Abstract

In the present dissertation, we have probed the piezoresistive properties of the twin silicon nanowire configuration and polycrystalline MoS_2 MEMS sensor. The piezoresistive response of twin Si nanowire - based junctionless FET has been investigated experimentally and analytically for pressure sensing applications. A top - down approach has been used to fabricate the gate - all- around (GAA) twin Si - NWFET MEMS sensor with nanowire diameter 20 nm and channel length 170 nm). The de- vice shows excellent sensitivity for the applied strain up to 350 μm/m. Further, to understand the underlying mechanism, the 3D numerical simulation has been performed. The simulation results reveals that the gauge factor of the GAA JL-NWFET increases with decreasing the nanowire diameter. The 10 nm diameter device exhibits a higher gauge factor $\sim$200 in comparison with larger diameter GAA JL -NWFET. Moreover, to investigate the effect of strain on the charge transport within the nanowire channel, the mobility of the carriers as a function of strain has been extracted from the numerical simulation. It has been observed that the electron mobility increases linearly with increasing strain on the device, which has also been reflected in the drain current of the GAA JL- NWFET.

The polycrystalline MoS_2 has been synthesized by the hydrothermal method. The thin films of polycrystalline MoS_2 are deposited on the SiO_2/Si diaphragm by spray coating of well dispersed MoS_2 using a shadow mask. To investigate the piezoresistive behavior of polycrystalline MoS_2, the fabricated devices are subjected to the external stress upto 20 kPa. The polycrystalline MoS_2 MEMS sensor shows excellent sensitivity and high gauge factor 92 ± 5. This excellent sensitivity in poly-crystalline MoS_2 system is attributed to the grain boundaries. The linear output behavior shows the good stability of the polycrystalline MoS_2 sensor over the ap- plied pressure range. Further, the fabricated devices are tested for the N_2 gas flow measurements and displays the good accuracy towards the gas flow pressure sensing. Additionally, we have investigated the impact of light on the piezoresisitivity of the polycrystalline MoS_2 MEMS sensor. The simultaneous effect of piezoresistive and optoelectronic results in the enhancement of GF to 108 ± 3.

Further, we have developed the polycrystalline MoS_2 based flexible stress sensor using PET as a flexible substrate. We also successfully demonstrated a new method to passivate (SU - 8 as a passivation 1ayer) the active channel area (polycrystalline MoS_2) to improve its durability in terms of operating stress range. With the in- creasing thickness of the SU - 8, the decrease in GF was observed due to the shifting of the neutral axis. Herein, we have observed a trade - off between the passivation layer thickness and the performance of the devices. Thus, the GF (80 ± 2) of the 2 μm thick SU - 8 passivated device is stable throughout the wide range of stress ($\geq$ 14 MPa), and it is comparable to the GF of non - passivated MoS_2/PET device (GF=102 ± 5; $\leq$ 14MPa).