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Novel InN-based SESAMs with ultra-short time response

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Semiconductor saturable absorbers are becoming a matter of interest since they are keystone elements of pulsed lasers, leading to ultrashort pulses with high peak intensities and wide optical spectra. This kind of ultrafast lasers are empowering new applications in the fields of optical telecommunications and nonlinear optics. In order to improve the radiation source with regard to pulse energy and temporal duration, new saturable absorbers are still under development.

In this work, we study semiconductor saturable absorbers (S1 and S2) consisting of an active InN layer grown by molecular beam epitaxy directly on a 10-μm-thick GaN-on-sapphire template [1]. We compare structures with an InN thickness of 400 nm (S1) and 900 nm (S2). The energy band gap of the samples extracted from optical transmission measurements is $E_{g1} \sim 0.69$ eV (1782 nm) and $E_{g2} \sim 0.70$ eV (1767 nm) for samples S1 and S2, respectively.

The nonlinear absorption of the samples at 1550 nm has been measured by the Z-scan method [2], using a radiation source which delivers 250 fs pulses with an average power of 35 mW and a repetition rate of 5.2 MHz. To increase the power density impinging the sample, the laser is focused with a lens with a focal length of 3 cm in the Z-scan scheme, attaining an energy fluence of $E = 5.2\ \mathrm{mJ/cm^2}$. The nonlinear optical response of the samples is obtained by measuring the optical transmittance as a function of the incident peak intensity on the sample, as depicted in fig 1(a). In both samples, a huge nonlinear change is observed. The linear transmittance at 1550 nm has been estimated in $T_{lin} = 17$ % for S1 and $T_{lin} = 2.6$ % for S2, and the modulation depth is $\Delta T\ (S1) = 22.6$ % and $\Delta T\ (S2) = 21.8$ %, respectively [3]. Thus, sample S1 exhibits a nonlinear transmittance change (T_{ns}/T_{lin}) above ~ 240% at the maximum peak intensity (optical bleaching), whereas for S2 the total change in transmittance reaches 815%. These results reveal that the thickness of S2 is particularly adapted for the fabrication of saturable absorbers at 1550 nm, since it is thick enough to get a low linear transmittance but keeping the maximum modulation depth.

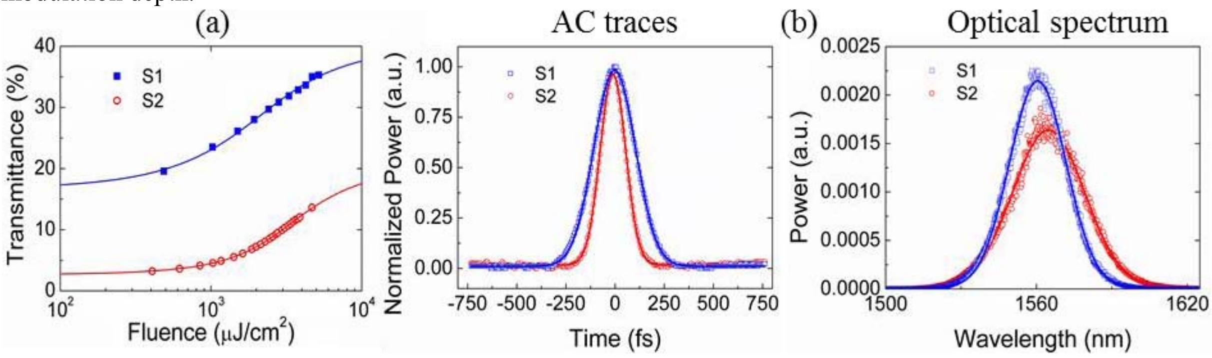

Fig. 1 **(a)** Transmittances of both samples estimated from the Z-scan curves and plotted as a function of the peak intensity. Fit curves are adjusted by equation described in [3]. **(b)** Autocorrelation (AC) and optical spectrum traces of the two samples fitted to a Gaussian pulse.

Semiconductor saturable mirrors (SESAMs) have been implemented by deposition of an aluminium mirror directly on the InN sample surface. Optical fiber mode-locked lasers have been developed with these SESAMs, following the scheme in ref. [4]. The AC traces and optical spectra for lasers using samples S1 and S2 are plotted in fig. 1(b). The traces have been fitted to Gaussian curves with a temporal width of 210 fs for S1 and 150 fs for S2.

In conclusion, we present a new SESAM technology based on InN thin films which displays huge nonlinear effects. Optimized InN layer thickness results in more than 800% change in transmittance, which makes it possible to generate ultrashort pulses with temporal duration as low as 150 fs.

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