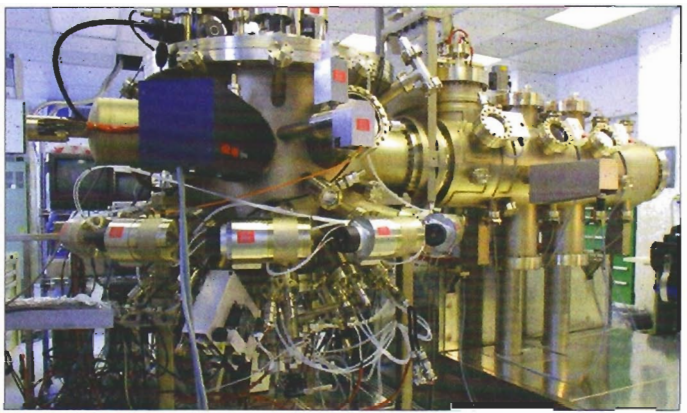
GaAs-based VCSELs shine into the C-band

Gallium arsenide (GaAs)-based vertical-cavity surface-emitting lasers (VCSELs) that emit at 1300 nm are already a commercial reality. But the ability to shift the emission wavelength into the C-band could bring the material's processing benefits to mainstream telecoms applications. Now, researchers at the University of Strathclyde in Scotland, working in collaboration with scientists at the National Research Council (NRC) of Canada, have demonstrated pulsed emission at 1547 nm from an optically pumped GaAs VCSEL.

"GaAs-based VCSELs can be grown monolithically, which offers simplified fabrication compared with indium phosphide devices," explained Strathclyde researcher Stephane Calvez. "Moreover, this technology could benefit from established datacoms (850 nm) VCSEL manufacturing capabilities, with potentially lower cost."

The team achieved C-band emission by using GaInNAsSb/GaNAs quantum wells to form the active region. Adding nitrogen (N) to GaAs redshifts the laser's wavelength, but too high a nitrogen content degrades the material. To combat this effect the researchers added antimony (Sb) to the GaInNAs to improve its structure. This enhances the photoluminescence at high nitrogen content and enables longer wavelength emission.



Building it up: the researchers used molecular beam epitaxy to grow the lower distributed Bragg reflector and the VCSEL's active region on a GaAs substrate.

The VCSEL is formed by sandwiching the active region between a top dielectric distributed Bragg reflector (DBR) and a bottom semiconductor DBR. The team characterized two devices using 1064 nm optical pumping: an as-grown VCSEL and a thermally annealed (at 700 °C for 3 min before deposition of the top DBR) version, both emitting 1547 nm light at 20 °C.

At 10 °C the annealed sample exhibited a greater peak-pump-power threshold (60 W) than the as-grown device (30 W), indicating that the post-growth annealing induces a blueshift of the gain peak. Both samples exhibited similar slope efficiencies, which suggests that annealing does not greatly decrease the defect-related recombination rate. The researchers also noted standard degradation of both threshold and efficiency as the temperature increased.

"The device was actually designed as a vertical-external-cavity surface-emitting laser and, as such, it contains five groups of three GaInNAsSb/GaNAs quantum wells. Such a structure should ultimately enable Watt-level output power," Calvez noted. "In parallel, the NRC is also developing electrically pumped 1550 nm VCSELs grown monolithically on GaAs. These structures use epitaxial DBRs for both mirrors, with active regions containing a single set of one to three quantum wells."

The next stage in the research, says Calvez, is continuous-wave operation, achieved by "improving the growth quality to reduce the number of defects and modification of the quantum-well structure to reduce temperature sensitivity".