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Ultrasensitive and Rapid Detection of LPG Below Sub-LEL Using $MoTe_2$ Thin Film: A Room Temperature Approach

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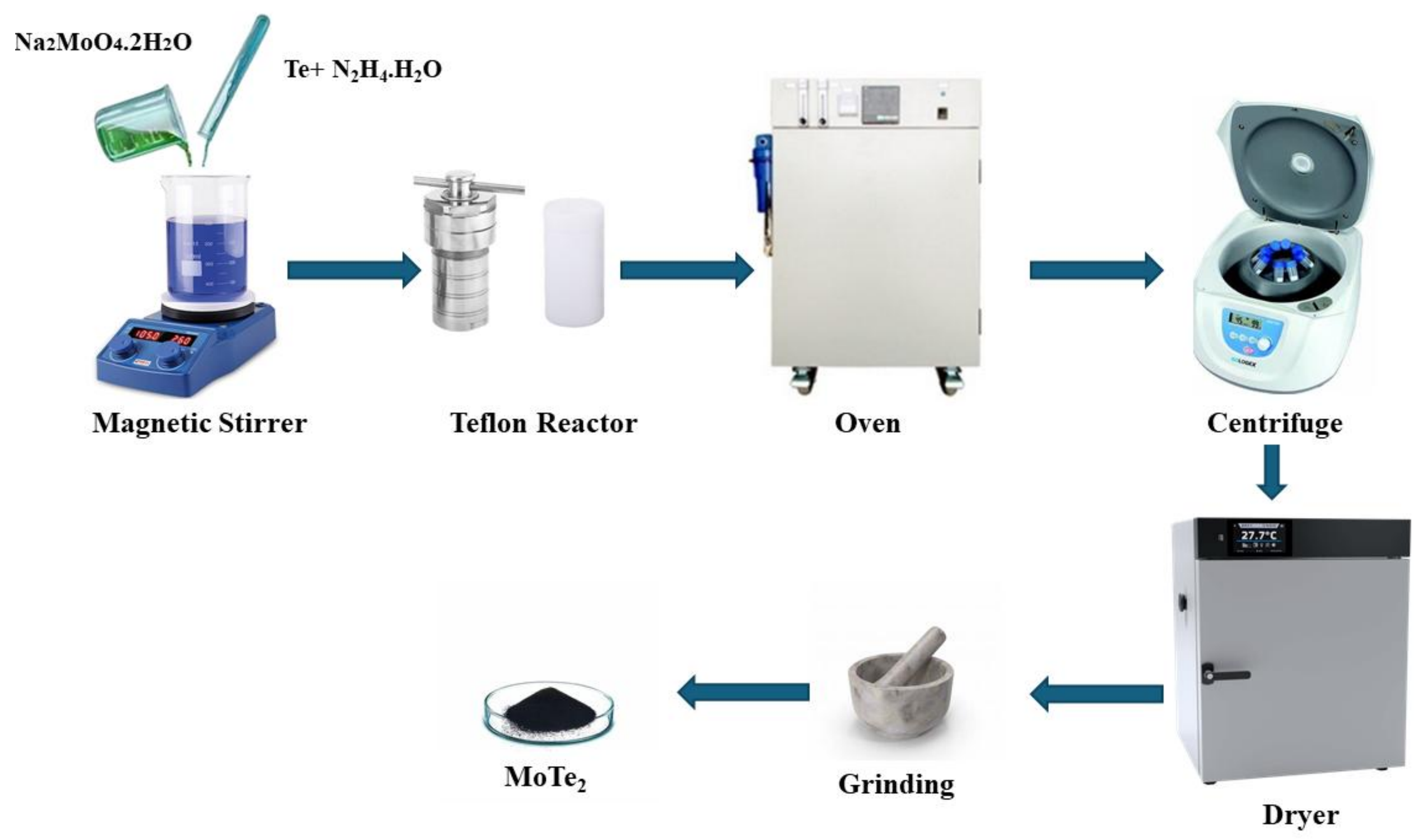
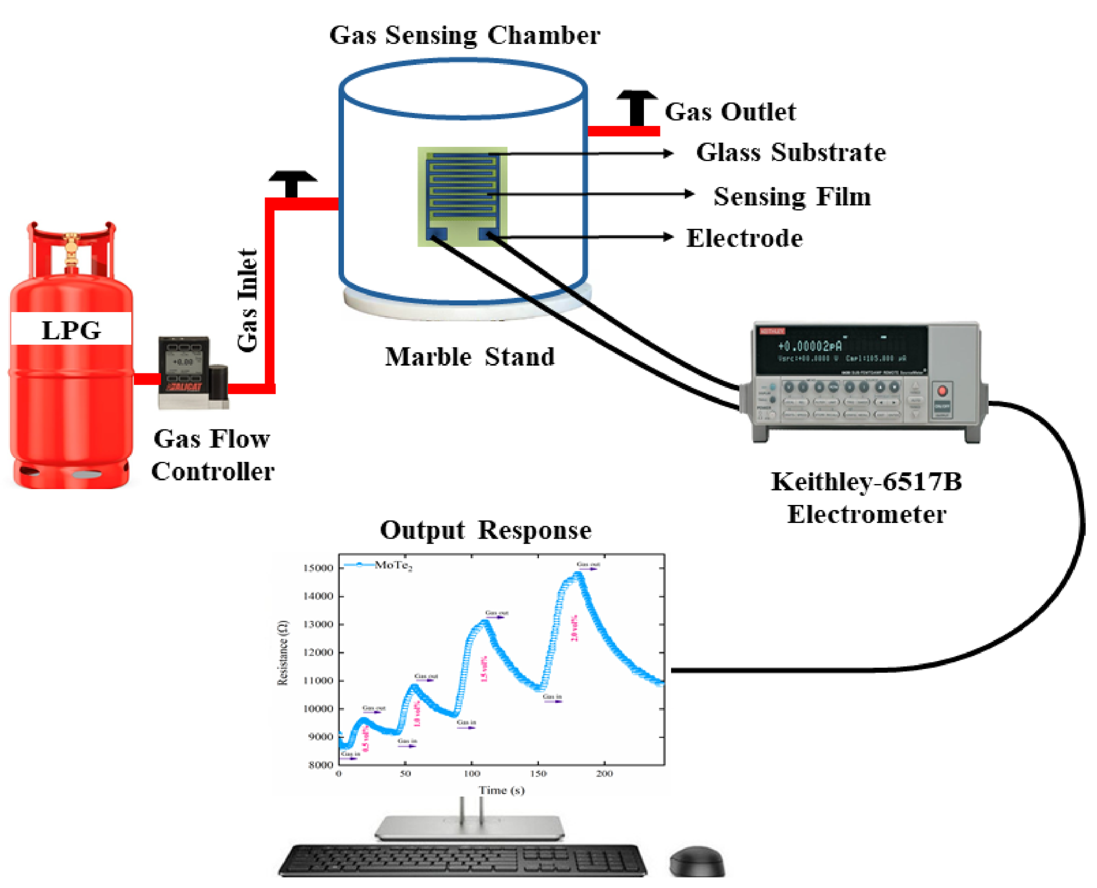
INTRODUCTION & AIM

- LPG (Liquefied Petroleum Gas) is a commonly used household and industrial fuel composed mainly of butane (C_4H_{10}) and propane (C_3H_8).
- It is colorless, odorless, and highly flammable therefore detection is crucial to ensure public safety, environmental protection, and industrial security.
- Usually, Traditional metal oxide sensors (e.g., ZnO, SnO_2) require high operating temperatures leading to high power consumption, thermal instability, long recovery times, and reduced selectivity.
- Recently Density functional theory and first-principles calculations shows $MoTe_2$'s sensitivity to various gas molecules. The present work addresses this gap by investigating the LPG sensing behaviour of hydrothermally synthesized p-type $MoTe_2$ thin films at room temperature.

METHOD



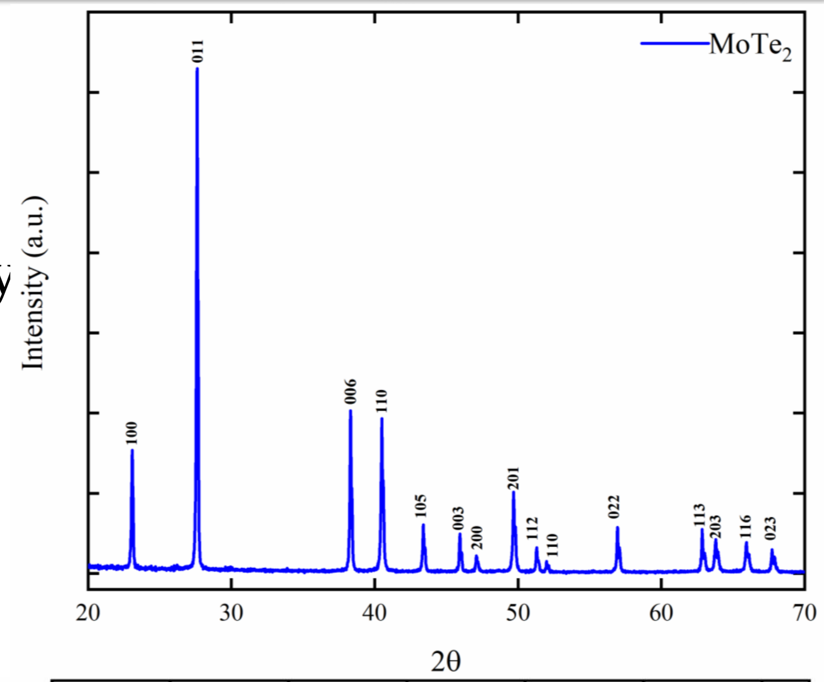
- $MoTe_2$ prepared hydrothermally using $Na_2MoO_4\cdot 2H_2O$, Te powder, and $N_2H_4\cdot H_2O$ at 200°C for 12 h.
- Product washed using DI water and ethanol by centrifugation and dried at 60°C for 12 h.
- Thin Film was prepared using 2x1 cm^2 glass substrate using photo resist spin coater.



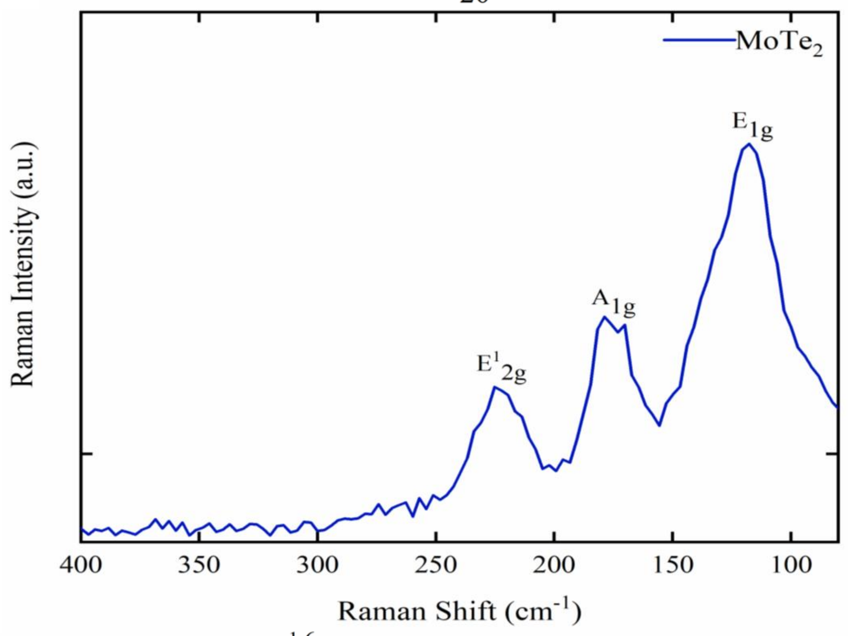
- Borosilicate gas chamber connected to LPG source and Keithley 6517B electrometer to measure resistance changes at different LPG concentrations below lower explosive limit at room temperature (25˚C).

RESULTS & DISCUSSION

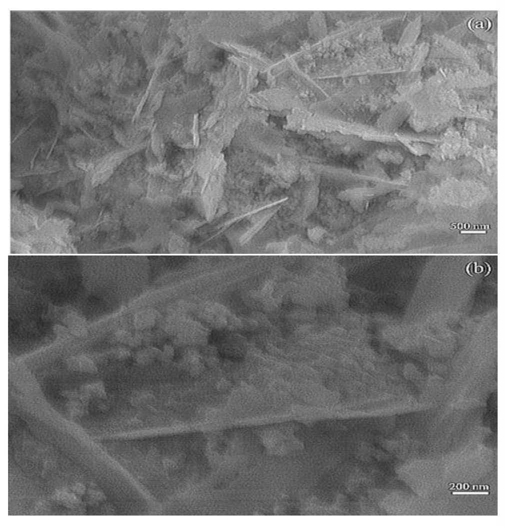
- The $MoTe_2$ crystal plane (006), (105), (110), (203) and (116) exhibits a high degree of crystallinity, attributed to a precisely controlled synthesis process utilizing high-purity precursors and the possible presence of weak Te rings. These Tellurium rings may act as the nucleation centre or substrate for $MoTe_2$ formation.

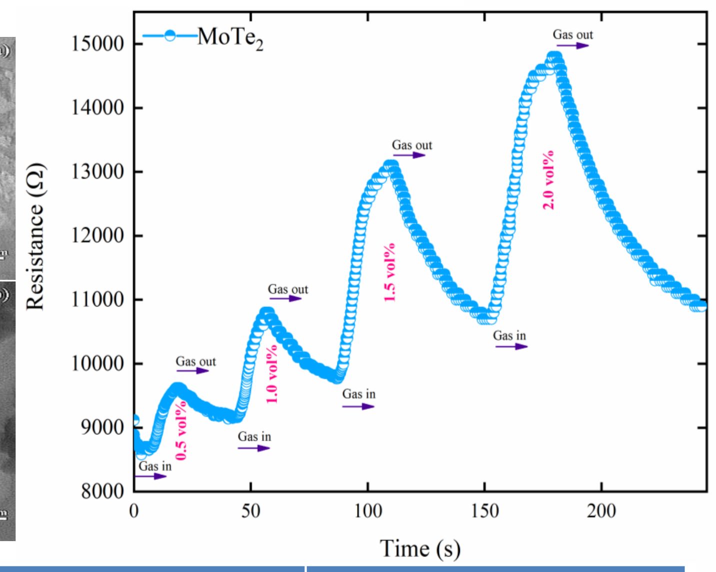


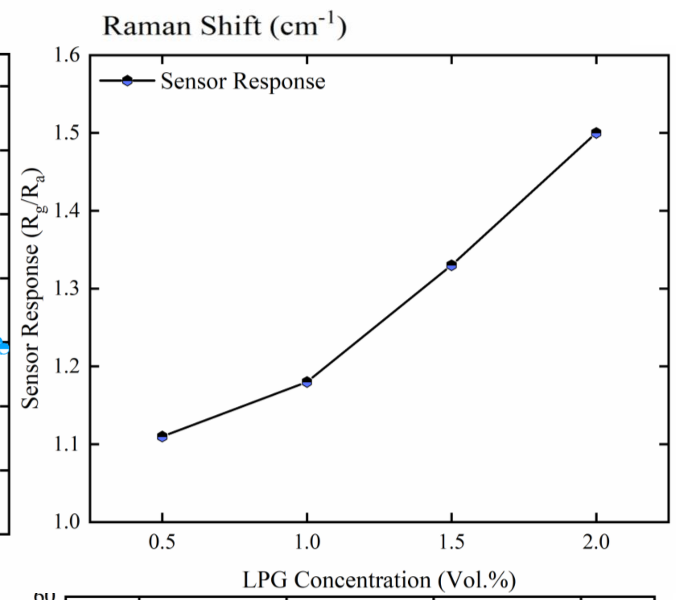
- The in-plane E_{1g} mode is at 118 cm^{-1}, out-of-plane A_{1g} mode 175 cm^{-1} and the conspicuous in plane E^1_{2g} mode at 224 cm^{-1} Confirmed Mo–Te vibrational modes in 2H–$MoTe_2$.



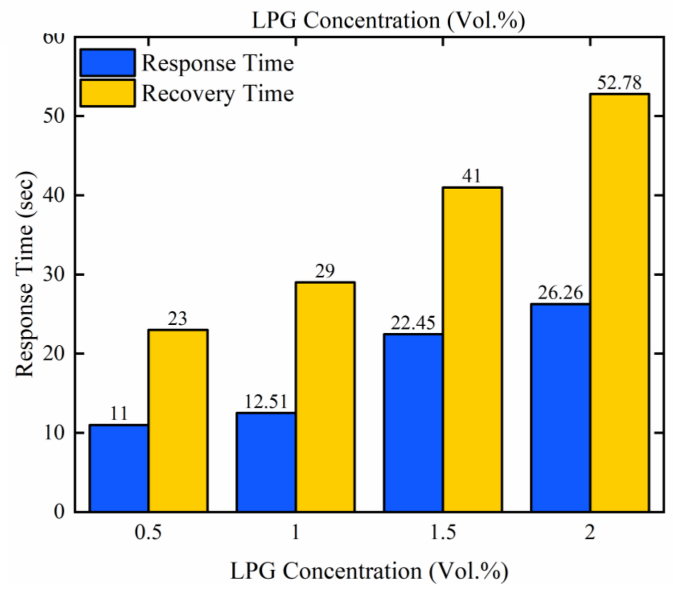
- Flake and platelet like structure.

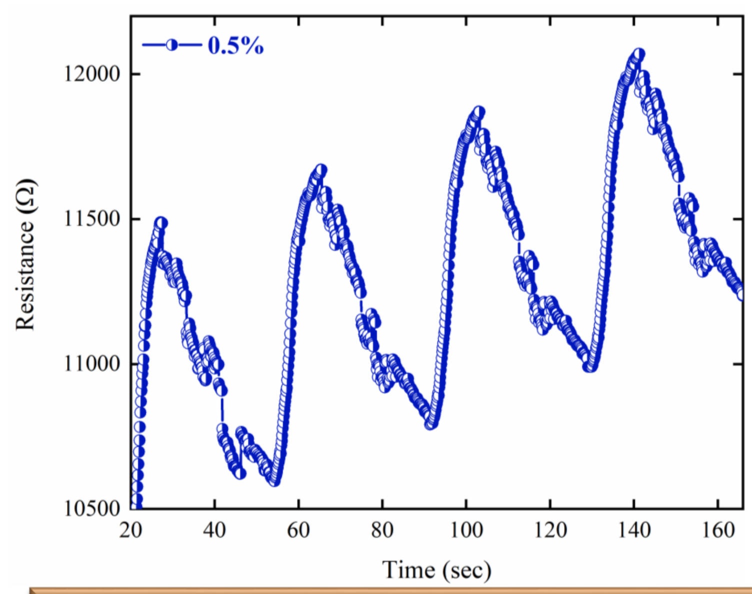






LPG Conc. (Vol%)	Response Time	Recovery Time
0.5	11	23
1.0	12.51	29
1.5	22.45	41
2.0	26.26	52.78





- Operating range: 0.5–2.0 vol% LPG (below LEL).
- 11 s (response) and 23 s (recovery).
- Repeatability: 99.09% with 0.91% error over 4 cycles.

CONCLUSION

- Successfully synthesized 2H–$MoTe_2$ nanomaterial via a simple, low-cost hydrothermal route.
- Achieved fastest response (11 s) and recovery (23 s) time. Demonstrated high selectivity and repeatability, making it suitable for portable, low-power LPG sensors.

FUTURE WORK / REFERENCES

- Integration of $MoTe_2$ sensor into IoT-enabled smart safety systems for real-time gas monitoring.
- Exploration of $MoTe_2$-based heterostructures ($MoTe_2/TiO_2$, $MoTe_2$/MXene) for multi-gas sensing applications.