dynamic type I energy band alignment governs the strong decrease in carrier radiative lifetime and further increase in the luminescence quantum efficiency. In contrast to the strongly temperature dependent and slow radiative carrier recombination found in bulk Si, Auger mediated photoluminescence emanating from the nanometer-thick Si layers is found to be nearly temperature independent with a radiative lifetime approaching 10^{-8} s, which is comparable to that found in direct band gap III-V semiconductors. Such nanostructures are thus potentially useful as CMOS compatible light emitters and, for example, could be used for on-chip optical interconnects.

[1] L. Pavesi and D. J. Lockwood, *Silicon Photonics*, Springer, Berlin (2004).

[2] J.-M. Baribeau, X. Wu, N. L. Rowell, and D. J. Lockwood, *J. Phys. Condensed Matter* **18**, R139 (2006).

[3] L. Tsybeskov, E.-K. Lee, H.-Y. Chang, B. V. Kamenev, D. J. Lockwood, J.-M. Baribeau, and T. I. Kamins, *Adv. Optical Technologies* **2008**, 218032 (2008).

* E-mail: david.lockwood@nrc.ca