

Project Completion Report

“Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors
subjected energetic ion irradiation”

UFR-50307

(2011-2014)

(DoRD/Phy/DM/20-93)



Principal Investigator

Dr. Dambarudhar Mohanta

Project fellow: Rizwin Khanam

Department of Physics,

Tezpur University

P.O. Napaam, Tezpur-784028,

Assam, India

Comprehensive report

2011-2012 (FUC and report submitted before)

The approval letter for the aforesaid project was received in September 2011. After following the general procedures the project fellow was selected and the fellow (Miss Rizwin Khanam) joined in the department on 26-09-11. Apart from the relevant literature survey, a few experimental works related to nanoscale semiconductor oxides based on synthesis of TiO_2 nanostructures have been carried out. The structural and optical properties have been studied.

(A) TiO_2 nanotubes

The TiO_2 nanoparticles were prepared by a simple sol-gel process. The synthesized nanoparticles were treated as the seed material for synthesis of TiO_2 nanotubes (TNTs). TiO_2 nanotubes were prepared by a hydrothermal method [1]. Fig. 1 depicts X-ray diffractograms of hydrothermally prepared TNT and sol-gel derived TNP samples. As can be found, distinct diffraction peaks located at $2\theta \sim 25.54, 38.02, 48.231, 55.14$ and 63.02 correspond to (101), (004), (200), (211) and (204) planes of the anatase phase of TNPs and are consistent with other works. In case of TNTs, the poorly resolved peaks at $\sim 24^\circ, 28^\circ, 48^\circ$ and 62° are from the TNTs containing H^+ and/or Na^+ ions [2]. The characteristic peak around 9.2° is ascribed to the interlayer spacing of TNT walls. The presence of sharp peaks in TNP sample signifies diffraction from periodic lattices thus exhibiting higher order crystallinity while TNTs show a few blunt peaks indicating insufficient diffraction signals owing to significant missing planes when TNPs were transformed to TNTs.

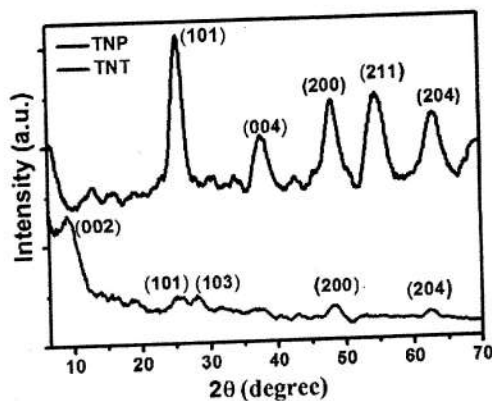


Figure 1: XRD pattern of TiO_2 nanoparticles and nanotubes

The as received TNPs were subjected to hydrothermal processing at $\sim 130^\circ\text{C}$ for 24h and this has resulted in the development of TNTs. Fig. 2(a-c) shows a set of TEM images of TNTs. Largescale TNTs with different lengths and wall sizes are evident from Fig. 2(a). The enlarged view of definite TNTs, shown in Fig. 2(b), has revealed that each of the tubes is consisting of 5-7 walls with a fixed inner diameter of ~ 4.2 nm but varying outer diameter. The length of the TNTs was found to be in the range 130-150 nm. A complete transformation of nanoparticles into nanotubes is indicated by nonexistence of undeveloped TNPs or/and granular particles on the surface of TNTs. From the high resolution micrograph shown in Fig. 2(c), the interlayer spacing between the walls was estimated to be ~ 0.36 nm. Considering 5 walled morphology, the thickness (shell) of the TNTs is estimated to be ~ 1.8 nm and hence, an approximate outer diameter of TNT as 7.8 nm.

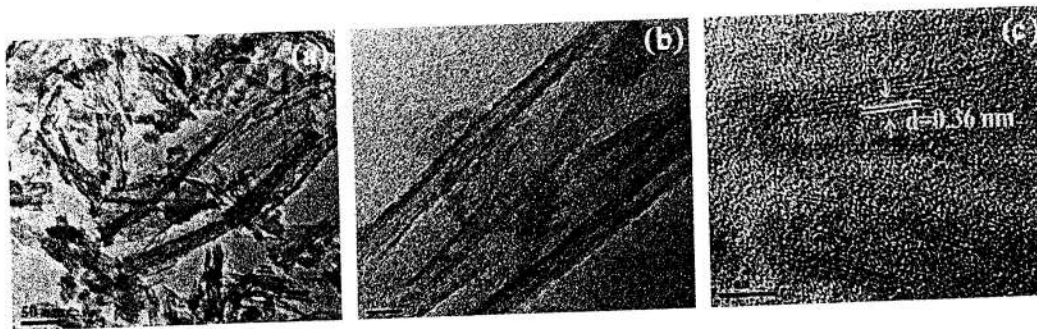


Figure 2: TEM micrographs of TiO₂ nanotubes prepared by the hydrothermal method: (a) aggregated morphology, (b) enlarged isolated view, and (c) view of crystal lattice fringes.

The UV-Vis optical absorption spectra of TNPs and TNTs are shown in Fig. 3(a). The absorption spectra showed two characteristic features at a low and at a relatively higher wavelength regime. The absorption band at ~390 nm can be ascribed to the interband *1s-1s* carrier transition from the valence band to the conduction band. The broad peak, observable at ~600 nm, may be associated with the carrier transitions mediated via oxygen vacancies. Also, slightly red-shifted absorption response of TNTs, as compared to TNPs may be due to the elongated nature of the former. The TNTs owing to hollow nature exhibits relatively higher absorbance values in the higher wavelength regime.

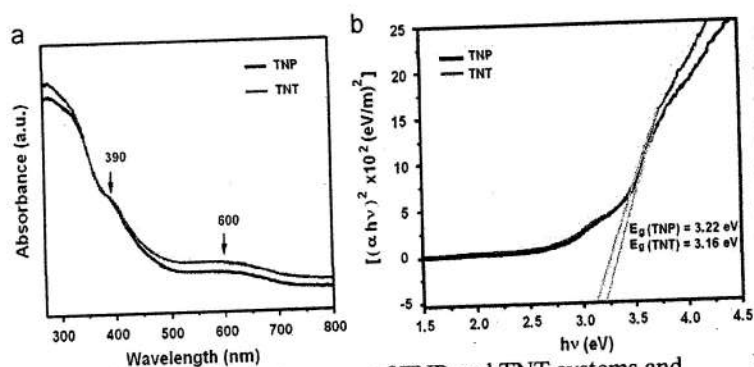


Figure 3: (a) UV-vis spectroscopy of TNP and TNT systems and (b) corresponding Tauc plots for estimating energy band gaps

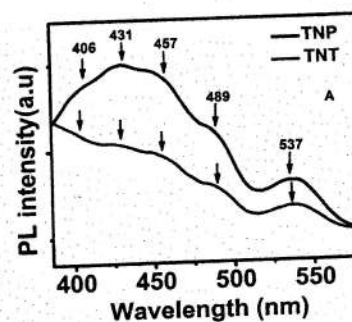


Figure (4): PL spectra of TNP and TNT the systems.

The optical band gap, E_g , was calculated using the Tauc's relation for direct and allowed type of carrier transitions:

$$\alpha h\nu = A (h\nu - E_g)^{1/2}, \quad (1)$$

where, $h\nu$ is the photon energy, α is the absorption coefficient and A is a system dependent parameter. The band-gaps, as estimated through the linear extrapolation of $(\alpha h\nu)^2$ vs. $h\nu$ curves and shown in Figure 3(b), are 3.22 eV and 3.16 eV for TNPs and TNTs; respectively. The band gap of TNTs might have decreased due to the creation of additional localized states during hydrothermal treatment and subsequent annealing process. This could provide a basis for improving photocatalytic activity which rely on free radical generation.

PL spectroscopy is an effective technique through which one can evaluate the nature of radiative transitions and defect-mediated emission response of a given system. Figure 4 shows PL emission response of TNPs and TNTs considering excitation at ~325 nm. The characteristic peak at 406 nm is due to the near band edge emission (NBE). Whereas, the emission peak at ~431 nm can be assigned to the self

trapped excitons (STE) localized on TiO_6^{2-} octahedra. Additionally, the peak at ~ 489 nm is attributed to the oxygen vacancies originated from the charge transfer from Ti^{3+} to O^{2-} in TiO_6^{2-} octahedra. The two other peaks around 457 nm and 537 nm have occurred due to color centers associated with oxygen vacancies. The former peak is ascribed to the oxygen vacancy with two trapped electrons (F center), and the latter is ascribed to the oxygen vacancy with one trapped electron (F+ center) [3]. The radiative emission response displayed by TNTs is relatively weak compared to TNPs owing to a lower concentration of trapping sites available in the former system.

2012-2013 (FUC and report submitted before)

(B) TiO_2 nanoparticles irradiated with 80 KeV Xe^+ ions

Teflon impregnated TiO_2 nanoparticles were subjected to 80 keV Xe^+ ion irradiation using the low-energy ion beam facility (LEIBF) available at Inter University Accelerator Centre, New Delhi. The beam current was kept at ~ 1 μA , while the fluences were varied as 1×10^5 (F1) ions/ cm^2 , 5×10^{15} ions/ cm^2 (F2), 2.5×10^{16} ions/ cm^2 (F3) and 1.25×10^{17} ions/ cm^2 (F4).

The surface morphology of un-irradiated and Xe^+ ion irradiated TiO_2 nanoparticles were characterized by AFM measurements. The presence of well organized and uniformly distributed grains is clearly visible for the un-irradiated nanotitania particles (Fig. 5 (a)). The three-dimensional micrograph, shown on the right side of Fig. 5(a) depicts a distributed view of hillocks of uniform size. Upon irradiation with the first fluence F1, the tendency of aggregation and/or swelling comes to the forefront. In either case, the surface roughness is likely to get enhanced substantially. It is possible that, the hillocks with large outer diameters might have experienced an overlapping feature at a higher fluence (F3) causing thereby flattening of the TiO_2 surface. In our case, ion energy is substantially low (80 keV, $S_e < S_n$), therefore swelling action is due to incorporation of Xe^+ ions into nanotitania forming thereby van der Waal crystals. The excessively swollen particles at a still higher fluence (F4) are likely to be thermodynamically unstable and split into isolated ones with a relatively smaller magnitude of surface roughness. The approximate particle size and roughness as predicted from the AFM images are presented in Table 1. Basically the difference in surface roughness is due to the invariable alteration of the hillock size induced by Xe implantation, while scanning area is considered as $1 \mu\text{m} \times 1 \mu\text{m}$.

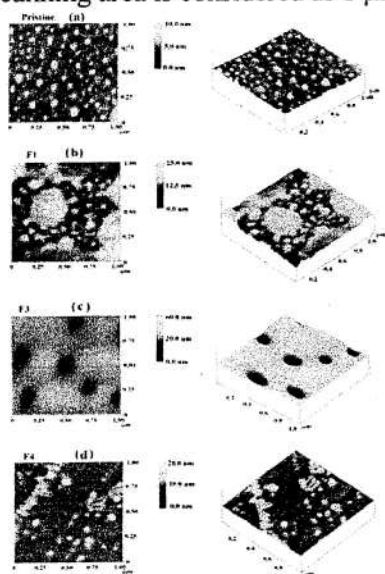


Table1:

Sample	RMS roughness	Particle Size (nm)
Pristine	0.525 nm	10-15 nm
F1	1.630 nm	20-27 nm
F3	2.712 nm	-----
F4	0.902 nm	30-40 nm

Figure 5: AFM images of: (a) pristine, (b) F1 (c)F3 and (d) F4

The visible evidence of un-irradiated and irradiated TiO₂ nanoparticles is obtained from the TEM micrographs, highlighted in Fig. 6(a-d). Both a distributed view and an isolated titania particle of typical dimension ~9 nm are shown in the micrograph (Fig. 6(a) and inset). Fig. 6(b) and (c) depict respective micrographs of samples F1 and F4. The diameter of sample F1 was estimated to be in the range of 8 - 15 nm. As compared to the un-irradiated TiO₂ system, the particle dimension of sample F4 has increased and found to be in the range of 20-30 nm. A close look on the micrograph shown in Fig 6(d) of the irradiated sample has revealed wave like surface patterns (nanoripples). The inter planar lattice spacing of titania nanoparticle is estimated to be ~0.26 nm, which corresponds to (004) plane of TiO₂ (Fig. 6(b)). A relatively darker segment (indicated by arrow) can be witnessed within the particle where the lattice spacing is found to be ~0.65 nm. Since the *d*-spacing (0.62 nm) is close to the (100) plane of Xe, we speculate formation of vander Waal crystals of Xe within TiO₂ nanostructured system owing to coherent implantation of Xe ions. Several years ago, Iakoubovskii *et al.* [4] have demonstrated the structure and pressure inside Xe nanoparticles embedded in Al where three types of particles were believed to coexist: crystalline, semi-crystalline, and amorphous form. They anticipated that the particles get pressurized by the matrix with the pressure increasing as the inverse particle diameter, d^{-1} . The large particles with *d* > 10 nm are amorphous, whereas particles with *d* < 10 nm are cubo-octahedral having the same fcc structure as the Al matrix but with an adequately large lattice spacing ($a_{Xe} \sim 0.61$ nm and $a_{Al} = 0.405$ nm). Nevertheless, particles with *d* ~ 10 nm are likely to be semi-crystalline. We speculate that, the size of the Xe crystals formed in our case is less than 10 nm which can be visualized from the relatively darker part, highlighted in Fig. 6(b).

The elemental composition of Xe irradiated (F1) TiO₂ nanoparticles is also substantiated by energy dispersive X-ray (EDX) spectroscopy analysis, shown in Fig. 7. It shows strong Ti and O signals. The weak Xe peaks (Xe M_{γ1} and Xe L_{γ2}) have also been detected in the EDX spectrum [5].

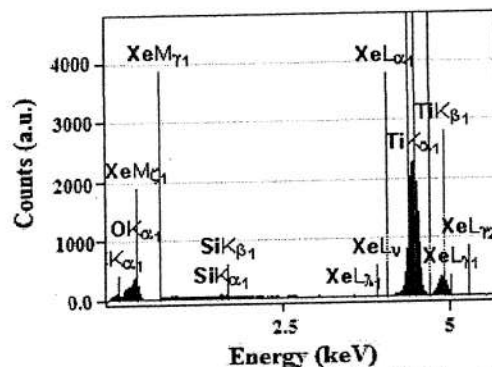
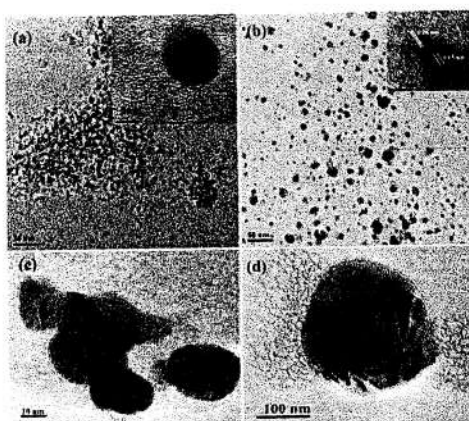


Figure 6: TEM micrographs of (a) un-irradiated and irradiated (b) F1, (c) F4 titania nanoparticles. The formation of nanoripples on the surface of an isolated TiO₂ particle after irradiation with fluence F4 is depicted in (d). Figure 7: High resolution EDX spectrum of an irradiated nano titania particle (F1).

(C) TiO₂ nanoparticles doped with different concentration of silver

The sol-gel prepared TiO₂ nanoparticles were doped with different concentrations of AgNO₃ as 1% (A1), 1.5% (A2), and 3% (A3). Fig. 8 depicts X-ray diffractograms of undoped and silver doped TiO₂ nanoparticle samples. Diffraction peaks located at $2\theta \sim 25^\circ, 38^\circ, 48^\circ, 55^\circ, 62^\circ$ correspond to (101), (004), (200), (211) and (204) planes of the anatase phase in case of both undoped TiO₂ nanoparticles (A) and doped TiO₂ nanoparticles. A small peak observed at $2\theta \sim 31.2^\circ$ is corresponded to the plane (121) which is the characteristic peak of brookite phase [6]. This shows that there is an evolution of brookite phase

with the incorporation of silver into TiO₂. Anatase and brookite are the metastable phases of TiO₂ and usually formed at low temperature during solution growth process.

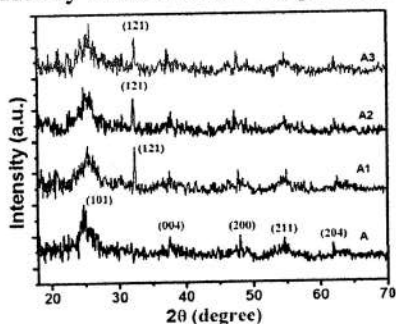


Figure: (8) XRD pattern, and undoped TiO₂ nanoparticles

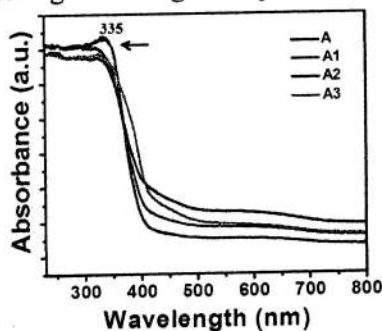


Figure: (9) UV-Vis absorption spectra

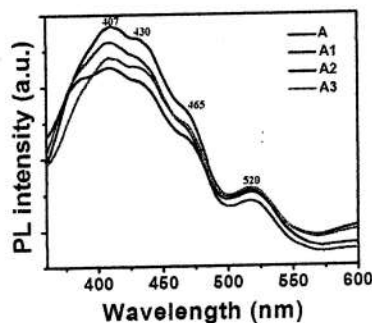


Figure: (10) PL spectra of doped

In Fig 9, the absorption spectra show an absorption band at ~ 335 nm due to the interband *Is-Is* carrier transition. The absorption is found to be slightly red shifted with increasing dopant concentration. For the undoped sample, the band gap was calculated to be ~3.20 eV which further reduced from 3.09 eV to 2.85 eV for concentrations A1 and A3; respectively.

In Fig 10, the decrease in the intensity with increase in dopant concentration might be because of the silver ions which diffuse into the crystal lattice of TiO₂ can act as traps to capture the photoinduced electrons thereby suppressing recombination events of electron-hole pairs.

2013-14 (FUC and SE submitted before)

(D) Tb³⁺ doped TiO₂ nanotubes irradiated with 80 MeV C⁶⁺ ions

As synthesized TiO₂ nanotubes were first dispersed in PVA and films of 1cm X 1cm were casted and were then irradiated in the Material Science chamber under a high vacuum (pressure ~10⁻⁶ mbar) condition using 80-MeV C⁶⁺ ion beams (with low beam current of ~1 pA, particle-nanoampere), available at the 15 UD tandem pelletron accelerator of IUAC, New Delhi. The fluence was varied as 1x 10¹¹ (C1), 3x10¹¹ (C2), 1 x10¹² (C3) and 3 x 10¹² (C4) ions/cm².

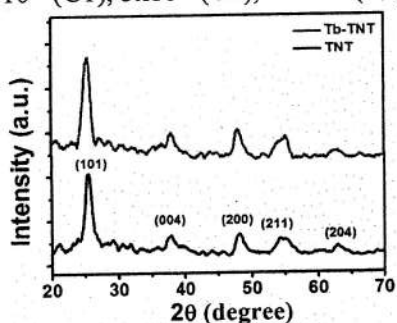
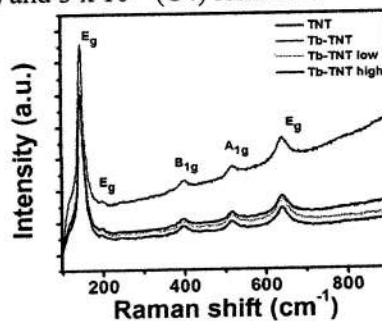
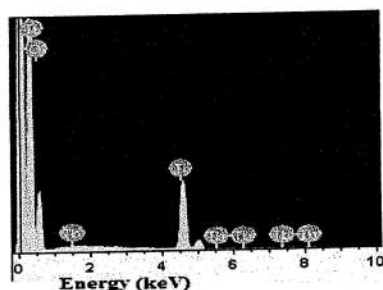


Figure 11: (a) XRD pattern of undoped and Tb³⁺-doped TiO₂ nanotubes,



(b) Raman spectra of TNT, Tb-TNT, samples irradiated with fluence C1 and C4



(c): EDX spectra of Tb-TNT sample

Fig.11 depicts a set of XRD pattern of the pristine sample (TiO₂ nanotubes dispersed in PVA films before doping and irradiation) and Tb³⁺ doped TiO₂ nanotubes. The distinct diffraction peaks located at 2θ ~ 25.48°, 37.85°, 48.19°, and 54.74° and 63.04° for TNTs and at 25.30°, 37.71°, 48.00°, 54.72° and 62.66° for Tb-TNTs corresponded to the crystallographic planes (101), (004), (200), (211) and (204) of the anatase phase of TiO₂ nanoparticles .

The average crystallite size of the TiO₂ nanotubes can be calculated using the Williamson-Hall (W-H) plot considering the most prominent diffraction peaks of the diffractogram.

Table 2:

Sample	Crystallite size (nm)	Microstrain (X 10 ⁻³)
TNT	6.99 ± 0.001	3.20
Tb-TNT	7.47 ± 0.001	1.57

The Table 2 shows the calculated values of the crystallite size and microstrain of the TNTs and Tb-TNTs (with standard errors). We notice an increment of the crystallite size upon doping. This could be due to significant lattice expansion owing to different ionic radii of Tb³⁺ =92 pm and Ti⁴⁺=64 pm.

Fig.11 (b) shows the Raman spectra of TNT, Tb-TNT and Tb-TNT irradiated with fluences C1 and C4. The Raman lines appearing at 144 cm⁻¹ (E_g), 197 cm⁻¹ (E_g), 399 cm⁻¹ (B_{1g}), 513 cm⁻¹ (A_{1g}), and 639 cm⁻¹ (E_g) correspond to anatase phase of TiO₂ [7]. Such an inference is consistent with the XRD data shown in fig.11(a) which indicates no phase transition even after irradiation.

Fig.11 (c) represents the EDX spectra of Tb-TNT which shows strong Ti and O elemental signals along with weak Tb peaks.

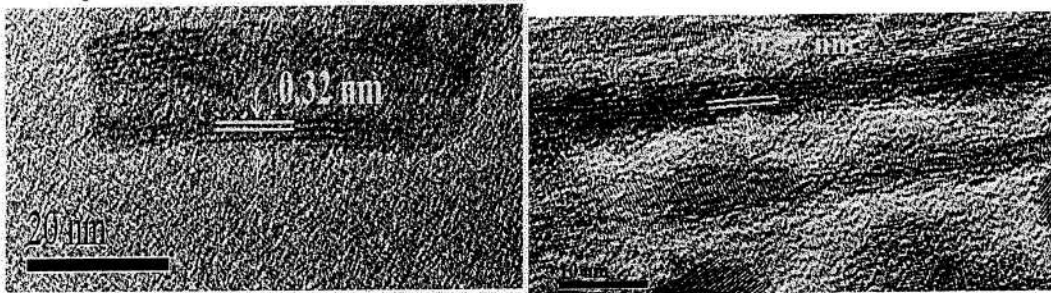


Figure 12: TEM images of TiO₂ nanotubes prepared by the hydrothermal method: (a) view of crystal lattice of TNT (b) enlarged view of a nanotube after 80 MeV C⁶⁺ irradiation with fluence C4

Fig. 12(a,b) depicts the TEM images of undoped and unirradiated TiO₂ nanotube and the one irradiated with highest fluence (C4). The first image depicts well defined multi-walled nanotube with 5-7 walls and with an interlayer spacing between the walls as 0.32 nm. After irradiation the walls are dismantled and the separation is found to be increased to 0.37 nm. There could be change in surface morphology of the nanotubes, but without any phase transformation.

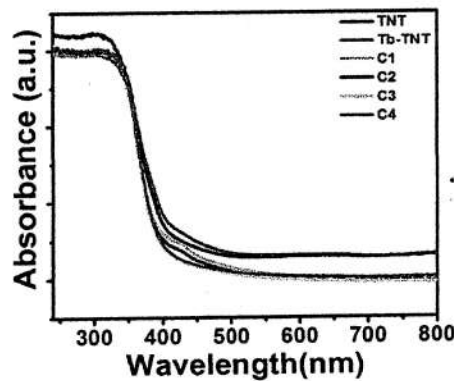


Figure 13: UV-Vis spectra of TNT, Tb-TNT and irradiated Tb-TNT samples

The UV-vis optical absorption spectra of TNTs, Tb-TNTs and the samples irradiated with various fluences are shown in Fig.13. The absorption spectra that showed a characteristic feature at ~325 nm can be ascribed to the interband I_s-I_s carrier transition from the valence band state to the conduction band state. The optical band gap calculated are shown in the table:

Table 3:

Sample	Band gap (eV)
TNT	3.16
Tb-TNT	3.07
C1	3.19
C2	3.21
C3	3.23
C4	3.21

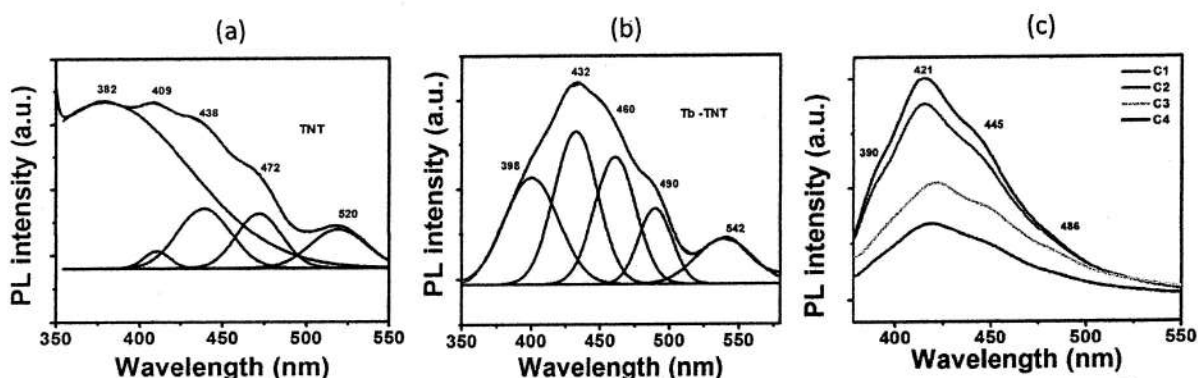


Figure 14: Photoluminescence spectra of (a) undoped ($\lambda_{ex}=300$ nm), (b) Tb^{3+} doped ($\lambda_{ex}=300$ nm), and (c) C^{6+} irradiated Tb^{3+} doped TiO_2 nanotubes ($\lambda_{ex}=325$ nm).

Fig. 14(a) and (b) show emission response of the undoped and un-irradiated TiO_2 nanotubes and terbium doped TiO_2 nanotubes respectively considering excitation at ~300 nm. In order to resolve independent emission peaks, the spectra were subjected to multipeak Gaussian fitting. The peak located at ~390 nm is due to the self trap exciton of Ti^{4+} ions whereas, an emission band centered at ~432 nm is ascribed to the oxygen vacancy (Vo). The peak positioned at 472 nm and 520 are ascribed to the charge transfer from the Ti^{4+} to oxygen ions in TiO_6 octahedra associated with the oxygen vacancies. In fig 14(b) two weak emission bands mediated via Tb^{3+} states could be noticed at 490 nm for ${}^5D_4 \rightarrow {}^7F_6$ and at 542 nm for ${}^5D_4 \rightarrow {}^7F_5$ transitions [8]. There can be mismatch of the energy levels of the emitting state of the Tb^{3+} ions with that of the defect states of TiO_2 because of these peaks have overlapped. Fig 14(c) shows PL spectra of Tb-TNT samples irradiated with various fluences excited at a wavelength of 325 nm. It denotes that the peaks related to Tb^{3+} emission is apparently quenched with increasing fluence.

(E) Hydrogenated black titania

Apart from irradiation related features, through this project we have been able to prepare a new material called "black titania". Black titania' as the name suggests appears black unlike often synthesized white titania. Its recent realization has been a breakthrough in TiO_2 based photocatalysis due to its long wavelength optical absorption [9]. The synthesized white titania turns black by hydrogenation at elevated temperature.

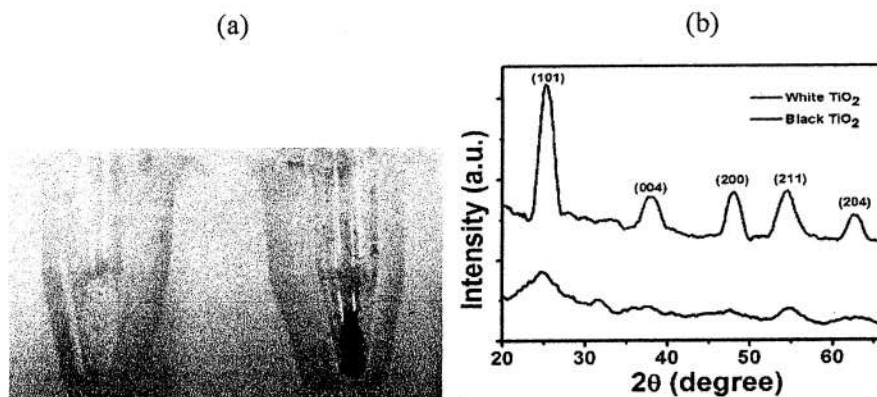


Figure 15: (a) White and black TiO₂ powder

Figure 15: (b) XRD patterns of white and black TiO₂ nanoparticles

Fig. 15 (a,b) depict digital photograph and X-ray diffractograms of sol-gel derived white TiO₂ and hydrogenated black TiO₂ nanoparticles. The diffraction peaks of TiO₂ nanoparticles are located at $2\theta \sim 25^\circ$, 37° , 48° , 54° and 63° and corresponded to (101), (004), (200), (211), and (204) planes of the anatase phase. Since the intensity of the peaks is highly suppressed in black TiO₂ system, it indicates a decrease of crystallinity due to hydrogenation, while anatase tetragonal phase remains intact.

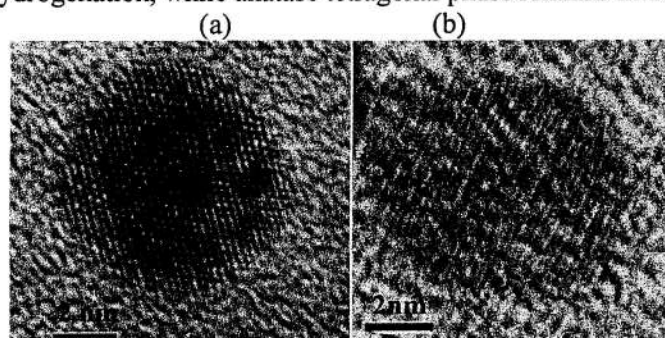


Figure 16: TEM images of white and black TiO₂ nanoparticles

Fig.16 shows a set of TEM images of white TiO₂ and black TiO₂. Fig 16 (a) shows a single crystalline white TiO₂ nanoparticle with distinct lattice fringe pattern. The image of a hydrogenated black TiO₂ nanoparticle has relatively unclear fringe owing to introduction of thin amorphous region into the crystal lattice. This is because H-atoms take unspecified positions in the lattice forming TiO₂:H_x complex. Detailed analysis is in progress [*].

References

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- [2] J. Yu, H. Yu, B. Cheng, C. Trapalis, *Nanotechnology* 19 (2008) 045606.
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[8] D.Wojcieszak, D.Kaczmarek, J. Domaradzki, A.Lukowiak, Wieslaw, *Eur. J. Phys. II.* (2013) 239
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Outputs

1. Rizwin Khanam, Dambarudhar Mohanta, *Physica E*, Properties of hydrothermally processed multi-walled titania nanotubes, 49 (2013) 39-43
 2. Rizwin Khanam, Nibedita Paul, P. Kumar, D. Kanjilal, Gazi A. Ahmed, Dambarudhar Mohanta, *Nucl. Instr. Methods B*, Teflon impregnated anatase TiO₂ nanoparticles irradiated by 80 keV Xe⁺ ions, 336 (2014) 135-142
 3. Rizwin Khanam, Nibedita Paul, Pravin Kumar, D. Kanjilal, Gazi. A. Ahmed, Dambarudhar Mohanta, Structural and optical properties of teflon-impregnated TiO₂ nanoparticles irradiated by 80 keV Xe⁺ ion, *IUAC Annual Report 2012-2013*, 114-115
 4. Poster presentation in SHIMEC, 2014 held at IUAC, New Delhi: *Effect of 80 MeV C⁶⁺ ion irradiation on hydrothermally derived terbium-doped TiO₂ nanotubes.*
- [*] To be communicated.

FUND UTILIZATION CERTIFICATE

(PROJECTS/SCHEMES)

Name of the Nodal institution /

Department of Organisation : TEZPUR UNIVERSITY

Name of the project : **“Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation.”**

Certified that out of Rs.49335/of grant-in aid sanctioned on the head fellowship and Rs.25000/on the head contingency during the financial year 2011-2012 as per sanction order no. IUAC/UFR/50307/1980 dated October 10, 2011 and IUAC/XIII.7/UFR-50307/1516 dated August 29, 2011 respectively in favour of Tezpur University on the subject **UFR-50307** project IUAC, New Delhi, a sum of Rs. 74,333 has been utilized till 31st March 2012.



10.5.12
Project Investigator
Principal Investigator
Project Title :
Sponsor / Agency :
Department of Physics
Tezpur University


Finance officer
Tezpur university

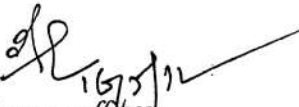
EXPENDITURE STATEMENT OF IUAC(UFR-50307) PROJECT

TITLE: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected ^{to} energetic ion irradiation."

Sl.no	Heads of account	Received grant(Rs.)	Expenditure during 2011-2012 (Rs.)	Unspent balance (Rs.)
1.	Contingency	25,000	25,000	0
2.	Fellowships	49,335	49,333	2
	TOTAL	74,335	74,333	2


Registrar

Tezpur University


Finance officer

Tezpur university

FUND UTILIZATION CERTIFICATE

(2012-2013)

(PROJECTS/SCHEMES)

Name of the Nodal institution/

Department of Organisation

: TEZPUR UNIVERSITY

Name of the project

: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation".

Certified that out of **Rs. 1, 68,000/-** of grant-in aid on the head "fellowship" and **Rs. 25,000/-** on the head "contingency" during the financial year **2012-2013** as per sanction order no. **IUAC/III.01/443** dated July 31, 2012 and **Rs. 37,000** as arrear as per reference no. **IUAC/III.01/7131** dated April 23, 2012 in favor of Tezpur University on the subject IUAC project (No.UFR-50307), New Delhi and from the unspent balance of **Rs. 2/-** carried over from the financial year 2011-12, a sum of **Rs. 2, 30, 000/-** has been utilized till 31st March 2013.

[Handwritten Signature]
15 - Associate Professor
Dept. Of Physics
Tezpur University

Co- Principal Investigator

[Handwritten Signature]
Finance Officer

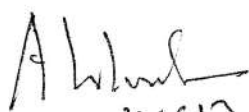
Tezpur University

CCD Finance
Tezpur University

EXPENDITURE STATEMENT OF IUAC (UFR-50307) PROJECT (Year: 2012-13)

TITLE: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation".

Sl.no	Heads of account	Received grant (Rs.)	Expenditure during 2012-2013(Rs.)	Unspent balance(Rs.)
1.	Contingency	25,000 (with no unspent balance of previous year)	25,000	0
2.	Fellowships	1,68,000 (with Rs.2 unspent balance of previous year)	1,68,000	2
3.	Arrear	37,000	37,000	0
	Total	2,30,002	2,30,000	2


21/05/13
Registrar

Tezpur University
Registrar
Tezpur University


Finance Officer

Tezpur University
Finance
Tezpur University

FUND UTILIZATION CERTIFICATE

(2013-2014)

(PROJECTS/SCHEMES)

Name of the Nodal institution/

Department of Organisation

: TEZPUR UNIVERSITY

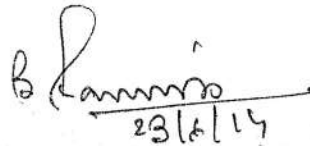
Name of the project

: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation".

Certified that out of Rs. 1, 67,998/- of grant-in aid on the head "fellowship" and Rs. 25,000/- on the head "contingency" during the financial year 2013-2014 as per sanction order no. IUAC/XIII.7/UFR-50307/ dated 5th September 2013 in favor of Tezpur University on the subject IUAC project (No.UFR-50307), New Delhi and from the unspent balance of Rs. 2/- carried over from the financial year 2011-12, a sum of Rs. 1,93, 000/- has been utilized till 31st March 2014.


Principal Investigator

Title *photonic prop.*
Department of Physics
TEZPUR UNIVERSITY



23/6/14
Finance Officer

Tezpur University
Finance Officer
Tezpur University

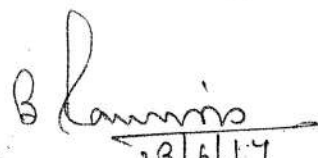
EXPENDITURE STATEMENT OF IUAC (UFR-50307) PROJECT (Year: 2013-14)

TITLE: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation".

Sl.no	Heads of account	Received grant (Rs.)	Expenditure during 2013-2014(Rs.)	Unspent/committed balance(Rs.)
1.	Contingency	25,000 (with no unspent balance of previous year)	25,000	0
2.	Fellowships	1,67,998(+2) {with Rs.2 unspent balance of previous year}	1,68,000	0
	Total	1,92,998+2=1,93,000	1,93,000	0


Registrar

Tezpur University
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Finance Officer

Tezpur University
Finance Officer
Tezpur University

FUND UTILIZATION CERTIFICATE

(2014-2015)

(PROJECTS/SCHEMES)

Name of the Nodal institution/

Department of Organisation

: TEZPUR UNIVERSITY

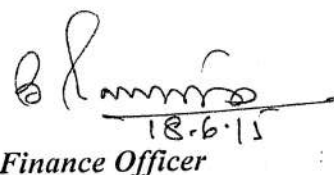
Name of the project

: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation".

Certified that out of Rs. 1,05,669/- of grant-in aid on the head "fellowship" during the financial year 2014-2015 as per sanction order no. IUAC/XIII.7/UFR-50307/ dated 30th October, 2014 in favor of the Registrar, Tezpur University on the subject IUAC project (No.UFR-50307), New Delhi , the whole sum of Rs. 1,05,669/- has been utilized till 31st March 2015.



Principal Investigator



Finance Officer

Tezpur University
Finance Officer
Tezpur University

EXPENDITURE STATEMENT OF IUAC (UFR-50307) PROJECT

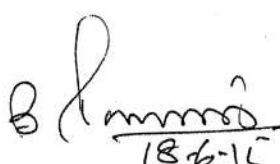
(Year: 2014-15)

TITLE: "Photonic properties of rare-earth impurity doped nanoscale oxide semiconductors subjected energetic ion irradiation".

Sl.no	Heads of account (Fellowship)	Received grant (Rs.)	Expenditure during 2014-2015 (Rs.)	Unspent/committed balance (Rs.)
1.	Net fellowship (@Rs.16,000/- p.m. for 01.04.14 to 25.09.14)	93,333/-	93,333/-	0
2.	Arrear (01.04.13 to 31.03.14)	12,336/-	12,336/-	0
	Total	1,05,669	1,05,669	0


Registrar

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