GaAs Doping Superlattice Emitters

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In a bulk semiconductor, the light emission wavelength is limited by the bandgap energy. Thus, to achieve 2-4 micron wavelength emission requires narrow bandgap semiconductors. A novel approach for emission from semiconductors at wavelengths less than the bulk bandgap is to employ doping superlattices [1, 2]. We have achieved the first laterally defined GaAs short period doping superlattices and observe emission below the bandgap energy. In a doping superlattice, alternating p-type and n-type layers are introduced, as sketched in Figure 7.7.1, which create a succession of lateral pn junctions. The result of the electrostatic band bending perpendicular to the alternating-doped regions is to introduce confinement for electrons and holes and enable radiative recombination at wavelengths below the bulk bandgap. Intermeshed n- and p-type regions that are microns in length but with widths varying between 20 to 100 nm have been defined in the surface of a 100nm thick membrane using electron-beam lithography; an example of one dopant region is shown in the inset of Figure 7.7.1. After the mask definition, ion implantation is used to introduce one dopant, and the second region is defined (after careful alignment) to create the varying dopant grating periods. Planar light emitting diodes have been fabricated and characterized within GaAs due to its concomitant mature processing to demonstrate the viability of below bandgap light sources. Figure 7.7.2 shows the electroluminescence versus the period of the doping superlattice; as expected increasing period leads to longer wavelength emission. Doping superlattice light emitting diodes can be heterogeneously integrated onto flexible substrates using printed assembly [3].

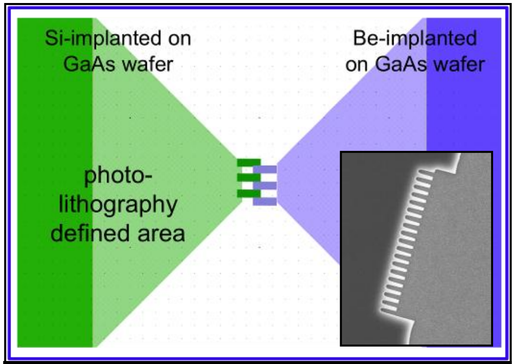

Figure 7.7.1: Sketch of lateral doping superlattice. The inset shows the mask for one impurity.

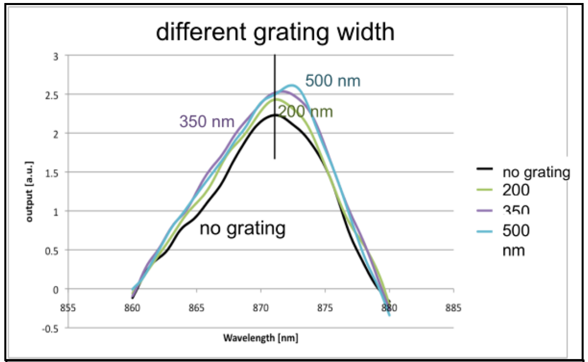

Figure 7.7.2: Emission spectrum versus grating period of doping superlattice.

[1] G. Dohler in Synthetic Modulated Structures, ed. L. Chang and B. Giessen, Academic Press (1985).
[2] K. D. Choquette, D. K. Misemer, L. McCaughan, Phys. Rev. B, **43**, 7040 (1991).
[3] S. Park, Y. Xiong, R Kim, P. Elvikis, M. Meitl, D. Kim, J. Wu, J. Yoon, C. Yu, Z. Liu, Y. Huang, K. Hwang, P. Ferreira, X. Li, K. Choquette, J. Rogers, Science **325**, 977 (2009).

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