Deposition of the $MoSe_2$ Ethanol Dispersions on Tapered Fiber

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Abstract— The method of Ethanol catalytic deposition (ECD) had been proposed and demonstrated in the deposition of $MoSe_2$ on the tapered fiber. ECD method can significantly improve the velocity and the efficiency of deposition. In our work, we used the ECD method to deposit the two-dimensional (2D) $MoSe_2$ materials to prove that the ECD method can be applied to many similar 2D materials. Also, we compared the ECD method to the conventional optical driven deposition using water and organic solvent and verified the effectiveness of ECD method. One of the influential factors, i.e., injected optical power was also discussed.

1. INTRODUCTION

After the discovery of graphene, people began to pay attention to the two-dimensional (2D) materials for their abundant electronic and photonic properties [1–3]. These materials include graphene, graphene oxide, topological insulators, and transition metal dichalcogenides (TMDs). Among various properties of 2D materials, people have intense interest for the nonlinear property. The nonlinear property can be used for saturable absorption, which means the transmission of the material is dependent on the incident optical intensity [4]. The beam of higher intensity would have higher transmission. The saturable absorptive property is important for Q-switched lasers and the mode-locked lasers [5, 6]. To verify the nonlinear property of materials such as $MoSe_2$, it is effective to deposit the $MoSe_2$ [7–9].

In this paper, we use the Ethanol catalytic deposition (ECD) method to deposit the 2D material $MoSe_2$. And we compared it to the conventional optical driven deposition using water or organic solvent to prove that ECD method can significantly improve the velocity and the efficiency of deposition. At the same time various influential factors in deposition such as optical power was well studied to better control the deposition process. We believe this easy, effective and controllable deposition method will play an important roles in the further research on the optical nonlinearity of 2D materials.

2. EXPERIMENT AND RESULTS

The experiment setup was similar to a conventional setup for optical driven deposition. The difference was that we used the ethanol as a solvent. The setup of $MoSe_2$ deposition on the tapered fiber was shown in Fig. 1. The temperature of the experiment was 25°C. The wavelength of input light is near 1550 nm generated by a continuous wave laser and amplified by a commercial erbium-doped fiber amplifier (EDFA) to about 19 dBm. We fixed the tapered fiber in a slot of a slide glass. The output light would be monitored by an optical power meter after a 20 dB attenuator. This attenuator was set for the output power to meet the measurement range of the power meter. Meanwhile we also used a microscope to observe the progress of the deposition.

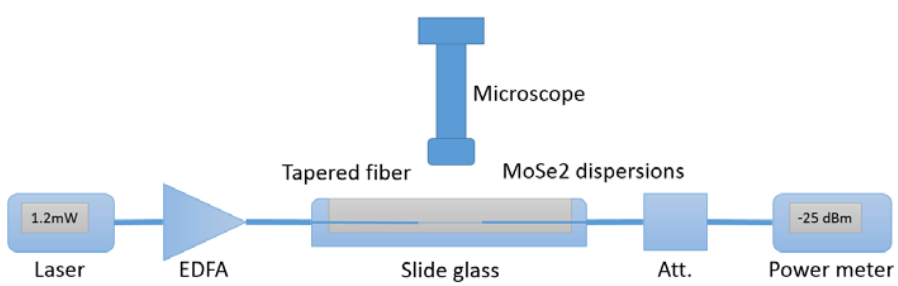

Figure 1: Experimental setup for ethanol catalytic $MoSe_2$ deposition on taper fiber.

When the experiment began, the input light went through the tapered fiber and attracted the $MoSe_2$ nanosheets to deposit onto the tapered fiber. The output power was continuously decreasing, and it meant the loss of the tapered fiber was increased. The diameter of the tapered fiber was fixed to 9 μm diameter and the input optical power is 19 dBm.

To compare the effects of different solvents in the deposition process, we also used water and DMF as the solvents for the deposition process. The diameters of the tapered fibers were fixed to 9 μm, and the input optical power was fixed to 19 dBm. The measurement results are shown in Fig. 2. From this figure, we can obviously observe that the deposition rate of $MoSe_2$-ethanol dispersion is about 4.2 times higher than that of $MoSe_2$-DMF dispersion and 8.1 times higher than that of $MoSe_2$-water dispersion. These data mean ECD method can significantly improve the velocity and the efficiency of deposition than the conventional ways.

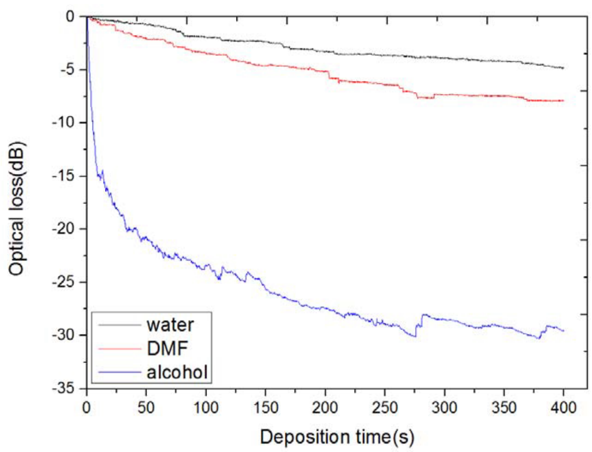

Figure 2: Deposition process using water, DMF and ethanol as solvent.

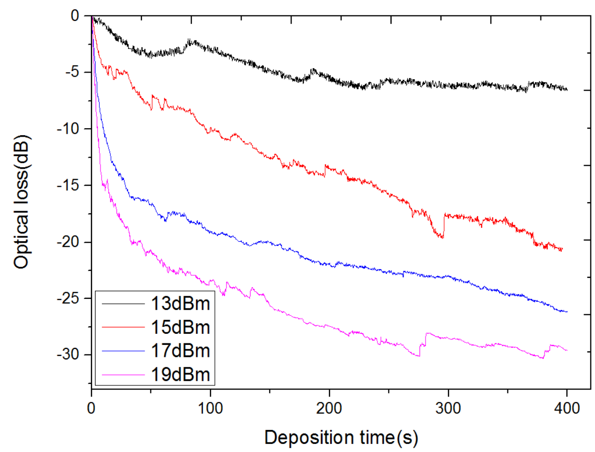

Figure 3: Deposition progress using different input power.

3. DISCUSSION

To investigate the influence factors of the deposition process, it is necessary to control the input power in different situation. Four different input power levels, 13 dBm, 15 dBm, 17 dBm and 19 dBm, were used for comparison. The measurement results of the different input power are shown in Fig. 3.

It can be observed that the speed of the deposition became faster with the increase of the input power. It is because that the higher input power have stronger light force to attract the $MoSe_2$ nanosheets deposited onto the tapered fiber. When the higher power light went through the tapered fiber, the ethanol solvent became easier to volatile and the Brownian motion became faster. Thus more $MoSe_2$ nanosheets would attach onto the tapered fiber and the change of the fiber loss would be larger. It can be concluded that in a suitable range of the input power the higher of the input power, the faster of the deposition process.

4. CONCLUSION

In this paper, we have investigated the ECD of $MoSe_2$ dispersions on the tapered fiber. We proved that the ECD method can suitable for another 2D material. In the deposition driven by ECD method, the movement speed of the $MoSe_2$ nanosheets is significantly increased whereas the deposition quality was nearly unaffected. Compared to the deposition with the DMF and water being the solvent, the ECD method have many advantages, such as faster deposition, easier control and higher quality. We believe our research can be helpful to further research on Q-switched and mode-locked lasers.

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