

## Type-I and type-II interband cascade lasers emitting around 2.7 $\mu\text{m}$

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### ABSTRACT

We compared the performance of ICLs with different active zone designs (type-I or type-II QW). The type-I ICL showed higher performance than the conventional design, with lower threshold currents and higher operating temperature. These results are promising for improving laser performance at short wavelengths.

### 1. INTRODUCTION

In recent decades, interband cascade lasers (ICLs) have emerged as the leading mid-infrared source, with a performance sweet spot between 3 and 4  $\mu\text{m}$ . Extensive studies have been carried out to extend their operating wavelength range [1]. In contrast, little work has been done at shorter wavelengths, where most applications use type-I laser diodes. However, their performance degrades significantly above 2.5  $\mu\text{m}$  [2]. In this case, developing ICLs in this range could improve laser performance and cover the 2.5 – 3  $\mu\text{m}$  range.

### 2. STUDY DESCRIPTION

In this work, we compare the performance of ICLs using type-I and type-II QWs. Both lasers are designed to emit at 2.7  $\mu\text{m}$ , the first one with a GaInAsSb QW and the second with a conventional W-QW. The structures are grown by molecular beam epitaxy on GaSb substrates and consist of a 5-stage active zone, comprised between two n-doped InAs/AlSb superlattice claddings and two n-doped GaSb separate confinement heterostructures. The lasers are then processed into 100  $\mu\text{m}$  x 2 mm and 8  $\mu\text{m}$  x 2 mm Fabry-Perot cavities using standard photolithography and etching techniques.

### 3. RESULTS

The type-I and type-II ICLs were studied in the pulsed regime at 20°C and showed threshold current densities of 100 A/cm<sup>2</sup> and 360 A/cm<sup>2</sup>, respectively (Figure 1). In CW operation, both structures share a common characteristic temperature of 44 K, but the type-I ICL operates at less than half the threshold current of the type-II ICL. In addition, the maximum operating temperature was of 70°C, whereas the type-II ICL does not exceed 55°C (Figure 2). A study as a function of the cavity length showed that the internal losses were the same for both

structures (7 cm<sup>-1</sup>), but the internal quantum efficiency was much better in the type-I ICL (208%) than in the type-II structure (116%). This result was expected as the recombination probability is higher in a type-I QW due to the better wavefunction overlap.

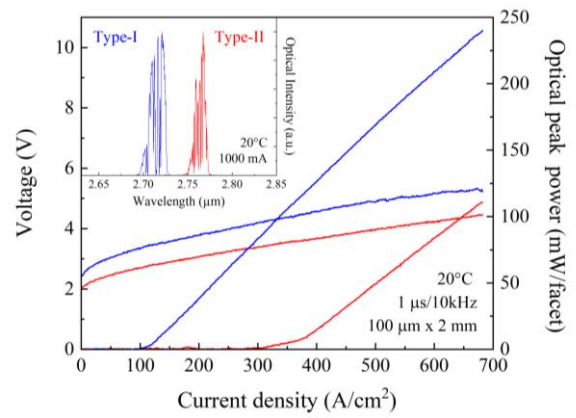


Figure 1: L-I-V curves of broad area type-I and type-II ICLs measured in pulsed regime at 20°C. Insert: Spectra in pulsed regime, at 20°C for an injection current of 1 A.

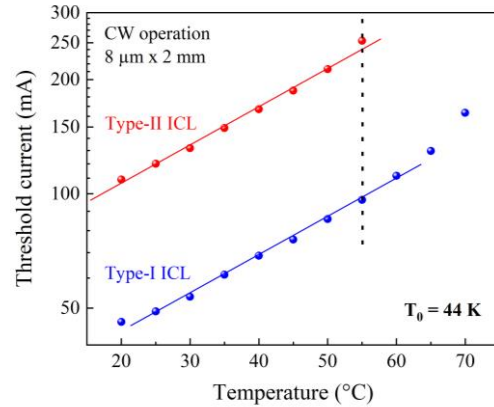


Figure 2: Threshold current vs operating temperature for type-I and type-II ICLs.

### 4. CONCLUSION

These initial results show that while the performance of the conventional ICL design is limited below 3  $\mu\text{m}$ , type-I ICLs open the way to high-performance lasers in the 2.5 – 3  $\mu\text{m}$  range.

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