Semiconductor Lasers Beyond Quantum Dots

Nikolai Ledentsov
Technical University of Berlin and *Ioffe Institute, Russia*

Quantum dots (QDs) enable new laser devices with dramatically improved properties, including:

- ultralow threshold currents;
- very high temperature stability of the threshold current and negligible chirp (wavelength shift with current);
- complete suppression of spreading of injected carriers;
- zero beam filamentation ;
- high modal gain by stacking of QDs and high frequency operation (>10 GHz);
- extension of the wavelength range up to 1.5 µm on GaAs substrates;
- edge emitters and VCSELs;
- ultrafast optical amplifiers;
- possibility of resonant carrier injection in QDs;
- transverse cavity-induced longitudinal mode grouping allowing better spectral control and better temperature stability of the lasing wavelength.

A number of challenging questions for semiconductor lasers still remain:

- Can we create active media with complete polarization control (TE/TM/unpolarized edge emitters, polarized VCSELs, *etc*.)?
- Can injection lasers on GaAs operate beyond 1.5 µm? Can we realize green laser on GaAs using GaAs-AlAs type-II QDs?
- Can we realize Si-based laser using Si-Ge QDs?
- Can we improve diode laser beam quality to the level of solid-state lasers?
- Can we increase the single-mode continuous wave power to 10 W and pulsed single-mode power to 1 kW?
- Can we realize high-power wavelength-stabilized edge-emitting lasers without DFB gratings or external cavities?
- Can we realize resonant-cavity surface-emitting lasers with >100 mW single mode cw output using only few µm-size light output aperture?

The answer to all of the above is, hopefully, in the affirmative and the recent active media and laser design developments will be addressed.