Enabling Novel Features of Heterogeneous III-V on Si Lasers with Resonant Si Embedded Photonic Molecules Mirrors

G. F. M. de Rezende[1], **G. Roelkens**[2], **and N. C. Frateschi**[1]

[1] "Gleb Wataghin" Physics Institute, University of Campinas, 13083-859 Campinas, SP, Brazil
[2] Photonics Research Group, INTEC, Ghent University-imec 9052 Ghent Belgium

Abstract— We report on the design, fabrication, characterization and applications of a III-V-on-Si laser with a tunable resonant optical mirror based on Si coupled microring resonators. The mirror tunability allows the laser to operate in different configurations including low threshold current, improved linewidth and latching, the last one also due to nonlinearities.

Heterogeneous III-V-on-Si lasers are the most prominent sources of coherent light for Si photonic integration due to their high gain, good scalability and yield [1].

Among different geometries, ring-resonator-based lasers are extensively studied due to their compactness and efficient tunability compared to Fabry-Perot, Distributed Bragg Reflector (DBR) and Distributed Feedback lasers (DFB).

The main sought features of such a laser include wide tunability, high optical output power, low threshold current, high side mode suppression ratio (SMSR), low intensity noise, narrow linewidth, among others [2].

Here we present the design and fabrication of a novel III-V-on-Si laser with tunable coupled ring resonators mirrors implemented in the silicon device layer. Vernier-based wavelength-selective mirrors allow for wide tunability. Trimming the reflection to its maximum allows low threshold operation. The optical coupling of the microrings allows supermode-induced reflectivity, which can be tailored in magnitude, phase and dispersion response. Therefore, linewidth reduction can be obtained by selecting appropriate feedback strength parameters (associated with the mirror's dispersion). Lastly, nonlinearities in the Si microrings such as induced by two photon absorption lead to interesting pump dependent features in reflection, which allows non-conventional applications such as on-off latching. This latching is related to a bi-stable behavior between optical output power and injection current caused by a power dependent optical feedback from the photonic molecule mirrors.

ACKNOWLEDGMENT

The authors acknowledge the Sao Paulo Research Foundation (2016/03714-2, 2016/23451-6).

REFERENCES

1. Z. Zhou, B. Yin, and J. Michel, "On-chip light sources for silicon photonics," Light: Science & Applications **4** (2015).
2. M. A. Tran, T. Komljenovic, D. Huang, L. Liang, M. J. Kennedy, and J. E. Bowers, "A Widely-Tunable High-SMSR Narrow-Linewidth Laser Heterogeneously Integrated on Silicon," pp. 5–6 (2018).