Fabrication and Characterization of synthetic diamond radiation detectors

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INTRODUCTION

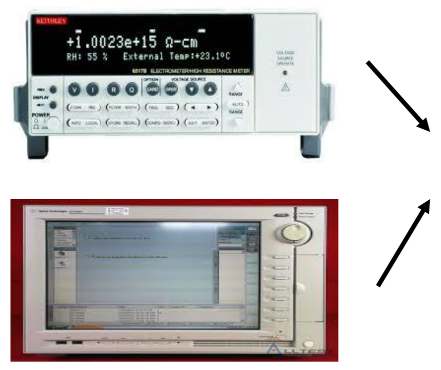
- Wide bandgap, high carrier mobility and high displacement energy of diamond make it suitable for harsh environment applications.
- Recently lab grown synthetic single-crystal diamond based photodetectors are favourable for Ultra-Violet(U-V) and radiation detection studies.
- Defects in the diamond bulk affect the spectroscopic performance of the devices and hence needs to be identified in the diamond bulk for possible passivation.

Objectives

- Optical studies on the diamond plates.
- Fabrication of Diamond electronic devices.
- Electrical Characterizations.
- Defect Characterizations.
- Numerical Modelling of diamond bulk.
- Packaging of diamond detectors.
- High energy radiation detection studies.

Experimental setup and procedure

Micro-Fabrication Lab IIT Bhubaneswar



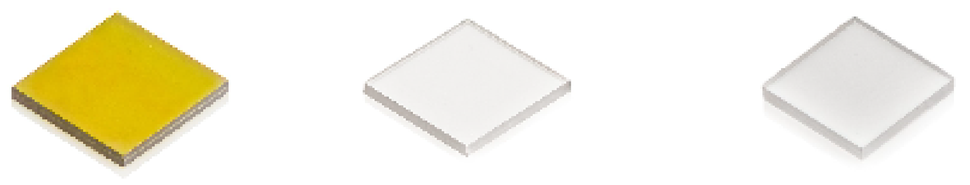
Electrical and Defect Characterizations

- Photoluminescence and Lifetime studies of optically active defects in diamond using Horiba Jobin Yvon-Fluro Cube TRPL system.
- Alpha Spectroscopy at Institute for plasma research.

Major Challenges

- ❑ Defect Identification in the diamond bulk.
- ❑ Correlation of the defects with the spectral characteristics.

Fabrication and Packaging of Diamond bulk devices



$[N_S]$< 200ppm $[N_S]$< 1 ppm $[N_S]$< 5 ppb

Cleaning

•The diamond plates are cleaned in a saturated solution of CrO_3 in H_2SO_4.

Plasma Treatment

• The diamond surfaces are treated with oxygen plasma.

Metal Deposition

•Cr/Au (50nm/200nm) deposition.

Post-Metallisation Annealing

•In Argon environment at 350° C.

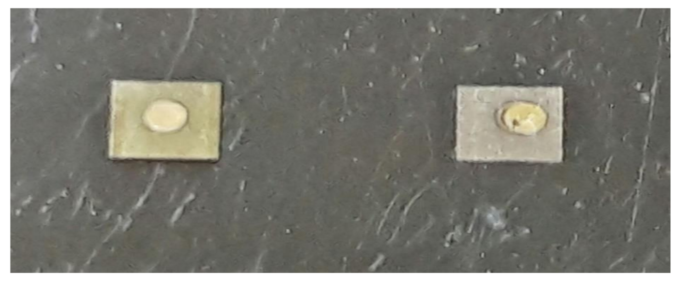


Figure 1: Fabricated diamond devices

Packaging of diamond detectors

•The diamond plates are packaged onto TO8 headers.

- For alpha spectroscopy measurements.

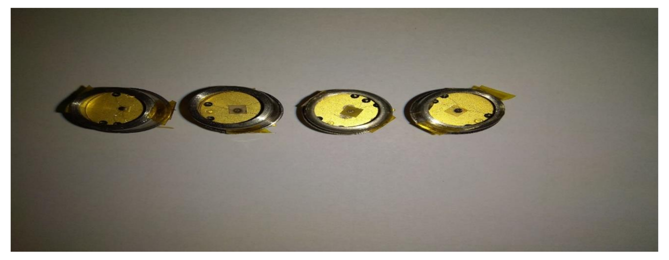


Figure 2: Packaged diamond detectors.

Results and discussions

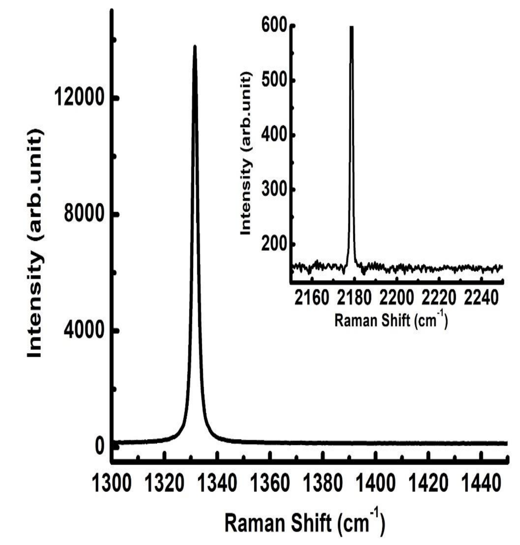


Figure 3: Raman Spectrum of the diamond.

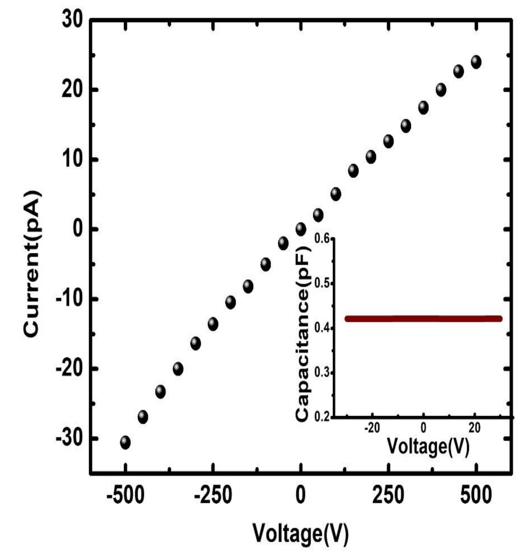


Figure 4: I-V and C-V of the diamond bulk device.

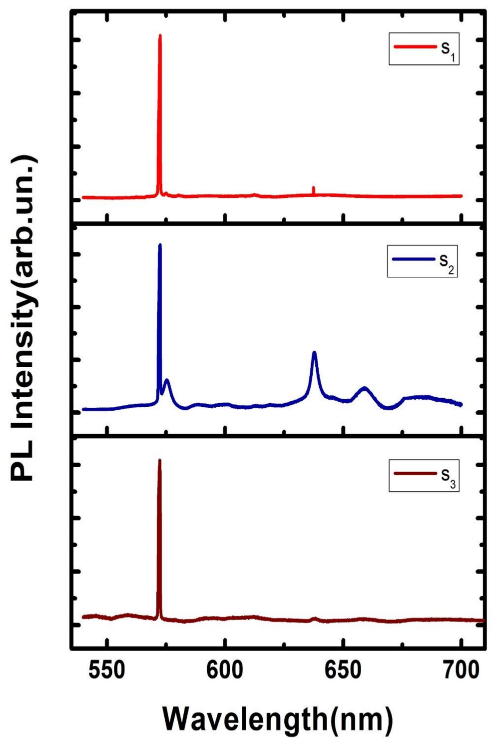


Figure 5: PL Spectra of the diamond plates.

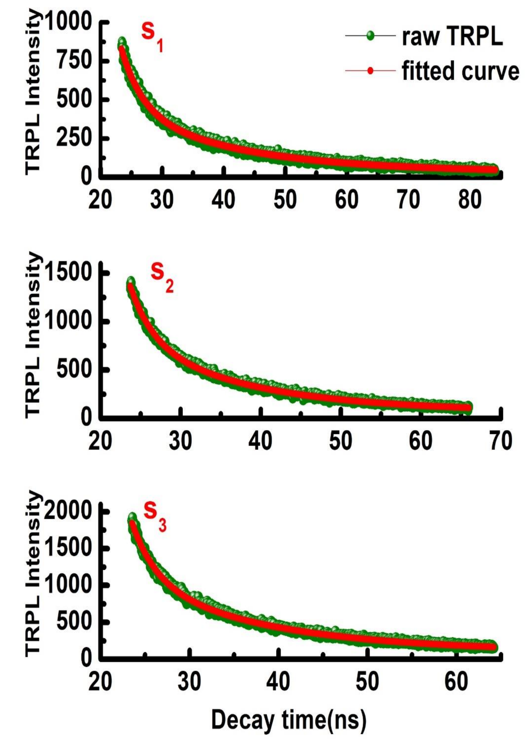


Figure 5: TRPL studies in the diamond plates.

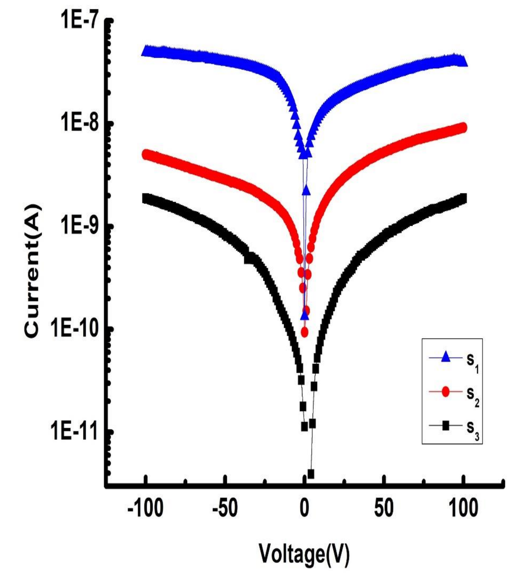


Figure 7: UV-Response of the diamond detectors.

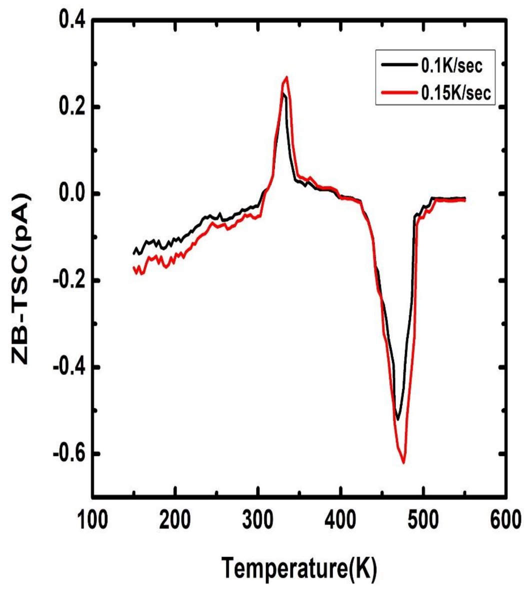


Figure 8: Defect studies in the diamond detectors.

Results and discussions(Contd.)

- Lower leakage current in diamond electronic devices ~ Pico Ampere-favorable for alpha spectroscopy.
- Presence of optically and electrically active defects in the diamond bulk (PL, TRPL and TSC studies).
- Presence of defects are detrimental to the device response in the presence of excess carriers(UV response studies).
- Constant capacitance values indicate the ohmic nature of the contacts.
- Spectral characteristics need to be investigated.

Conclusions

- Lower leakage current (~ pA) favorable for radiation detection studies .
- Higher order of magnitude of UV response current in the EL diamond detector owing to the presence of less defects.

Acknowledgments

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Major References

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3. H. Pernegger *et al.*, Charge-carrier properties in synthetic single-crystal diamond measured with the transient-current technique, J. Appl. Phys. 97 (2005) 73704.