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Acousto-Optically Tunable Integrated Ti:Er:$LiNbO_3$ Laser

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Wavelength tunable, narrow linewidth lasers are of growing importance for optical communication systems using wavelength-division multiplexing (WDM). A diode-pumped packaged acousto-optically tunable integrated Ti:Er:$LiNbO_3$ waveguide laser was reported by K. Schäfer et. al. [1]. It could be tuned (not continuously) over 31 nm in the wavelength range 1530 nm $<\lambda<$1610 nm with an emission linewidth of 0.3 nm. Here we report an improved version of the laser with a modified design; its tuning range is extended to 47 nm with a linewidth smaller than 12 pm in appropriate operating conditions adjusted.

The architecture of the 94.2 mm long laser is sketched in Fig. 1. 80 mm of the sample are Er-diffusion-doped (21.1 nm; 1130 °C; 150 hrs) prior to waveguide fabrication by standard Ti-indiffusion (7 µm wide Ti-stripes of 104 nm thickness; 1060 °C; 7.5 hrs). An intracavity acousto-optical filter allows the wavelength-tuning of the laser output. The filter consists of two polarization splitters and an acousto-optical polarization converter with a tapered acoustical directional coupler in between [2]. The splitters are designed to route TM-polarized light to the bar-state and TE-polarized light to the cross-state. A second acousto-optical polarization converter serves as compensator for the frequency shift imposed to the optical wave by the first converter. The laser cavity is formed by two dielectric mirrors of ~97.5 % reflectivity, deposited on the waveguide end faces. The end face of the lower arm of the left polarization splitter is AR-coated allowing efficient pumping by a fiber-coupled, Bragg-grating stabilized laser diode of 1480 nm wavelength. TM polarization is necessary to ensure pumping of the laser-active waveguide along the whole length following the dotted path in Fig. 1.

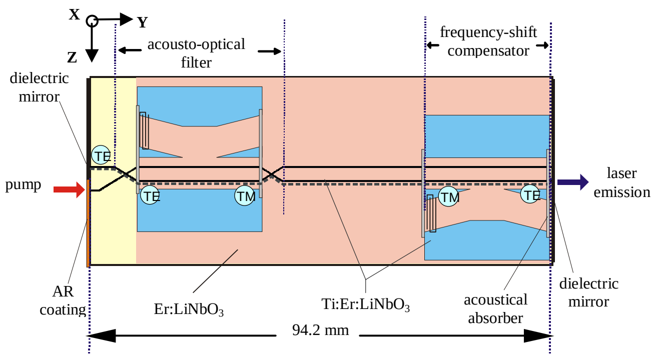

Fig. 1. Schematic diagram of the laser. A TM polarized pump leads to a TE polarized laser output.

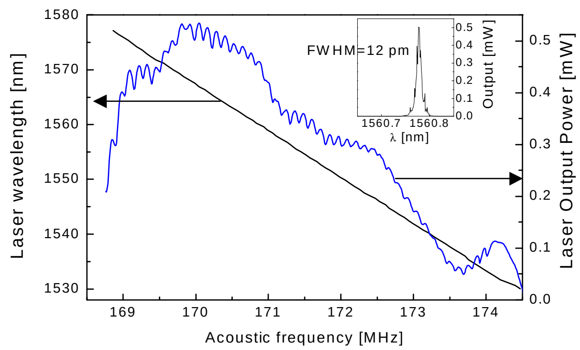

Fig. 2. Emission wavelength and output power (at 135 mW pump power) versus acoustic frequency. Inset: laser emission spectrum taken with a resolution of 10 pm.

Inside the cavity the resonant laser field of a wavelength determined by the acoustic frequency undergoes four times a polarization conversion during one round trip; the states of polarization are indicated in the figure. The laser emission wavelength can be continuously tuned from 1530 nm to 1577 nm corresponding to acoustic frequencies from 174.5 MHz to 168.8 MHz; the tuning slope is about 8 nm / MHz (see Fig.2). With a pump power of 135 mW (in TM-polarization) up to 500 µW output power is obtained. At 1561 nm the laser threshold is 45 mW pump power. The linewidth of the laser emission can be as narrow as 12 pm (see Fig. 2), which nearly corresponds to the spectral resolution of the optical spectrum analyser used. We therefore assume, that the true linewidth is much smaller corresponding to single frequency operation.

By changing the relative phase of both electronic drive signals together with the frequency in an appropriate manner even continuous mode-hop free tuning should be possible. However, it seems to be necessary to shift the polarization converters/frequency shifters in undoped waveguide sections at both ends of the structure to completely avoid spatial hole-burning leading to mode coupling. Such a modified laser architecture will be investigated in the future.

[1] K. Schäfer et. al. (1997), IEEE Journal of Quantum Electronics, Vol. 33, No. 10, pp. 1636-1641.
[2] H Herrmann et. al. (1995), Journal of Lightwave Technology, Vol. 13, No. 3, pp. 364-374.