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Effect of gold-nanoparticle size on microfiber saturable absorber for mode-locked erbium-doped fiber lasers

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ABSTRACT

The optical performance of passively mode-locked erbium-doped fiber laser incorporating gold-nanoparticles (Au-NPs) of different sizes as saturable absorbers (SAs) was compared. A composite of Au-NPs with polydimethylsiloxane was spin coated on the surface of a microfiber waveguide. The fabricated Au-NP-based SA was deployed in a ring cavity erbium-doped fiber laser and its lasing performance was evaluated by comparing SA characteristics as well as pulse qualities among the different Au-NP sizes. The optimum pulse performance was realized when the SA was fabricated with 20 and 40 nm Au-NP size. For the former, time-bandwidth product of 0.34 was demonstrated which was the closest to its bandwidth-limited pulse. As for the latter, the fabricated SA exhibited 4.0% modulation depth and an average pulse duration of 886.7 fs. The research work has demonstrated the functionality of Au-NPs as a saturable absorption material for ultrashort pulses generation. In addition, the influence of nanomaterial size towards the characteristics of saturable absorbers, ergo the quality of laser pulse, was verified. This finding is also valuable in customizing ultrashort pulse output that can effectively suit system performance need.

1. Introduction

The quest for new material with robust optical saturation absorption property suitable for ultrafast pulse laser generation is still on going. This includes metallic nanostructures, a material known for its surface plasmon resonance (SPR) effects [1]. SPR is the resonant oscillation of conduction electron stimulated by incident lights at the metallic particle's surface [2]. Currently, metal nanoparticles such as gold and silver have seen various applications in chemical and biological sensing [3,4], microscopy [5], and solar cells [6,7]. Light confinement effect due to the plasmonic structures of metal nanoparticles plays a vital role in the development of novel nonlinear optical devices [8,9]. Amongst metallic nanostructures, gold nanoparticles (Au-NPs) have been extensively employed and studied owing to their distinctive absorption spectra in the region of SPR [10], which opens up an exciting potential for ultrashort pulse laser generation.

Measurement using an open z-scan picosecond white light supercontinuum has shown that Au-NPs possess saturable absorption

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