STUDIES OF RARE EARTH IMPLANTATION IN III Nitride Approach to white LED

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Rare earth implantation in III-V Nitride

- Introduction
- Objective
- Mechanism
- Previous Work
- Simulation Results
- Future Work

Introduction

- III-V Nitride semiconductors are attractive materials for optoelectronic devices.
- Since the III-V nitrides are wider band gap material so there is less possibility of PL quenching at higher temperature and that makes it suitable for higher temperature working.
- Rare earth ions act as a effective luminescence center in III-V nitride and give a very sharp peak emission.

Objective

- Study the effect of rare earth implantation in III-V semiconductor and explore optical properties of these materials.
- Application of RE doped III nitride to produce multi color output.
- Application in fabricating white LED.

Mechanism:

- R E impurities in III-V semiconductors create isoelectronic traps.
- There are two excitation process for RE ions-

  -Direct Excitation: selective excitation of 4f electrons by photons or in CL/EL by collision with hot electron.

  -Indirect Excitation: Transfer of energy to the 4f electron from e-h pairs generated by photons, hot carriers in CL/EL.

Previous Results & Work

- Pr Implantation in GaN
- Eu Implantation in GaN
- Er Implantation in GaN
- Tb Implantation in GaN

Pr Implantation in GaN

Dose	5.7E13
Implant Energy	300 KeV
Typical GaN thickness	0.8 micron
Annealing Temp	750-1050 C
Annealing Time	10-20 min
Emission wavelength (nm)	650,950,1100 1300

Eu Implantation in GaN

Dose	10E14
Energy	200 KeV
Typical GaN thickness	2.0 micron
Annealing temp and time	1050 C for 60 min
Emission wavelength (nm)	600

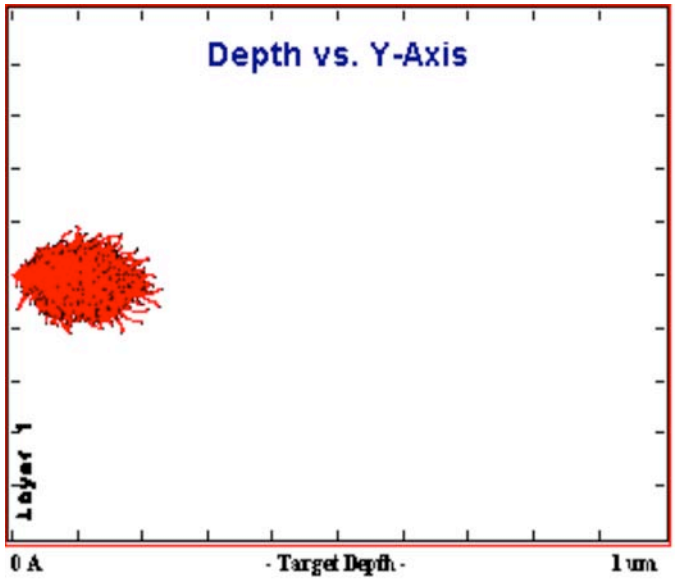
Simulation

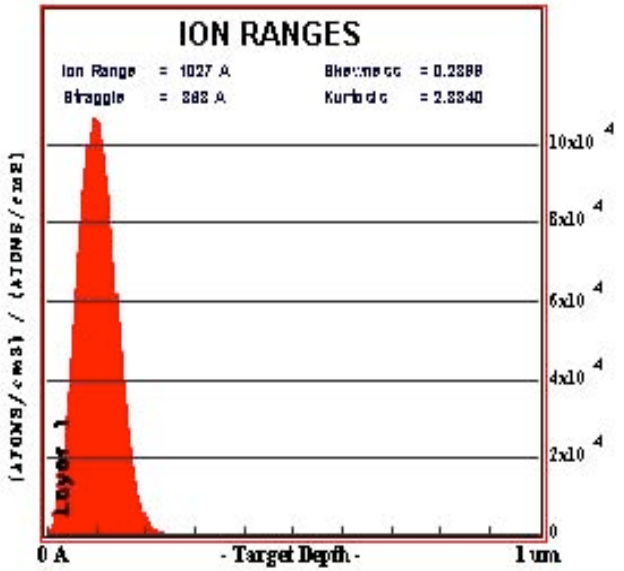
- Minimum GaN thickness is determined by the projected ion range on implantation of rare earth species in GaN.
- We are using TRIM-2000(Transport of ions in matter) Simulation package for that purpose.
- The input parameter to the simulation are implantation energy, dose, implanted angle of incidence and implanted species.
- Implanted angle of incidence is taken as 7 degree to prevent channeling.

Result Summary:

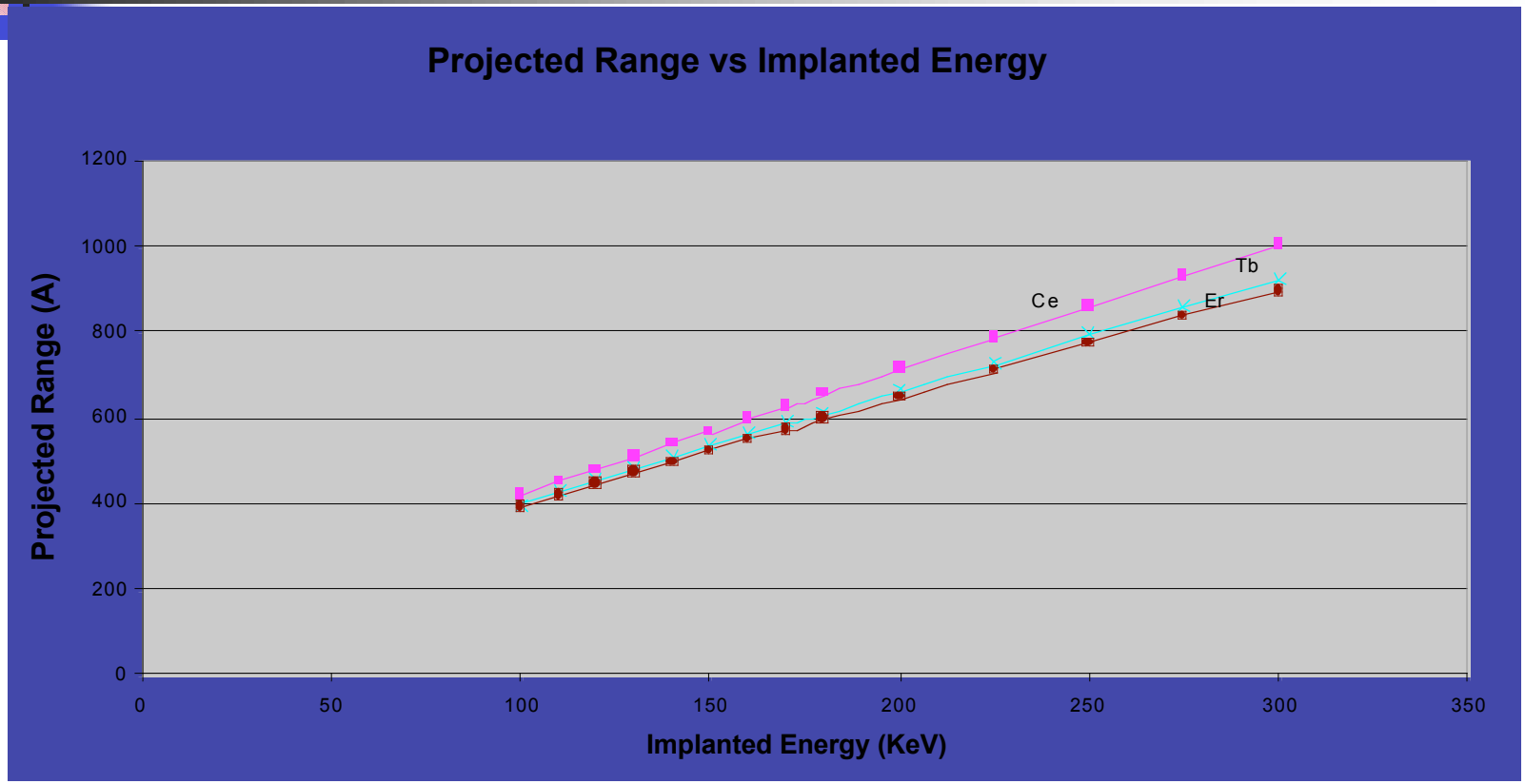
Energy (KeV)	Projected Range (A)						
	Ce	Pr	Eu	Tb	Er	Tm	Yb
100	417	413	402	397	390	388	387
110	448	443	431	425	417	415	413
120	478	472	459	453	444	442	440
130	508	502	487	480	470	468	465
140	538	531	515	507	496	494	491
150	568	560	542	534	522	519	516
160	597	589	570	560	548	545	541
170	626	618	597	587	573	570	566
180	655	646	624	613	598	595	591
200	713	703	678	665	649	645	640
225	786	774	744	730	711	706	700
250	858	845	810	794	772	767	760
275	929	915	876	858	834	827	820
300	1001	985	942	921	894	888	879

Simulation Result For Ce:





Result Summary:



White LED

- Common method to fabricate white LED is to combine blue emission GaN with yellow phosphor.
- Blue emission wavelength pumps the phosphor atom to emit yellow color.
- Combination of blue and yellow color produce white color.

White LED contd….

- This approach is called LUCOLED and can be understood by this diagram.
- Recently park et al fabricated LED by combining blue emission of GaN with Sr2SiO4:Eu phosphor.

White LED

- Park et al approach has luminescence efficiency better than the industrial available InGaN White LED combined with YAG.
- Although further modification can be possible by using nano wires concept.

Future Work

- Implant rare earth atom Ce or Tb in GaN and combine with yellow emission phosphors.
- It may produce higher luminescence intensity due to more intense blue emission of Ce implanted GaN chip.

Thank you