Q-switched fiber laser using a torsional micro-mirror

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1 Introduction

Micro-optical and micro-electro-mechanical technology has been highlighted during the past 5 years. Thanks to their potential of batch processing and cheap replication these technologies are merging to create a new and broader class of micro-opto-electro-mechanical (MOEM) devices.
The goal of this paper is to study the functionality of a micro-mirror in a switchable opto-mechanical system. For that purpose, we have built a compact pulsed fiber laser with a torsional micro-mirror as switching element.

2 Fibre laser

Figure 1 shows the setup of the Q-switched fiber laser. The fibre laser is based on a $120mm$ long Nd^{3+} doped fiber. The cavity consists of a micro-mirror and a Bragg grating. The fiber laser is spliced on a wavelength division multiplexing (WDM) coupler, allowing to use the Bragg grating as output reflector, while pumping through it. With this configuration, we measured the laser threshold (3 mW) and the slope efficiency (19 %). Figure 2 shows the output power versus the absorbed pump power. The measured value for the threshold is in good agreement with results commonly reported in the literature [1].

3 Torsional micro-mirror

The torsional micro-mirrors ($50\mu m \times 70\mu m$) are fabricated by polysilicon surface micro-machining. They are covered with $2\mu m$ of aluminum [2]. The SEM picture of Fig. 3 shows the address electrode and the landing electrode below the mirror. When a voltage of $35V$ is applied to the address electrode, the electrically grounded mirror rotates by an angle of 2.6^o and hits the landing electrode (Fig. 4).

4 Results

In order to get a pulsed fiber laser, the micro-mirror was actuated at frequencies between $1kHz$ and $30kHz$ to produce a modulation of the resonator loss. In such a configuration, we were able to get pulses which are about 100 times higher than the continuous emission. Figure 5 shows a typical output train at $20kHz$ mirror frequency. The pulse width at half maximum is typically $2\mu s$. If the mirror is operated at lower frequencies, the switching is too slow to get Q-switched pulses; the laser produces multiple pulses, corresponding to relaxation oscillations. Figure 6 shows such relaxation peaks for $7kHz$ mirror frequency.

5 Outlook

We have demonstrated a Q-switched fiber laser using a torsional micro-mirror. The technology for the fabrication of these mirrors is compatible with the fabrication of other micro-optial elements, such as microlenses, fan-out and fan-in elements [3]. Furthermore, arrays of pulsed lasers can be combined with arrays of micro-optical elements in order to form highly parallel optical networks.
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References

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[2] V. P. Jaecklin and al. in *Tech. Dig. IEEE Micro Electro Mech. Syst. Workshop*, Fort Lauderdale, USA, 1993, p.124.

[3] H.-P. Herzig and al. in *Perspectives for Parallel Interconnects* (Springer, Berlin, 1993) p.71.

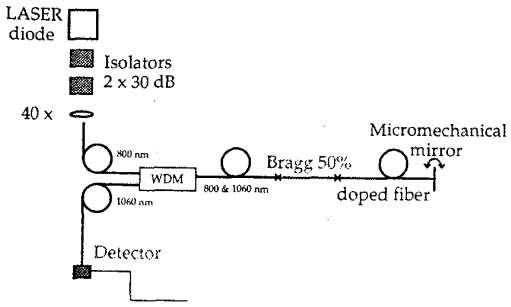

Figure 1: Schematic diagram of the Q-switched fiber laser system.

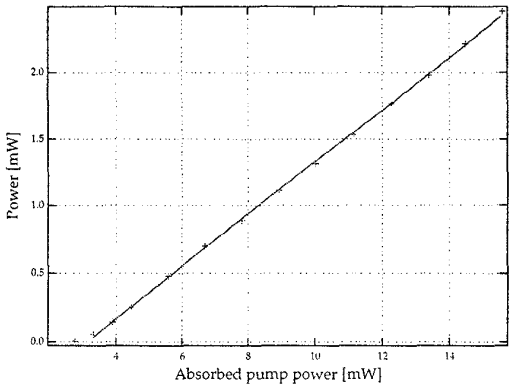

Figure 2: Characterisation of the cavity: output power vs absorbed pump power.

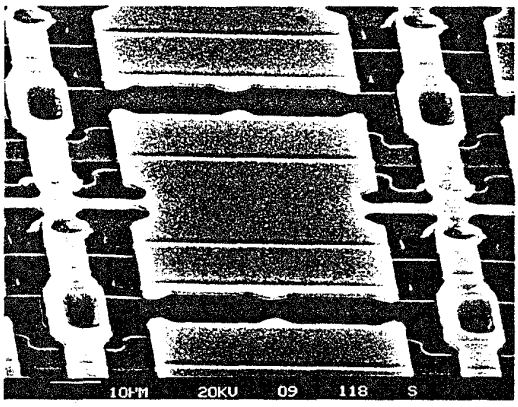

Figure 3: Top view (SEM) of a torsional micro-mirror without metallisation.

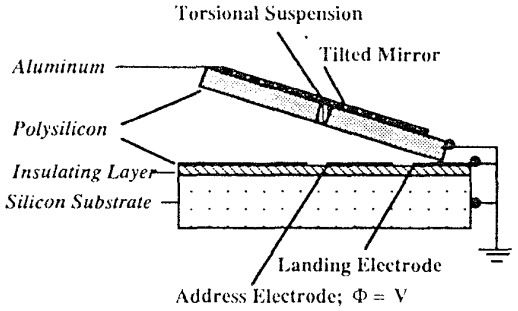

Figure 4: Crosssection of tilted position (schematic drawing).

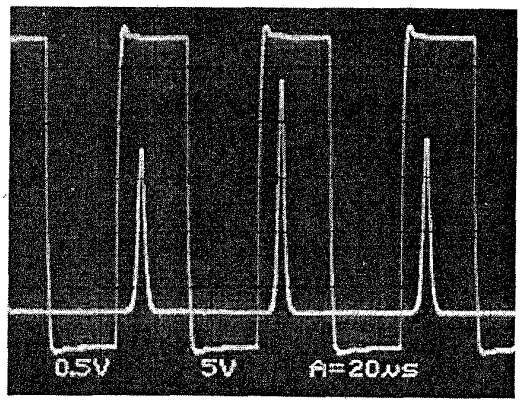

Figure 5: Q-switched output train with repetition rate $f = 20kHz$ and pump power $P = 15.8mW$.

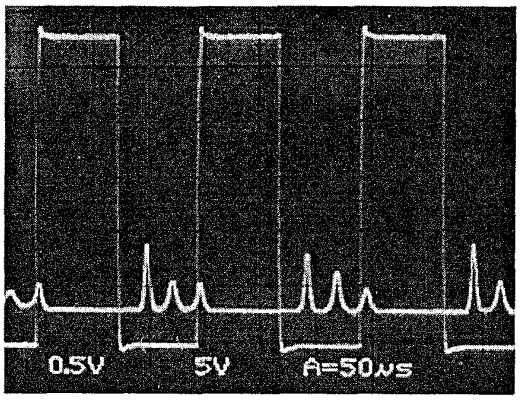

Figure 6: Output train with repetition rate $f = 7kHz$ and pump power $P = 15.8mW$.