Generation of laser pulses by Ag nanoplate based saturable absorbers

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Introduction

Ultrafast lasers are increasingly used in a variety of applications, ranging from sensors, to laser processing, and medicine, where cost-effective, broadband, and simple solutions are highly desirable. In most cases, an intensity-dependent element called a saturable absorber (SA) is used to transform the laser output into a train of ultrashort pulses [1]. Ag nanoplates show strong SA properties with ultrafast nonlinear response, as needed for ultrafast pulse generation. Moreover, they can be produced in liquid phase without any purification [2], significantly simplifying device processing. Here, we report on the optical characterization of Ag nanoplates and demonstrate their use as an SA for a fiber laser operating at 1032 nm.

Methods

Ag nanoplates are fabricated in two steps. Spherical Ag particles are firstly obtained by chemical reduction of $AgNO_3$ by $NaBH_4$, in presence of trisodium citrate as stabilizing agent, and secondly converted into flat triangular nanoplates by hydrazine and citrate. The so-obtained nanoplates are characterized by Scanning Electron Microscopy (SEM), UV-Vis absorption spectroscopy and open aperture Z-scan nonlinear measurements (Fig.1). The nanoplates are then deposited on top of an optical fiber connector, by optical deposition, and integrated into an Yb-doped fiber laser cavity with ~0.385 ps^2 total dispersion (Fig.2).

Results and Discussion

The Ag nanoplates feature a plasmon resonance that can be widely tuned across the visible and IR range, by simply varying the amount of Ag nanoplates subjected to transformation into the nanoplates [2]. For our laser, we prepare a solution with ~150 nm wide nanoplates, resulting in a plasmon resonance at ~1200 nm, as shown in Fig.1 along with their linear and nonlinear optical properties. The laser output characteristics are presented in Fig. 3. Dual-wavelength mode-locking is achieved at the center wavelength 1031.92 and 1033.24 nm. The pulse duration, repetition frequency, and average output power are 293 ps, 11.43 MHz, and 5.6 mW, respectively. This demonstrates the flexibility of our solution-processed Ag nanoplates-based SA, making it a promising candidate for a variety of stable and low-cost ultrafast lasers.

References

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2. G. Compagnini, et al., J. Nanomater. 7084731 (2019)