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Heterogeneously Integrated Evanescently Coupled Laser Systems on SiN Emitting in the Near-Infrared Band

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Silicon nitride (SiN) with its ultra-low loss has emerged as a powerful passive platform for visible photonics [1], enabling a wide range of applications such as optical coherence tomography. Central to the development of such systems is the integration of laser sources operating in these shorter wavelength ranges. By using heterogeneous integration technologies such as micro-transfer printing, a variety of different devices can be integrated onto the Si and SiN wafers [2]. In order to create lasers however a challenge remains to be addressed: SiN has a much lower refractive index compared to the III/V semiconductor optical amplifier (SOA) which impedes the development of evanescently coupled lasers. By using CMOS-compatible hydrogenated amorphous silicon (a-Si:H) as an intermediate layer, the SiN-III/V transition can be achieved [3]. In this work, we present heterogeneously integrated evanescently coupled gallium arsenide (GaAs)-based lasers on SiN emitting below 1 μm by utilizing an a-Si:H intermediate layer.

The fabrication of the chip is shown in Fig. 1 (a1-a7). The passive circuitry was patterned by electron beam lithography and reactive ion etching. The minimum feature size used is 150 nm, making it compatible with DUV processes. In total, two a-Si:H thicknesses are required for the adiabatic SiN-III/V transition: 220 nm for the coupling to the GaAs-based SOA (a2) and 70 nm for the coupling to the SiN (a3). After the SiN structures were fabricated (a4), a 30 nm benzocyclobutene (BCB) adhesive layer was spin-coated (a5). Subsequently, the micro-transfer printing of amplifiers took place at a temperature of 80 ºC (a6). Following their complete integration, BCB curing was performed at 280 ºC. Finally, contact pads were metallized to facilitate electrical connections (a7). SEM and optical microscope images of the device are shown in Fig. 1 (b-d). The laser cavity consists of a high reflectivity Sagnac loop mirror on one end and a partially reflective output mirror on the other. To capture the spectrum and the power of the laser, a single mode fiber was aligned to a grating coupler connected to the output mirror. Figure 1 (e) depicts the LIV curves of the device showing a threshold current of around 20 mA. An on-chip optical power of 0.5 mW was measured at a driving current of approximately 40 mA. The corresponding spectrum of the laser is plotted in Fig. 1 (f) along with the amplified spontaneous emission obtained at 10 mA.

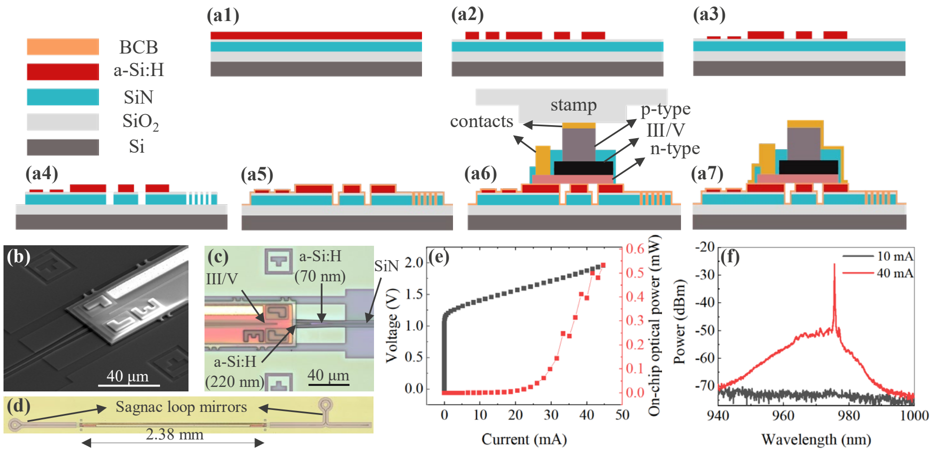

Fig. 1 (a1-a7) Process flow for the fabrication of lasers on SiN. (b), (c) SEM and microscope images of the printed SOA respectively. In (c) the various tapers are shown. (d) Microscope image of the laser cavity. (e) On-chip optical power and voltage as a function of driving current. (f) Spectrum of the laser at a driving current of 10 and 40 mA with a resolution of 60 pm.

In this paper we demonstrate the heterogeneous integration of GaAs-based amplifiers through micro-transfer printing on SiN. By using a-Si:H as an intermediate layer, an evanescently coupled Fabry-Pérot laser emitting in the submicrometre wavelength range was realized with an on-chip optical power of 0.5 mW.

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