From: "ynm" <ynm@iitk.ac.in>
Subject: [Scdt] Thesis Defence : Shikha Srivastav (MSP) on Electronic Properties of MoS2 Flakes
Date: Mon, September 12, 2022 8:54 pm
To: "FACULTY" <faculty@lists.iitk.ac.in>
Cc: MS698A@iitk.ac.in,"Scdt" <scdt@lists.iitk.ac.in>,"Shikha" <shikhasr@iitk.ac.in>,dhar@phy.iitb.ac.in,"Rajeev Gupta" <guptaraj@iitk.ac.in>,"Siddhartha Panda" <spanda@iitk.ac.in>,sudiptad@iitk.ac.in

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Indian Institute of Technology Kanpur

Materials Science Programme

Ph.D. Defence Seminar

Title: " Electronic properties of multilayer MoS_2 flakes: a study based on isotype diode"

Speaker: Shikha Srivastava

Date: 16 September 2022 (Friday)

Time: 3.00 pm (IST)

Join Zoom Meeting

https://iitk-ac-in.zoom.us/j/93242118428?pwd=VTFEbnFTcDRUdVc5dmlaRWdwcytJZz09

Meeting ID: 932 4211 8428

Passcode: 135494

Abstract:

Layered molybdenum disulfide (MoS_2) is a promising n-type semiconductor having an inherent bandgap in its bulk as well as in monolayer form. Multilayer molybdenum disulfide (m-MoS_2) has attracted much attention due to the indirect bandgap (1.2 eV) and wide spectral response. A lot of applications utilize multilayer MoS_2 flakes based heterostructures over the years. Among them, MoS_2|ZnO based devices is found to be suitable for charge separation and charge transport processes. However, the electrical properties of such devices are yet to be studied in detail.

In this thesis, we seek to study the transport properties across MoS_2|ZnO heterointerface. We utilize MoS_2 flakes, exfoliated from natural and synthetic MoS_2 single crystals in view of their possible applications in electronic devices. For this purpose, Au|m-MoS_2|ZnO isotype device is fabricated and characterized through temperature dependent current-voltage (J-V), capacitance-voltage (C-V), and Impedance analysis. The fabricated isotype device exhibits a rectification ratio of the order of ~103 over the measured temperature range of 19 K to 300 K. Temperature dependent J-V characteristics reveal that while tunneling is dominant at low temperature, diffusion mechanism controls the charge transport in the high temperature regime. The barrier height due to band-alignment at the interface is found to have Gaussian distribution with a mean energy of 0.95 eV. We also report charge carrier freezeout due to de-ionization of the dominant donor in MoS_2 at a characteristic temperature of approximately 37 K, which correlates with features of both J-V and C-V characteristics.

Further, a detailed temperature dependent analysis of the complex part of the impedance spectra Im (Z) in the space charge limited current (SCLC) regime is used to determine the inter-layer charge carrier mobility($\mu_\perp$) in m-MoS_2 flakes obtained from two different sources. The calculated inter-layer mobility exhibits $\mu_\perp \sim T^\delta$ temperature dependence with δ~0.9-1.6 and thereby revealing that impurity scattering is the dominant mechanism. A further confirmation that the mobility is limited by charged impurity scattering comes from the observation that it improves for temperatures lower than a characteristic temperature, which marks deionization of donor impurities.

In the last section, we have investigated the density and distribution of deep defect states in these MoS_2 flakes using temperature-dependent admittance spectroscopy. The defect density of states shows Gaussian distribution, and density was found to be around 10^{14} and 10^{13} $cm^{-3}eV^{-1}$ in the natural and synthetic MoS_2 flake-based devices, respectively. Both types of material showed a deep level around 0.8 eV below the conduction band edge, indicating the common origin corresponding to these defect states. In Synthetic MoS_2 flakes, an additional defect state at around 0.7eV was detected. It is for the first time that the defect

distribution in MoS_2 flakes have been obtained using this direct differential capacitance method, which was enabled by the Schottky barrier device structure used in this study.

These investigations will pave the way for defect engineering in multilayer MoS_2 flake devices for electronic and optoelectronic applications.

Y. N. Mohapatra

(Thesis Supervisor)

Dr. Yashowanta N Mohapatra
Professor, Deptt. of Physics
Materials Science Programme
Samtel Centre for Display Technologies
National Centre for Flexible Electronics
Indian Institute of Technology Kanpur
Kanpur 208016 INDIA

Tel: +91 512 259 7033 /6675
Fax: +91 512 259 0914/6620

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