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Towards group IV semiconductor laser

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The main drawback of group IV semiconductors is the indirect band gap which makes them poor light emitters. Ge with a quasi-direct band gap can be created by strain engineering, formation of binary (GeSn) and ternary (SiGeSn) alloys, quantum dots or ultra-high n-type doping. This can be realized only utilizing strongly non-equilibrium processing like ion implantation and molecular beam epitaxy followed by the ultra-short annealing.

Here an overview of different doping and alloying techniques (*in-situ* and *ex-situ*) will be presented. Special attention will be focused on the use of ion implantation followed by flash-lamp (FLA) annealing for the fabrication of heavily doped Ge, GeSn and SiGeSn. In contrast to conventional annealing procedures, rear-side FLA leads to full recrystallization of Ge and dopant activation independently of pre-treatment. The maximum carrier concentration is well above 10^{20} cm^{-3} for n-type and above 10^{21} cm^{-3} for p-type doping. The recrystallization mechanism and the dopant distribution during rear-side FLA are discussed in detail. In this work, we report on the strong mid-IR plasmon absorption from heavily n-doped Ge and GeSn thin films and the room temperature photoluminescence observed from the direct band gap in Ge.

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