

Post-treatment of DBR fibre lasers for enhanced beat-frequency in dual-polarization operation

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Short-cavity fibre lasers, in either DFB or DBR configurations, are well known as compact, efficient and low noise sources. In dual-polarization operation, such dual-frequency fiber lasers (DFFL) may be applied in a wide variety of sensors or as microwave-photonic sources. Indeed, the two polarization modes are split by the fibre birefringence which, in typical DFB lasers with photo-inscribed Bragg gratings, is of the order of 1 GHz. One issue regarding applications of these lasers come from up-scaling the beat frequency in order to meet microwave frequencies relevant for 5G telecoms or radars. Recent works have shown that compression of [1], or side-polishing [2,3], the active medium in DBR fibre lasers could lead to enhanced birefringence, hence higher beat frequencies. In this work we implement post-treatment of DBR dual-polarization fibre lasers using femtosecond UV laser pulses, in order to enhance the beat frequency from about 100 MHz up to 7 GHz.

We use fibre lasers made of co-doped Er:Yb silica fibres. A few cm-long pieces of doped fibre were spliced to regular SMF fibre. Two Bragg gratings were photo-inscribed on each doped sample, leaving a few mm of active medium in-between (from 2 to 6 mm depending on the samples). These lasers are pumped at 980 nm. The 10 mW-power dual-polarized output at 1535 nm is sent through a polarization controller and a polarizer to a 10 GHz bandwidth photodiode; the resulting RF signal is then monitored with an electrical spectrum analyser. During the following post-treatments, the lasers are pumped continuously and beat signals are measured, giving access to real-time birefringence measurement. In a first set of experiments, we have post-treated the active medium with the same 248 nm UV laser as for the photo-inscription process. In agreement with previous results on UV induced birefringence, we find a ten-fold enhancement of the birefringence, leading to beats slightly higher than 1 GHz (see Fig. 1(a)). Using other DBR samples, we directed another set of experiments that aimed at photo-ablating the fibre on one side of the active zone using femtosecond UV pulses at 343 nm (ALPHANOV Technology Centre). Laser operation is maintained during the photo-ablation process, with a dual-polarization beat frequency reflecting the induced birefringence. Starting from the common 125 μm fibre diameter we could reduce the radius by almost 40 μm (0.6 μm removed at each laser scan). The electron microscopy image of the fibre (one broken sample) shows the neat ablation wall in the cladding. As a consequence of the photo-ablation process, the stress-induced birefringence is considerably enhanced: the measured beat frequency starts from 100 MHz ($\sim 10^{-6}$ residual birefringence) up to about 6 GHz (birefringence 8×10^{-5}).

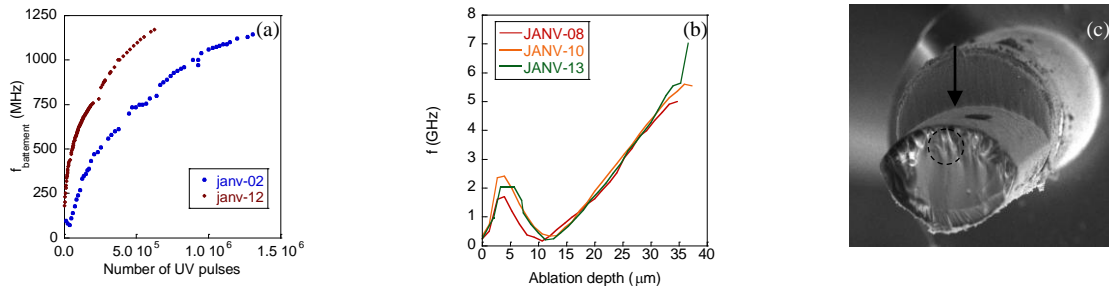


Fig. 1(a) Photosensitivity-induced birefringence in two different samples. (b) Photo-ablation-induced birefringence in three different samples. (c) SEM picture of a broken sample (after ablation down to more than 40 μm).

These first results show that UV photo-ablation of DBR fibre lasers provides an efficient and reproducible means to choose the beat frequency of a DFFL, independently of the active medium length. The peculiar shape of the curves is not fully understood yet but could be due to water removal in the first microns and then to stress relaxation mechanisms. For microwave-photonic applications, beat stabilization schemes demonstrated recently with optical phase-locked loops [4], or frequency-shifted feedback loops [5], could then be implemented to yield ultra-stable microwave-photonic signals. It is also foreseen that such post-treated DBR lasers could be used in sensing applications.

References

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