A Si-based infrared laser: obstacles and prospects

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We have recently demonstrated the electrouminescence from a Si/SiGe cascade structure with very promising properties, such as a narrow line width and a non-radiative lifetime of the higher state comparable to that of that of a GaInAs/AlInAs LED used for quantum cascade lasers [1]. The results raise intriguing questions: is a Si/SiGe infrared laser possible to realize; and what sort of impact would such a laser have?

The structures use transitions in the valence band to obtain emission in the 120–150 meV range, and so far have consisted of ten-period pseudomorphically-grown, highly strained cascades. In order to achieve a laser several problems still need to be solved, such as the increase from 10 to 30–50 periods, the choice of lasing scheme, the implementation of an optical cavity, and the reduction of the free-carrier absorption in the samples. Different strategies will be discussed how to overcome some these issues: the use of graded buffer layers (which allows for strain compensation and lowers the activation energy for the *p*-dopants), growth on SIMOX wafers (for wave guiding), and diagonal *vs*. vertical transitions.

The wavelength of such a laser would in all likelihood be limited to > 6 μm, due to the limits in the band offset and heavy-hole to light-hole energy separation. This would imply a relatively low bandwidth, making make it less desirable for integration of SI technology with optical communication. However, we propose other important applications, such as inter-chip communication, for which the bandwidth plays less of a role.

[1] L. Diehl *et al.*, Science **290**, 2277 (2000).