Abstract:
The project is focused primarily on materials, technologies and components for the III-V optoelectronic devices integrated with silicon platform. The goal is to provide design and technology for light emitters and photodetectors with strong optical and electrical confinement and high external efficiency suitable for hybrid microintegration on Si electronics into massively parallel arrays [1]. The major focus is on the microcavity optoelectronic devices, such as vertical cavity surface-emitting lasers (VCSELs), microcavity light-emitting diodes, and resonant cavity photodetectors, which are anticipated to play the major role in the future chip-level optical interconnect technology.

The project contains two tasks. The first one includes the use of novel quantum confined structures with increased electron correlation and electron-optical coupling, and novel processing technologies to enhance the performance of the optoelectronic devices and arrays [2]. The second task involves the investigation of the various III/V-on-Si integration protocols to transfer a massive array of optoelectronic devices onto an Si platform.

Summary:
In the past year, the work at the CNF has been focused on the design and implementation of technologies for heterogeneous integration of III-V components on an Si platform.

Reduction of the stresses produced in hybrid integrated structures due to thermal expansion coefficient difference requires removal of the substrate as one of the key elements. Commonly used epitaxial lift-off technique can hardly be employed for the fabrication of VCSELs with all-epitaxial DBRs due to the low etching selectivity between AlAs sacrificial layer and DBR layers with high Al contents. A novel method of substrate removal named oxidation lift-off was proposed and demonstrated [3]. This process shows higher selectivity against Al-content than epitaxial lift-off methods. This allows for the release of a VCSEL structure with epitaxial DBRs and separate individual components on Si, reduces the number of process steps and eventually reduces the cost of the fabricated/integrated devices. Au-Ge alloy was used for the metal bonding of the test oxidation lift-off structures grown by MBE. A 1 mm thick AlAs imbedded sacrificial layer was laterally oxidized to release the partially processed devices from the GaAs substrate. A 2D array of separated VCSELs was fabricated on top of the Si substrate. Contact annealing, substrate removal, device separation, bonding and formation of the oxide apertures were completed within a single processing step. Electroluminescent spectra, I-V and P-I characteristics of fabricated devices were measured. Series resistance of fabricated devices was found to be about 100 Ohms. Lasing with threshold current of 8 mA was demonstrated for the device with 25 mm aperture [4].

References:
Oxidation lift-off technology.

Bonding and substrate release in a single-step process.

High selectivity against Al content in AlGaAs alloys.

Oxide aperture fabrication in the same oxidation step.

Can be applied to integration of other GaAs-based components on Si, such as photodetectors, transistors, etc.