Preliminary study of MoS_2 based saturable absorber used for crystal based mode locking laser system

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Abstract

Due to the extremely high pulse peak power produced by ultrafast laser and its potential applications for precious material processing and cutting e.g. sapphire wafer surface processing [1] for mobile phone display technology, it has attracted great interests from the laser photonic industry [2]. Apart from Semiconductor Saturable Absorber Mirror (SESAM), the carbon based materials e.g. carbon nano tube or graphene and graphene oxide materials have demonstrated mode locking successfully by using different types of gain materials with operational wavelengths at near 1 micron [3-5], 1.3 micron [6], 2 micron [7], confirming their wide operational waveband properties. These carbon based absorbers can be fabricated by some simple technique that can be used for mass production of the absorber e.g. dip coating [5], ultrasound, chemical process etc.

2D layered transition metal dichalcogenides, TMDs, e.g. MoS_2 offers a wide range of intrinsic open band gap structure and favourable electrical and optical properties. Compared with graphene, MoS_2 has larger distance of the neighbouring layers (0.62 nm) than that of the carbon layers (0.34 nm) in graphite, leading to weaker Van Der Waals (VDW) force between inter-layers and being easily separated from bulk MoS_2 [8]. Additionally, their intrinsic open bandgap leads to its direct bandgap semiconducting properties, offering great potential for electronic and optical devices e.g. transistors [9], optical limiter [8], solar cells [10] etc.

Recently the mode locking operation has been demonstrated by using MoS_2 based saturable absorber in Yb fiber and Yb:Er fiber laser systems to generate ultrafast pulses operating at ~1μm [11] and ~1.5μm [12-14]. However, due to the limitation of fiber structure, the laser output power is limited to several mW [11]. Higher average output power can usefully be achieved by using diode pumped crystal laser [5].

The APCVD, Atmospheric Pressure Chemical Vapor Deposition, -grown MoS_2 film on quartz substrate [15] has been used as saturable absorber in the Nd:YVO_4 crystal laser system to produce mode locking pulses successfully for the first time as shown in Fig. 1. The Raman spectrum of the MoS_2 absorber has been shown in Fig. 2(a), with the Transmission Spectrum of the MoS_2-SAs samples of different initial transmission ratio had shown in Fig. 2(b). The preliminary mode locking features from this MoS_2 based Nd:YVO_4 crystal laser with repetition rate agree well with the laser cavity round trip time as Fig. 3 shown. These results indicate these MoS_2 based saturable absorbers offer great potential to be used for high power ultrafast mode locking laser. For next step, we are planning to add a protective layer on the MoS2-SA to further improve the output pulses stability and output power.

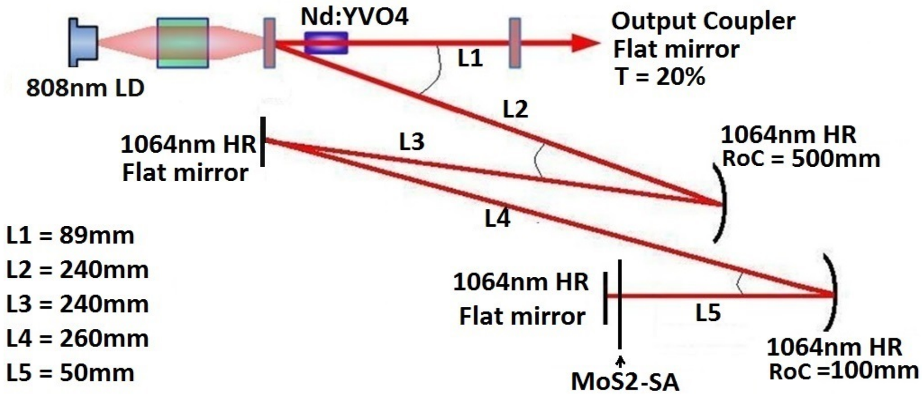

Fig 1. The schematic diagram of laser, HR-High reflection, T-Transmission ratio, RoC – Radius of Curvature of the mirror.

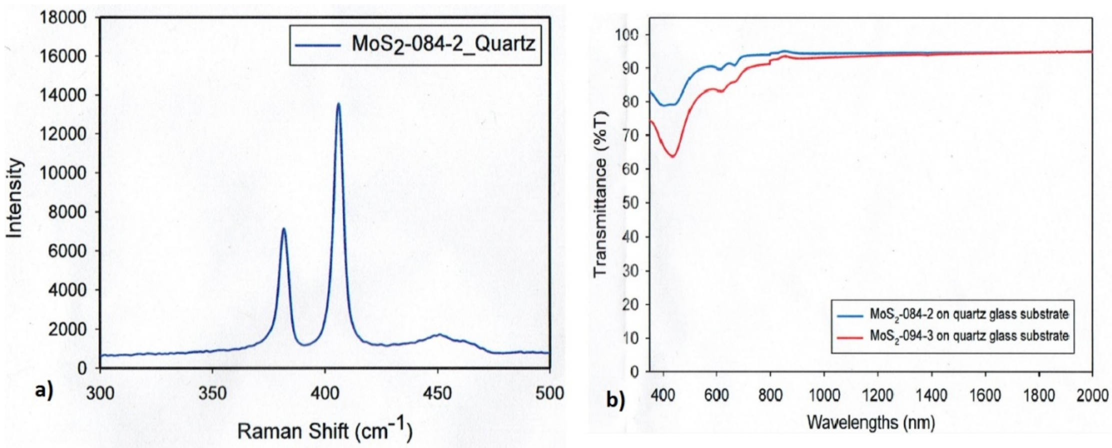

Fig. 2 (a) Raman spectrum of MoS2-084-2 quartz sample. (b) Transmission spectrum of the MoS2-SA samples.

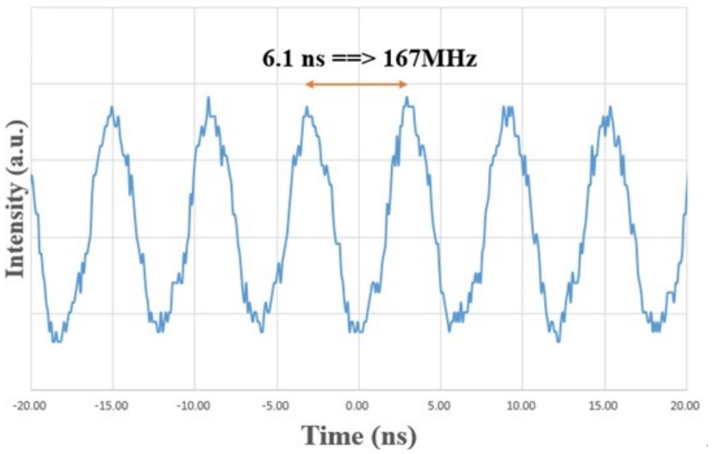

Fig. 3. The mode locked pulse train generated by using MoS2-SA.

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* A full paper should be submitted separately if authors intend to submit one.