Session Time: August 1, 2018 from 2:00 PM to 3:30 PM
CLEO Pacific Rim(2018)

Strong MoS_2 Photoluminescence on Graphene for Coupling with Silica Microcavity

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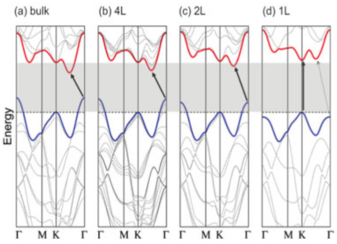
Abstract

Few studies have been reported on the integration of the 2D material on silica toroid cavity. This is because the cavity shape is curved thus being difficult to transfer monolayer onto the surface. The goal of this study is to understanding the interaction between the toroid cavity and MoS_2 monolayer by transferring the monolayer to the fiber tip and placing it close to the cavity. The optimum structure of the cavity is obtained with FEM. This experiment revealed that the insertion of a buffer graphene layer between MoS_2 and silica substrate (material with which we will fabricate the microcavity structure) will successfully enhance the emission and will enable us to perform cavity QED experiments.

Background

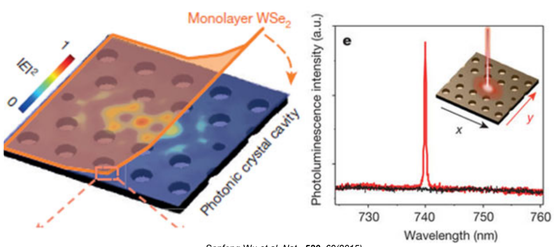
Band diagram of the MoS_2



A. Splendiani et al., Nano. Lett., 10, 1271 (2010)

MoS_2 evolves from an indirect bandgap to a direct bandgap semiconductor when thinned to a monolayer.

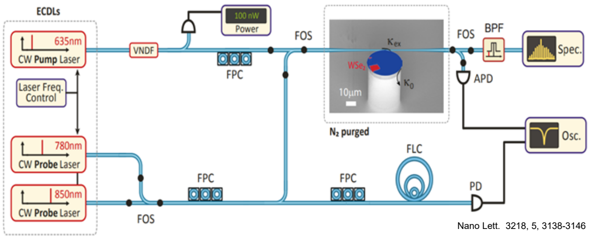
Photonic nanocavity



Sanfeng Wu et al.,Nat., 520, 69(2015)

Monolayer is transferred to the 2D photonic crystal. Spontaneous emission rate is enhanced by Purcell effect.

WGM microcavity



Nano Lett. 3218, 5, 3138-3146

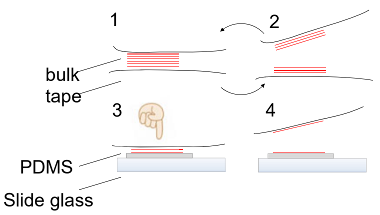
Monolayer is integrated with high-Q WGM silica disk cavity. By using taper fiber, monolayer is effectively excited.

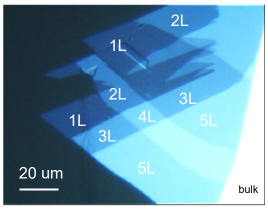
Monolayer fabrication

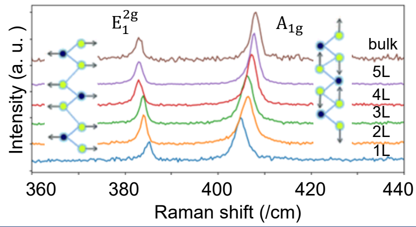
- Mechanical exfoliation
- CVD (MBE)
- Dispersion liquid

Advantage of the exfoliation

- Low cost
- Easy
- Relatively large size (20 um square)

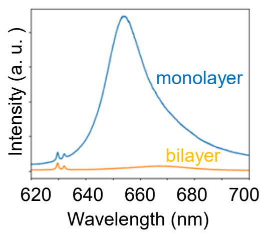


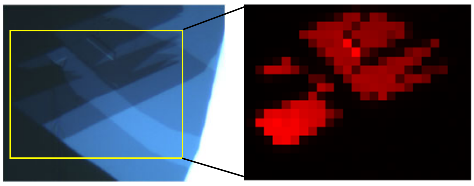




PL intensity and cavity structure

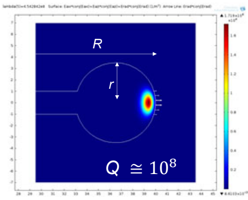
1. Optical property of the monolayer





Mapping @660 nm PL intensity

2. Light confinement in the cavity



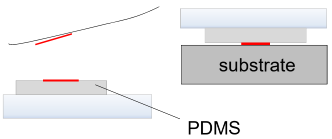
$$\text{Evanescent field ratio} = \frac{\int |E|^2_{\text{outside the cavity}}\, dr}{\int |E|^2_{\text{all}}\, dr}$$

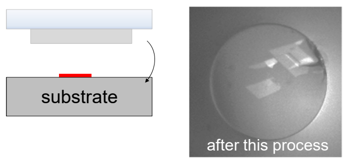
	r=2 µm	r=3.5 µm	r=5 µm
R=40 µm	0.792%	0.748%	0.697%
R=60 µm	0.532%	0.497%	0.471%
R=80 µm	0.403%	0.373%	0.347%

Small Major-R and minor-r is appropriate to enhance the interaction

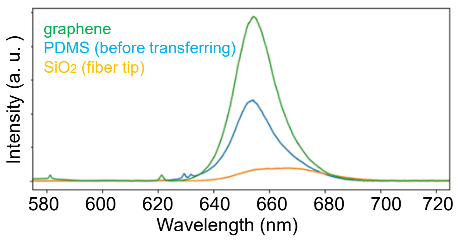
Influence of the substrates

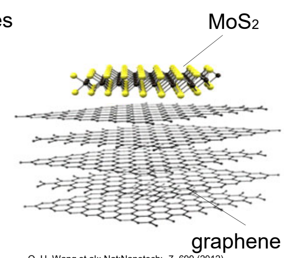
1. Transferring monolayer to the substrate





2. Monolayer PL intensity on various substrates





Q. H. Wang et al.; Nat.Nanotech:, 7, 699 (2012)

Future plan

1. Determination of the best substrate

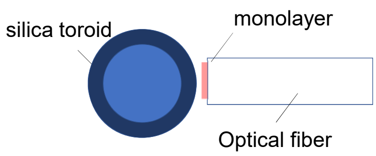
Very sensitive to
dangling bond
Surface roughness
Impurity
2D material is good candidate

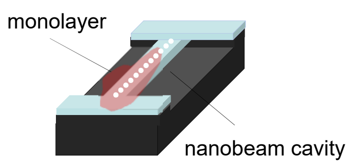
→

Other TMDs
h-BN
Graphene
or Sandwich structure…

2. Integration of the MoS_2 with silica toroid or photonic cavity

- PL enhancement due to Purcell effect $F = \frac{3Q}{4\pi^2 V}\left(\frac{\lambda}{n}\right)^3$
- Nonlinear effect by strong intra-cavity power





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Strategic Information and Communications R&D Promotion Programme (SCOPE), from the Ministry of Internal Affairs and Communications (MIC) (#152103015).

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