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SIMULATION STUDY OF THE ION IMPLANTATION ENERGY OF POTASSIUM IN THE ZnO MATRIX

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There are many methods used for doping the materials, the ion implantation method is one of those methods. It can be simulated by the TRIM software (Transport and Range of Ions in Mater) developed by Ziegler and al [1]. In this work, using the TRIM software is to study the effect of implantation energy and on distribution of implant ions in the target and to examine the different processes resulting from the interaction between the ions of potassium and the target atoms. Interesting physical effects have been simulated

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1. Introduction

Ion implantation was used initially for surface cleaning, the modification of the physical properties under the bombarded surface led to the use of implantation in the doping of semiconductors. In the case of ion implantation the concentration of doping introduced is not limited by their solubility in the target material. Controlling the distribution of doping , damaging the target material following ion implantation, its healing by thermal annealing and above all the electrical characteristics of the semiconductor after ion implantation and post-implantation annealing, are the factors which characterize the efficiency of doping by ion implantation. The amount of material implanted per unit area. The implanted dose, is measured by counting the charge arriving on the target by integrating the current for a well-determined surface over the duration of the ion implantation [2; 3]. Zinc Oxide has very interesting electronic, electrical and optical properties which make it a candidate for various applications in optoelectronics. In particular for the production of LED devices and in the photovoltaic field [4]. Because ion implantation is usually the best means to introduce dopants into materials in a controlled manner [5], the interest in understanding the effects of Potassium ion presence in ZnO is important for the further development of controlled manufacturing of this material. However, implantation cannot be done without the introduction of radiation damage into the sample. [5; 6].

2. Modeling software TRIM

The interaction between ions beam and the sample composed of two mechanisms: the first one is interaction between ions and the nucleus of the target atoms and the second is the interaction with the electrons of the target atoms, which are considered as independent mechanisms [8]. In this work we used the TRIM (Transport and Rang of Ion in Matter) in which is a collection of software packages developed by Ziegler and Biersack that calculate the stopping and range of ions into matter. TRIM is a reference and extremely popular program in the radiation effects community; it is based on a Monte Carlo simulation [8; 7].

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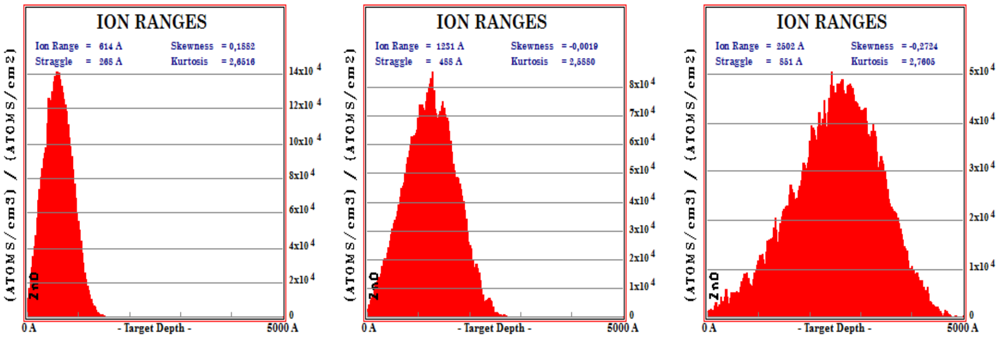
3. Results and discussion

So as to examine the effect of bombardment of potassium k ions falls in 0.5 μm ZnO target, with 9999 ions incident at an incidence normal to the plane of the material surface $(\theta = 0°)$ for variety implantation energy from 100 Kev to 1Mev.

3.1. Ion distribution

In Fig.1 we presented the ions distribution in ZnO layer, with the target depth for different energies. The distribution is a Gaussien type beam particles. When we bombard ZnO target with 100 KeV Potassium ions, we are looking that ion range achieve 614 A and the straggle to 265 A. when we changed the energy of ions beam we get a good distribution for Potassium ions in the depth of target ZnO.



(a) *(b)* *(c)*

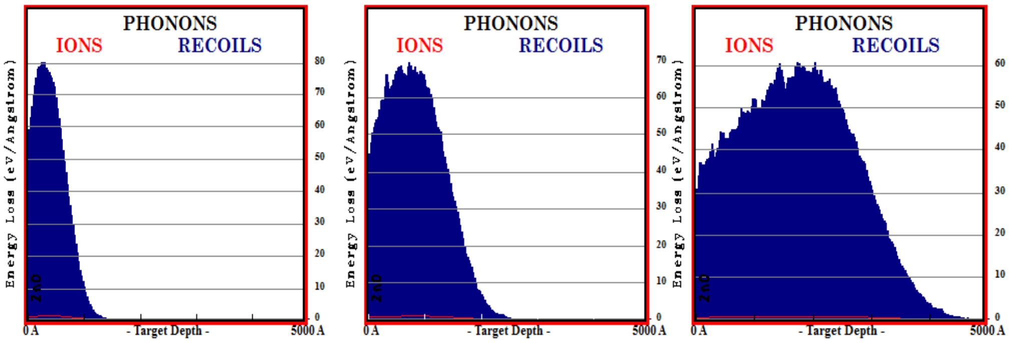
Fig.1. Probability of the presence of each implanted K ion (angle = 0°) in the ZnO; a= 100 KeV ; b= 200 KeV ; c= 400 KeV.

Table 1. Statistic for ion energy and straggle.

Energy	Ion Range A	Straggle A
100 KeV	614	268
200 KeV	1231	488
400 KeV	2502	551
600 KeV	3478	994
800 KeV	3739	981
1 MeV	3722	1017

3.2. Phonon production

The implantation of K ions in ZnO layer gives the Phonons. Fig. 2 illustrates the produced phonons, for different energies (100Kev, 200 KeV and 400KeV). In the bottom; the red line present the ion loss energy transferred to phonon. In the table 2 we present the energy loss for different value of energy ion incident.



(a) (b) (c)

Fig. 2.The distribution of target phonons produced
a= 100 KeV ; b= 200 KeV ; c= 400 KeV.

Table 2 present the statistic of energy loss for ions and recoils for different value of energy in the case of 100 KeV the ions losing from its energy about 0.82 %, to phonons, while the recoils are depositing 2.48 % of the energy into phonons. We note that the energy loss to phonons production is less than that to ionization. Vacancy production amounts to few per cent of the total energy in two cases.

Table2.Statistic for energy loss %.

	Energy loss	Ion %	Recoils %
100 Kev	ionization	19.94	20.61
	Phonons	0.82	2.48
	Vacancies	0.22	55.93
200KeV	ionization	28.32	20.02
	Phonons	0.63	48.68
	Vacancies	0.16	2.19
400KeV	ionization	39.01	18.44
	Phonons	0.49	40.12
	Vacancies	0.12	1.82
800KeV	ionization	56.44	14.57
	Phonons	0.08	1.25
	Vacancies	0.34	27.32

3.3. Stopping range ions

In Fig.3 is shown the variation of the electronic and nuclear stopping range the ions of Potassium K according to its incident energy presents a different variation. There is an exponential increase in electronic stopping range then decreases at nuclear stopping range until reaching an asymptotic value. Recall that the electronic stopping power is an inelastic interaction which takes place with the orbital electrons of the retarding medium. It is responsible for the excitation and ionization of the target atoms.

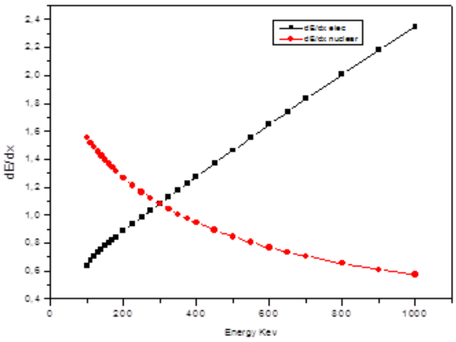


Fig.3. Electronic and nuclear stopping range for Potassium in ZnO.

4. Conclusions

Ion implantation simulation of Potassium ions in ZnO material show that most of the energy loss is due to ionization and phonon production. The variation of ionization energy has a big effect at ions distribution and phonon production. The ions distribution and penetration depth was determined as well as understanding the formation of defects in ZnO following K implantation.

The implanted ions have a concentration profile as a function of Gaussian-type depth. We can affirm the formation of nanostructures on the surface of the bombarded material but also and especially a new arrangement of the atoms of a new material containing in its matrix Potassium like doping. This operation is called ion implantation or doping.

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