Electrolytic Gating of High Carrier Density Thin Film Channel of InN and ZnO

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MOTIVATION

- Polymer electrolyte gate induces large surface charge density on thin films, nearly 100 times higher than that of normal insulting metal oxide gates.
- With a typical insulated gate of maximum carrier density change of ~10^{13} cm^{-2} for practical insulator thickness and gate voltages. That is why semiconductors can be gated but a thin film of metal cannot be gated.
- Polymer gate allows carrier density swings of upto ~10^{15} cm^{-2} . However the characteristics of a polymer gate is very different from a normal metal-on-insulator gate.

INTRODUCTION

- We used InN and ZnO devices in Hall-bar geometry, gated with polymer electrolyte by which large density changes are achieved.
- The gate bias leads to a electric double layer (EDL) forming at the channel-polymer interface and charge is induced in the channel electro-statically.

EXPERIMENTAL

- Mechanical etching of InN was done with a Diamond -tipped scriber and ZnO was etched by chemical process.
- EDL-device was fabricated on sapphire with 300 nm (InN) OR 50nm (ZnO) and Ohmic contact pattern was defined by optical lithography followed by thermal evaporation (10 nm Ti/ 40 nm Au).
- Gating was done using Poly Ethelene Oxide (PEO) and LiClO4.
- Polymer electrolyte solution was made in ambient conditions by dissolving PEO and LiClO4 (10:1) in Acetonitrile .
- Solution was mixed by magnetic stirring for 2 hours at room temperature and then allowed to evaporate in a Petri-dish for 3-4 hours.
- After this one drop of the viscous solution was put on the channel forming the gate.
- Hall measurement was carried out with a gate voltage bias at room temperature(300k) in a field up to 0.4T.
- Low temperature measurement was also taken by varying temperature from 300K to 80k by dipping the Dipstick into liquid nitrogen.

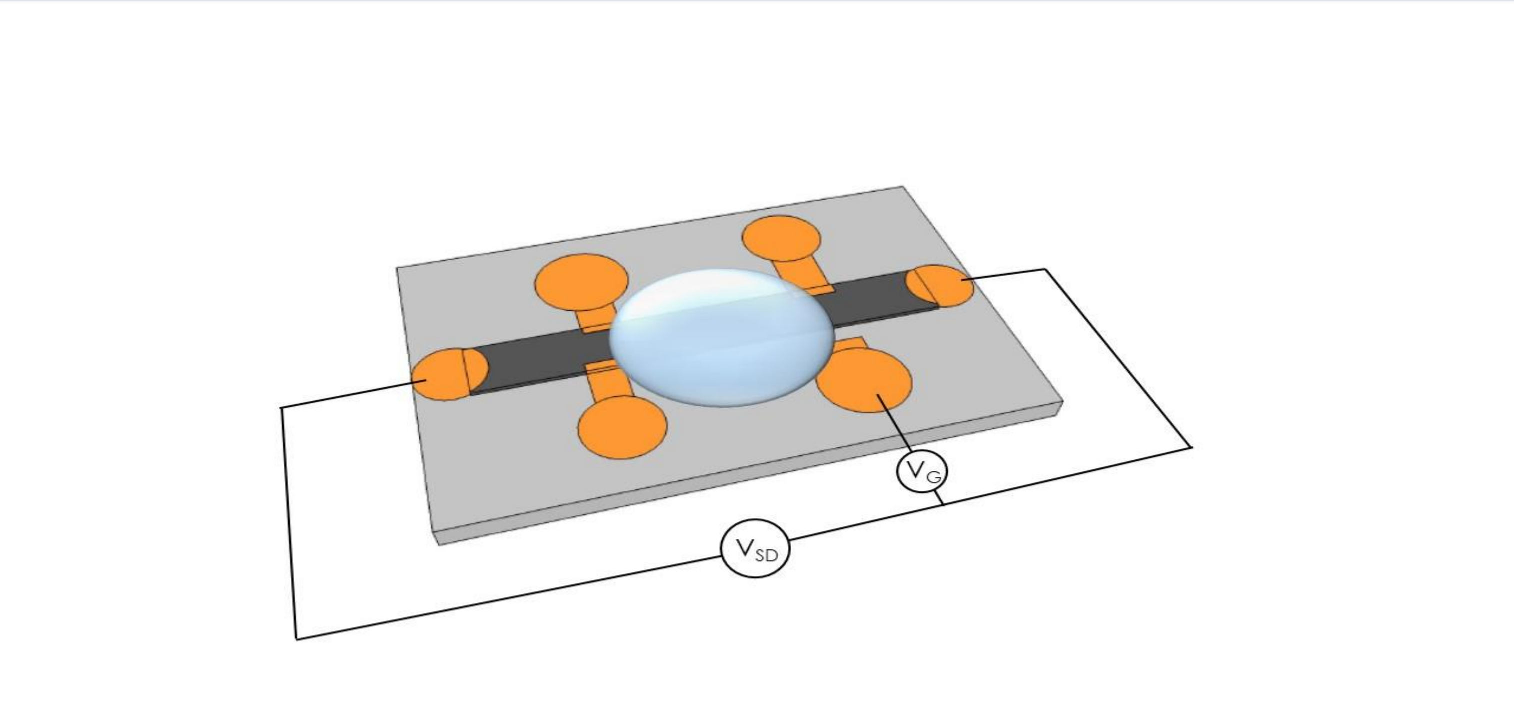

Fig.(1):-Schematic diagram of EDL-FET

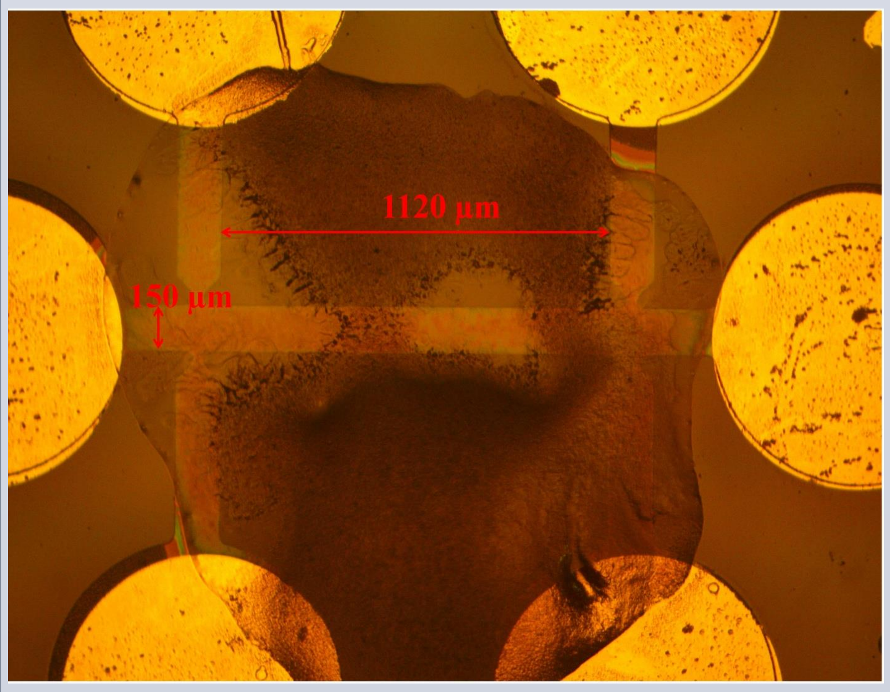

Fig.(2):-ZnO with polymer gate

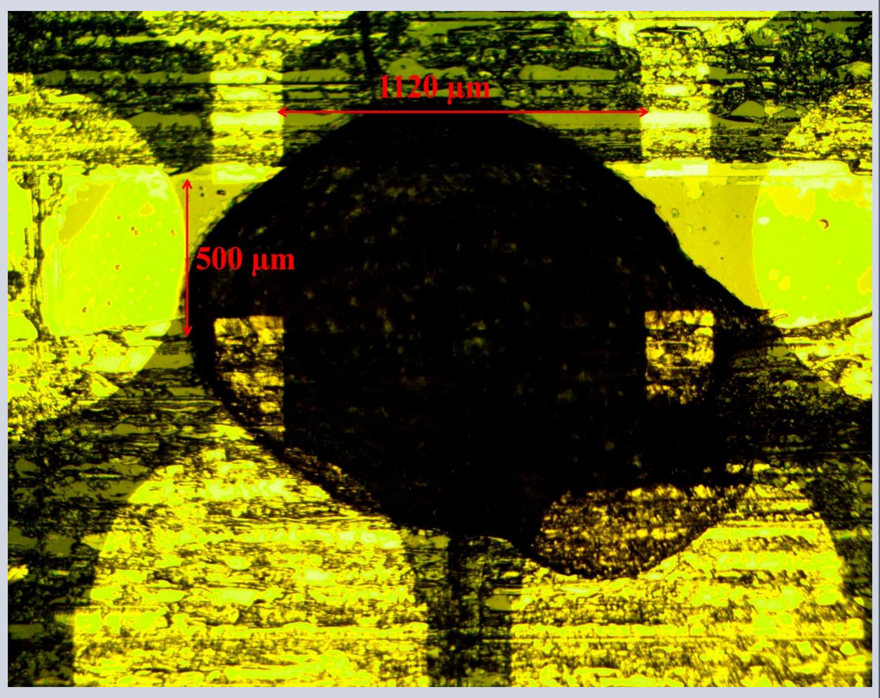

Fig.(3):-InN with polymer gate

RESULTS

- From fig.(4 AND 5) it can be seen that current through channel can be well controlled by gate voltage(Vg).
- Fig(7). Shows the temperature dependence of the conductance for fixed Vsd measure in the range 300 – 80K.

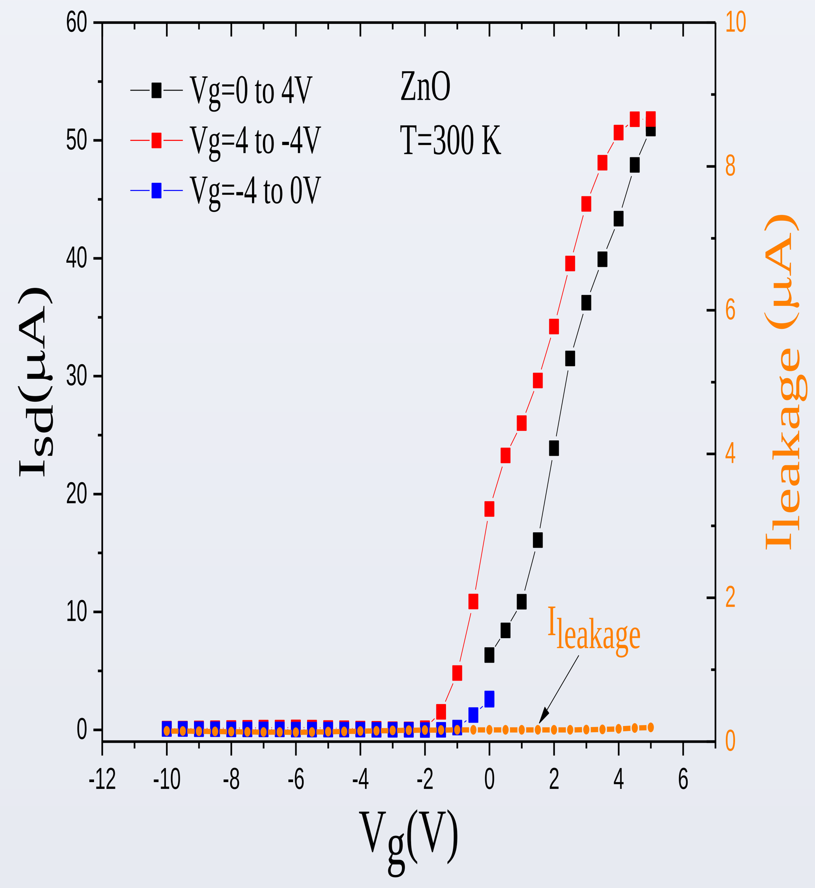

Fig.(4):-Transfer Characteristics (Ids – Vg)

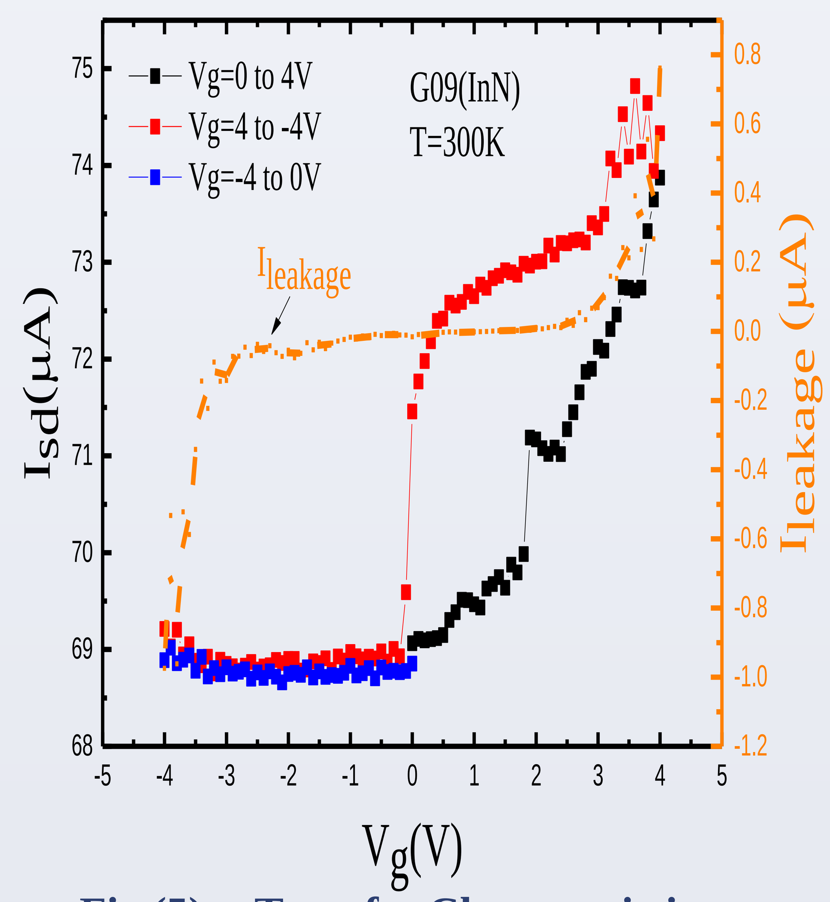

Fig.(5) :- Transfer Characteristics (Ids – Vg)

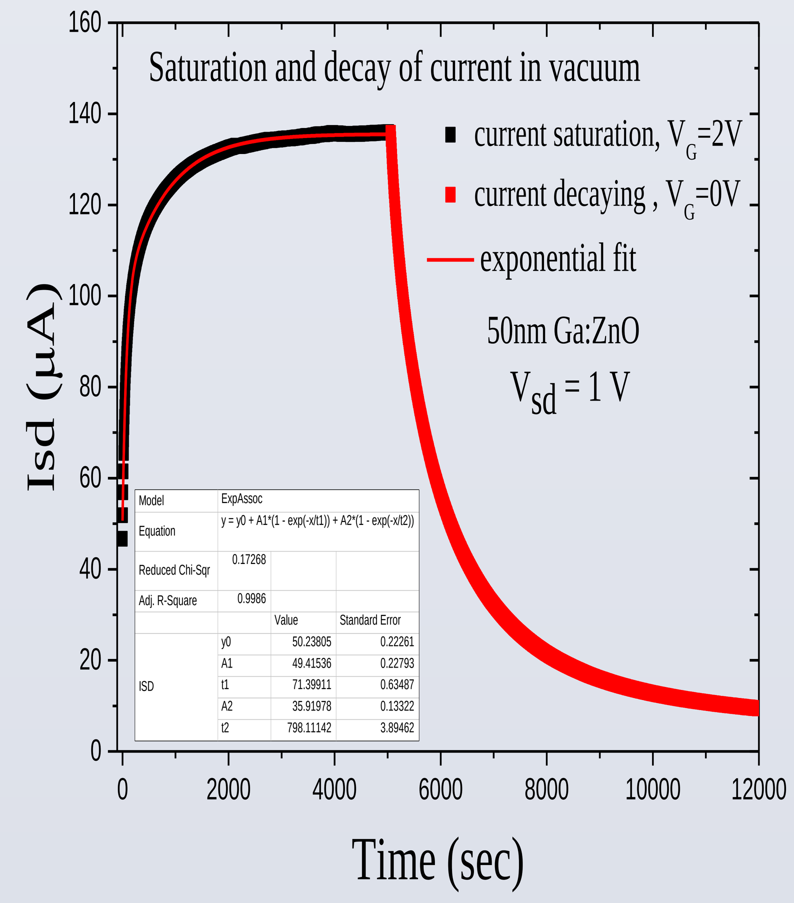

Fig.(6):- Slow Gate Response at room temperature

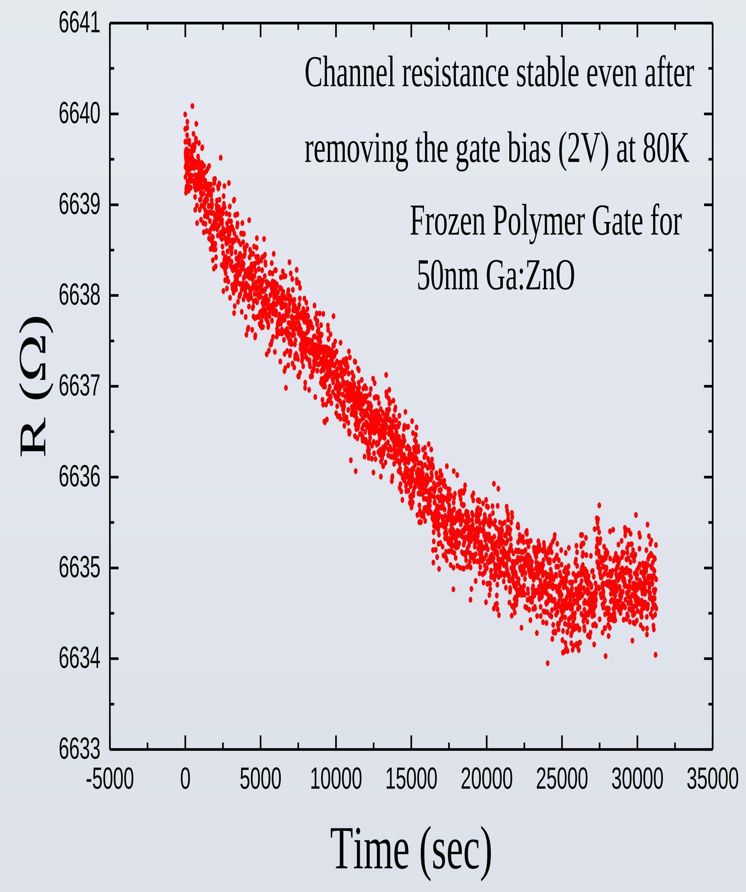

Fig.(7):- Frozen Gate effect of Polymer Gate At low temperature

CONCLUSION

- The EDL polymer gate can be applied to tune the carrier density of higher carrier density samples.
- Polymer gate could be an ideal gate at low temperature because even after removing the bias gate freezes.
- Polemer gates are slow, can not be used for fast switching, though useful for sensing purpose.

FUTURE PLAN

- As mentioned above the InN has reliable electrical properties with polymer electrolyte gate at room temperature ,Our next target is to look at the low temperature transport properties of InN with polymer and metallic gate

REFRENCES

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ACKNOWLEDGEMENTS

- I would like to thank IRCC, IIT Bombay and DST for their financial support.
- The ZnO sample provided by Shravan K Appani from Prof. S. S. Major Lab department of Physics IIT Bombay, and InN provided by Prof. Apurba Laha, department of Electrical Engineering IIT Bombay.