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Stable single-frequency laser with narrow linewidth emission (< 500kHz), fine tunability over a few GHz and output power in the 0.1W range is required to cold atom interferometry experiments. Until now different approaches have been studied in order to fulfil all these characteristics. Single frequency high power lasers have been demonstrated with distributed feedback diode lasers and tapered extended cavity diode lasers. However, these two solutions suffer from beam quality degradation at high power. A possible alternative solution to obtain a compact and simple single frequency source with narrow linewidth and good beam quality is an optically-pumped semiconductor vertical external-cavity surface-emitting laser (OPS-VECSEL), which has already demonstrated multi watt output power in the fundamental transverse mode [1] as well as high power single frequency operation [2]. Nevertheless the majority of these works using VECSEL are focused around 1µm emission. In this work we evaluate short external-cavities VECSEL for single-frequency emission at 852nm dedicated to Cs atom spectroscopy.

The 1/2-VCSEL chip has been grown by metal-organic chemical-vapor deposition on a 350µm thick GaAs substrate. It is composed by a multilayer Distributed Bragg Reflector, consisted of 32.5 pairs of $AlAs/Al_{0.225}Ga_{0.775}As$ quarter-wave layers resulting in a 99.95% reflectivity at 852nm, and seven 8nm thick GaAs quantum wells embedded between $Al_{0.22}Ga_{0.78}As$ barriers. This chip is fixed on a cooper heatsink, cooled by a Peltier element and optically pumped with a 690nm fiber-coupled diode laser; the pump spot diameter is 62 µm on the structure. The 2mm long cavity with a free spectral range of ~75GHz consists of the semiconductor and an output coupler mirror (Figure 1). Two configurations were studied: the first one uses a 25mm curve mirror as the output coupler; in the second one a plane output coupler is used and the cavity is stabilized by the strong thermal lens generated in the semiconductor chip.

The maximum output power is 106mW with the 2.1%-transmission concave mirror at a chip temperature of T = 15°C (Figure 2). Both configurations are limited by the thermal roll-over around 0.6W of incident power. However the plane-plane configuration has a three times higher laser threshold. Thanks to the short length of the cavity where only few longitudinal modes could oscillate, single frequency operation is obtained without any spectrally-selective intracavity element with a side-mode suppression ratio about 35dB. Stable single-frequency emission within a wide operating range is demonstrated only for output coupler transmissions higher than 2% as high cavity losses reduce competition between adjacent longitudinal modes [3]. The laser line is tuned to the cesium optical transition (~852.1nm) by adjusting the semiconductor temperature and the cavity length.

These first promising results show the prospect of using compact VECSEL as a single frequency source for Cs atomic clocks. The detailed characterization of the spectral properties of the short VECSEL is under progress.

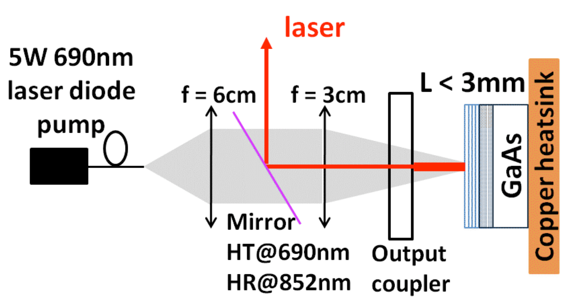

Fig. 1: Optically pumped VECSEL setup.

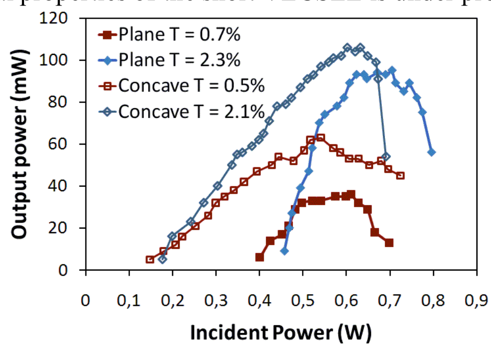

Fig. 2: Laser output power versus incident power for the different configuration and transmission output couplers used ($T_{substrate}$ = 15°C).

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