A REVIEW ON TWO DIMENSIONAL MATERIALS

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Objectives:

With the decreasing of atomic thickness can bring tunable properties in 2D materials. This work is specially focused on transition metal di-chalcogenides (TMDCs) which shows semiconductor properties when reduced to a single monolayer. The objectives in this work are:

1-Synthesize and study the properties of 2D materials deposited by Langmuir Blodgett balance method.
2- Study the characteristic behavior of monolayers of these materials at Terahertz frequency range.
3- Design and simulate devices working at Terahertz frequency range

Introduction:

Two dimensional materials have distinctive band structure along with astonishing electronic and optoelectronic properties which contributed to its growing fame. In a 2D material each layer have a covalent bond with dangling bond free surface and a week van der Waal's force between the layers makes it easy to obtain single layer from bulk crystal. The indirect bandgap which lies below the direct bandgap shifts upwards with the decrement in the thickness of the bulk materials to a single monolayer. This single monolayer exhibits an increase in luminescence quantum efficiency as compared with the bulk material. This work focused on the study of optical characterizations of monolayers of the transition metal di-chalcogenides (TMDCs) in terahertz spectrum. These monolayers are synthesized using Langmuir Blodgett Balance experimental technique which uses the surface pressure created at the air and water interface to fabricate a single monolayer.

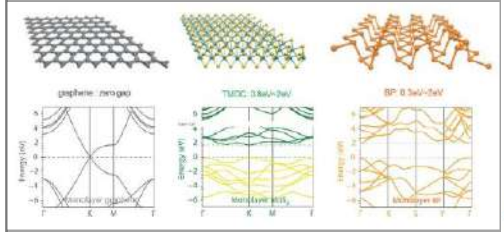

Fig. 1 Lattice structure and bandgap of different two-dimensional materials monolayers.

Experimental Details:

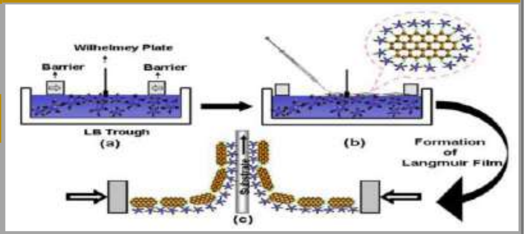

Fig. 2 Schematic diagram of Langmuir Blodgett Balance technique

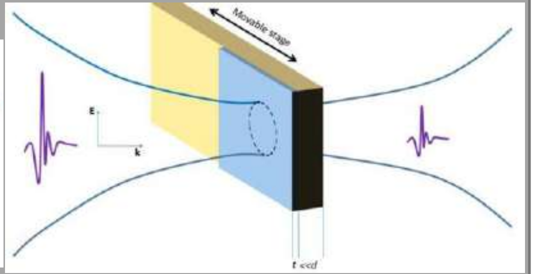

Fig. 3 Schematic diagram of Terahertz spectroscopy characterization

Discussions:

Terahertz spectroscopy of Sapphire and SiO$_2$ substrates at Transmission mode and Reflection mode:

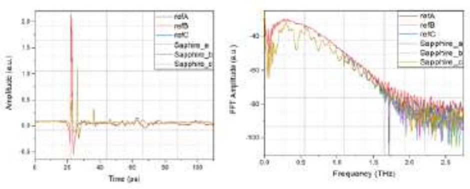

Fig. 4 Terahertz spectroscopy of Sapphire substrate in Transmission mode

Measurements	Amplitude	Time (ps)
Reference A	2.125	22.47
Reference B	1.127	25.93
Reference C	1.127	25.93
Sapphire_a	1.115	26.08
Sapphire_b	1.142	25.93
Sapphire_c	1.144	26.08

Table 1 Measurements of Amplitude and Time of Sapphire substrate in Transmission mode

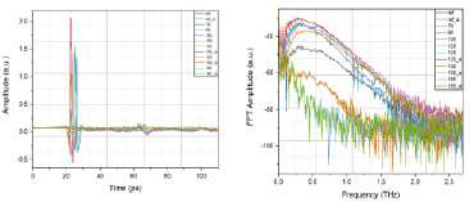

Fig. 5 Terahertz spectroscopy of Silicon oxide substrate in Reflection mode

Angle	Amplitude	Time (ps)
Reference	2.062	22.75
70°	1.359	25.93
90°	1.542	25.17
105°	1.452	23.83
120°	1.052	22.91
135°	0.414	22.47
150°	0.135	22.62
165°	0.106	24.28

Table 2 Measurements of Amplitude and Time of Silicon oxide substrate in Reflection mode

Summary:

Monolayers of TMDCs like MoS_2, $MoSe_2$, WSe_2, etc. have some intrinsic properties which makes them potentially eligible for future high frequency computing devices. This work is still at initial stage and further optical characterizations can also check the optical efficiency of the single monolayers of TMDCs. These monolayers has also been predicted better quantum efficiency for optoelectronic device such as photodetectors.

References:

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