Министерство образования и науки Российской Федерации
Федеральное государственное автономное образовательное учреждение
высшего образования
**«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**

Институт Физико-технический
Направление подготовки 14.04.02 Ядерные физика и технологии
Кафедра Физико-энергетические установки

МАГИСТЕРСКАЯ ДИССЕРТАЦИЯ

Тема работы
Профилирование нейтронного поля для облучения протяженных объектов

УДК 621.039.55

Студент

Группа	**ФИО**	**Подпись**	**Дата**
0АМ5И	Кумар Ашок		

Руководитель

Должность	**ФИО**	**Ученая степень, звание**	**Подпись**	**Дата**
Доцент	Наймушин А.Г	к.ф.-м.н.		

КОНСУЛЬТАНТЫ:

По разделу «*Финансовый менеджмент, ресурсоэффективность и ресурсосбережение*»

Должность	**ФИО**	**Ученая степень, звание**	**Подпись**	**Дата**
Доцент	Рахимов Т.Р	К.Э.Н		

По разделу «*Социальная ответственность*»

Должность	**ФИО**	**Ученая степень, звание**	**Подпись**	**Дата**
Ст. Преподаватель	Веригин Д.А	к.ф.-м.н.		

ДОПУСТИТЬ К ЗАЩИТЕ:

Зав. Кафедрой	**ФИО**	**Ученая степень, звание**	**Подпись**	**Дата**
ФЭУ	Долматов О.Ю.	к.ф.-м.н., доцент		

Томск – 2017 г.

Министерство образования и науки Российской Федерации
Федеральное государственное автономное образовательное учреждение
высшего образования
**«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**

Институт Физико-технический
Направление подготовки 14.04.02 Ядерные физика и технологии
Кафедра Физико-энергетические установки

УТВЕРЖДАЮ:
Зав. Кафедрой ФЭУ
________ ________ О.Ю. Долматов
(Подпись) (Дата) (Ф.И.О.)

ЗАДАНИЕ
на выполнение выпускной квалификационной работы

В форме:

Магистерской диссертации

(бакалаврской работы, дипломного проекта/работы, магистерской диссертации)

Студенту:

Группа	**ФИО**
0АМ5И	Кумар Ашок

Тема работы:

Профилирование нейтронного поля для облучения протяженных объектов	
Утверждена приказом проректора-директора (директора) (дата, номер)	

Срок сдачи студентом выполненной работы:	

ТЕХНИЧЕСКОЕ ЗАДАНИЕ:

Исходные данные к работе *(наименование объекта исследования или проектирования; производительность или нагрузка; режим работы (непрерывный, периодический, циклический и т. д.); вид сырья или материал изделия; требования к продукту, изделию или процессу; особые требования к особенностям функционирования (эксплуатации) объекта или изделия в плане безопасности эксплуатации, влияния на окружающую среду, энергозатратам; экономический анализ и т. д.).*	1.

Перечень подлежащих исследованию, проектированию и разработке вопросов *(аналитический обзор по литературным источникам с целью выяснения достижений мировой науки техники в рассматриваемой области; постановка задачи исследования, проектирования, конструирования; содержание процедуры исследования, проектирования, конструирования; обсуждение результатов выполненной работы; наименование дополнительных разделов, подлежащих разработке; заключение по работе)*.	1.
Перечень графического материала *(с точным указанием обязательных чертежей)*	Презентация – 20 слайдов;

Консультанты по разделам выпускной квалификационной работы	
Раздел	**Консультант**
Финансовый менеджмент, ресурсоэффективность и ресурсосбережение	Рахимов Т.Р
Социальная ответственность	Веригин Д.А.

Названия разделов, которые должны быть написаны на иностранном языке:
Теоретическая часть
Практическая часть
Результаты
Финансовый менеджмент, ресурсоэффективность и ресурсосбережение
Социальная ответственость

Дата выдачи задания на выполнение выпускной квалификационной работы по линейному графику	

Задание выдал руководитель:

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Доцент	Наймушин А.Г	к.ф.-м.н.		

Задание принял к исполнению студент:

Группа	ФИО	Подпись	Дата
0АМ5И	Кумар Ашок		

ЗАДАНИЕ ДЛЯ РАЗДЕЛА

«ФИНАНСОВЫЙ МЕНЕДЖМЕНТ, РЕСУРСОЭФФЕКТИВНОСТЬ И РЕСУРСОСБЕРЕЖЕНИЕ»

Студенту:

Группа	ФИО
0АМ5И	Кумар Ашок

Институт	ФТИ	Кафедра	ФЭУ
Уровень образования	Магистратура	Направление/специальность	Ядерные физика и технологии

Исходные данные к разделу «Финансовый менеджмент, ресурсоэффективность и ресурсосбережение»:	
1. Стоимость ресурсов научного исследования (НИ): материально-технических, энергетических, финансовых, информационных и человеческих	*- Стоимость ресурсов научного исследования (НИ): материально-технических, , финансовых, информационных и человеческих*
2. Нормы и нормативы расходования ресурсов	*- Нормы и нормативы расходования ресурсов*
3. Используемая система налогообложения, ставки налогов, отчислений, дисконтирования и кредитования	*- Используемая система налогообложения, ставки налогов, отчислений, дисконтирования и кредитования*
Перечень вопросов, подлежащих исследованию, проектированию и разработке:	
1. Оценка коммерческого и инновационного потенциала НТИ	…
2. Разработка устава научно-технического проекта	…
3. Планирование процесса управления НТИ: структура и график проведения, бюджет, риски и организация закупок	*- Планирование процесса управления НТИ: структура и график проведения, бюджет и организация закупок*
4. Определение ресурсной, финансовой, экономической эффективности	…
Перечень графического материала *(с точным указанием обязательных чертежей):*	
1. «Портрет» потребителя результатов НТИ *2. Сегментирование рынка* *3. Оценка конкурентоспособности технических решений* *4. Диаграмма FAST* *5. Матрица SWOT* *6. График проведения и бюджет НТИ* *7. Оценка ресурсной, финансовой и экономической эффективности НТИ* *8. Потенциальные риски*	

Дата выдачи задания для раздела по линейному графику	

Задание выдал консультант:

Должность	ФИО	Ученая степень, звание	Подпись	Дата

Доцент	Рахимов Т.Р	К.Э.Н		

Задание принял к исполнению студент:

Группа	ФИО	Подпись	Дата
0АМ5И	Кумар Ашок		

ЗАДАНИЕ ДЛЯ РАЗДЕЛА
«СОЦИАЛЬНАЯ ОТВЕТСТВЕННОСТЬ»

Студенту:

Группа	ФИО
0АМ5И	Кумар Ашок

Институт	ФТИ	**Кафедра**	ФЭУ
Уровень образования	Магистратура	**Направление/специальность**	Ядерные физика и технологии

Исходные данные к разделу «Социальная ответственность»:	
1. *Описание рабочего места (рабочей зоны, технологического процесса, механического оборудования) на предмет возникновения:* – *вредных проявлений факторов производственной среды (метеоусловия, вредные вещества, освещение, шумы, вибрации, электромагнитные поля, ионизирующие излучения)* – *опасных проявлений факторов производственной среды (механической природы, термического характера, электрической, пожарной и взрывной природы)* – *негативного воздействия на окружающую природную среду (атмосферу, гидросферу, литосферу)* – *чрезвычайных ситуаций (техногенного, стихийного, экологического и социального характера)*	1. Описание рабочего места инженера, выполняющего расчеты на ПК, на предмет возникновения: – вредных факторов производственной среды: повышенный уровень электромагнитных излучений, ионизирующее излучение; – опасных факторов производственной среды: вероятность возникновения пожара, вероятность поражения электрическим током.
2. *Знакомство и отбор законодательных и нормативных документов по теме*	2. Ознакомление с законодательной и нормативной документацией.
Перечень вопросов, подлежащих исследованию, проектированию и разработке:	
1. *Анализ выявленных вредных факторов проектируемой производственной среды в следующей последовательности:* – *физико-химическая природа вредности, её связь с разрабатываемой темой;* – *действие фактора на организм человека;* – *приведение допустимых норм с необходимой размерностью (со ссылкой на соответствующий нормативно-технический документ);* – *предлагаемые средства защиты (сначала коллективной защиты, затем – индивидуальные защитные средства)*	1. Анализ выявленных вредных факторов: – повышенный уровень электромагнитных излучений, ионизирующее излучение; – средства защиты.
2. *Анализ выявленных опасных факторов проектируемой произведённой среды в следующей последовательности* – *механические опасности (источники, средства защиты;* – *термические опасности (источники, средства защиты);* – *электробезопасность (в т.ч. статическое электричество, молниезащита – источники, средства защиты);* – *пожаровзрывобезопасность (причины, профилактические мероприятия, первичные средства*	2. Анализ выявленных опасных факторов: – электробезопасность (в т.ч. статическое электричество, средства защиты); – пожаровзрывобезопасность (причины, профилактические мероприятия, первичные средства пожаротушения)

пожаротушения)	
3. Охрана окружающей среды: – *защита селитебной зоны* – *анализ воздействия объекта на атмосферу (выбросы);* – *анализ воздействия объекта на гидросферу (сбросы);* – *анализ воздействия объекта на литосферу (отходы);* – *разработать решения по обеспечению экологической безопасности со ссылками на НТД по охране окружающей среды.*	
4. Защита в чрезвычайных ситуациях: – *перечень возможных ЧС на объекте;* – *выбор наиболее типичной ЧС;* – *разработка превентивных мер по предупреждению ЧС;* – *разработка мер по повышению устойчивости объекта к данной ЧС;* – *разработка действий в результате возникшей ЧС и мер по ликвидации её последствий*	
5. Правовые и организационные вопросы обеспечения безопасности: – *специальные (характерные для проектируемой рабочей зоны) правовые нормы трудового законодательства;* – *организационные мероприятия при компоновке рабочей зоны*	
Перечень графического материала:	
При необходимости представить эскизные графические материалы к расчётному заданию (обязательно для специалистов и магистров)	нет

Дата выдачи задания для раздела по линейному графику	

Задание выдал консультант:

Должность	ФИО	Ученая степень, звание	Подпись	Дата
Ст. Преподаватель	Веригин Д.А			

Задание принял к исполнению студент:

Группа	ФИО	Подпись	Дата
0АМ5И	Кумар Ашок		

Summary

The master dissertation consists of 67 pages; 12 figures; 8 tables; 19 references and 2 appendixes.

Key words: IRT; pool-type reactor ; burn up equation; neutron transport equation; doping of silicon; neutron transmutation method ; selection of filter material; optimization of filter material thickness; reaction rate; power distribution in filter material; heat transfer coefficient of coolant.

The objectиже of this work is to select suitable filter material (neutron flux screen) to achieve normalization of neutron flux in silicon so the doping process is uniform throughout the material.

This dissertation briefly explains about methodology of silicon doping by neutron transmutation method step by step.

First part of the dissertation deals with the detailed Literature review sourced from various references from leading journals.

Then a detailed neutron characteristics of the flux screen material is investigated and two materials or suggested for future research. A numerical model is created using WIMS ANL computer code based on the given task.Optimization of filter material thickness to achieve axial uniformity and developing a dependence on power distribution in the filter material. Calculation of heat transfer coefficient of the coolant for the given model.

Cost-effectiveness/value of the work: cheap, does not require much cost.

Applied areas: Can be used in all types of research reactors with specific model

Table of Contents

Abstract

For many years, research reactors are widely used for various research activities all over the world. Among various areas of research reactor utilization, the neutron transmutation doping of silicon is one well established technology desired by industry. Silicon semiconductors doped via the NTD method have been widely used in various industrial fields, especially for high quality semiconductor power devices.

Topicality: This dissertation presents basic design of one such model which describes the doping of silicon in pool type reactor and to achieve axial uniformity in silicon doping by using filter material (neutron flux screen).

- In this dissertation WIMS ANL program is used to create a geometry based on basic reactor parameters. $UO_2$is used as fuel with the enrichment of 5% and suitable diameter for silicon block is chosen and Europium element is used as neutron flux screen.

Purpose of this work: Optimization of filter material thickness in order to obtain axial uniformity of neutron flux and hence achieving uniform doping of the semiconductor material.

Tasks:

- Analysis of the materials, suitable for being used as a filter material.
- Neutron characteristics comparison of the filter materials.
- Defining 2 materials for the further investigation.
- Analysis of the neutron field distribution over the experimental channel volume.
- Calculation of the optimal filter design parameters.
- Evaluation of the power distribution in the filter components, determined by the ionizing radiation interaction with the filter materials.
- Developing filter based on pool-type reactor.

This dissertation primarily deals with theoretically generated computer model to investigate neutron flux distribution in model volume and there by developing neutron flux

distribution dependence along the axial volume of the generated model.The dissertation also shows a way how to implement this research results in improvising the filter material design parameters.

1. Literature review

1.1 Background

Based on the report of IAEA has conducted several missions to promote the research and development activities of research reactors. Among various areas of reactor utilization, the neutron transmutation doping of silicon is one well established technology desired by industry. Silicon semiconductors doped via the NTD method have been widely used in various industrial fields, for high quality semiconductor power devices.

NTD provide a direct commercial income to research reactors, and many research reactor operators desire to implement NTD at their facilities. This may have given a negative effect to industry's motive for adopting NTD technology for their products. Industry is basically reluctant to use nuclear reactors as a part of their production process based on worries about the availability of NTD, since many NTD reactors across the world are aged, some of them operate with reduced capacity or may even be closed. Therefore, enhancing NTD availability by involving more research reactor facilities would reduce the burden of potential industrial partners developing another technology or material that is costly and needs further R&D efforts. Benefitting not only industry but also the research reactor community, collaboration in NTD is needed.

The demand for NTD increased rapidly during the 1980s but decreased in the subsequent decade due to the development of gas doping technology, and then fluctuated between 2000 and 2005. Since then, NTD has faced another new circumstance. The demand for high power semiconductors was increasing constantly given the rapid increase of green energy technologies such as alternative electricity generation by wind mills and solar cells as well as hybrid and electric vehicles. The NTD method has several advantages in the production of high power semiconductors in comparison with other conventional doping technologies such as ion implantation or the diffusion method.

1.2 What is NTD

Nuclear transmutation is process of change of a nucleus to another or multiple other nuclides through a nuclear reaction. The transmutation is usually done by interaction with neutrons, photons or high energized charged particles. If a nucleus absorbs a neutron, the resulting compound nucleus may be in an unstable state and undergo some processes to become stable. If its atomic number is changed in this process, the original atom is changed into a new element and therefore will have different properties. Doping is a process of intentionally mixing a small amount of an impurity into a material to improve its properties for dedicated purposes. Particularly, doping in semiconductor technology is the insertion or creation of impurities in an intrinsic or extrinsic semiconductor material to improve its electrical properties. An intrinsic semiconductor is a pure semiconductor without any significant intentionally introduced dopant species present. Thus, its electrical properties are determined by the properties of the material itself. An extrinsic semiconductor, on the other hand, is a doped semiconductor. Therefore, NTD is defined as the process by which neutron irradiation creates the impurity in an intrinsic or extrinsic semiconductor to increase its value for various uses [1, 2, 3, 4].

1.3 Targets of NTD

The most common target or candidate materials for NTD are Si, Ge, GaAs, GaN, GaP [5], InP [6], InSe [7] and HgCdTe [8]. Among them, silicon and germanium belong to the carbon group, which are very common among them. Each of the elements in this group has four valence electrons in its outermost orbital. The valence electrons of Si or

Ge enter into covalent bonds with the valence electrons of adjacent atoms resulting in the formation of a diamond lattice, i.e. two penetrating face centred cubic Bravais lattices, displaced along the body diagonal of the cubic unit cell by one quarter the length of the diagonal. The covalent bonds in the diamond lattice make Si and Ge a semiconductor or in other words an insulator at low temperatures. Silicon atoms are composed of three isotopes, ^{28}Si (abundance: 92.23%), ^{29}Si (abundance: 4.67%) and ^{30}Si (abundance: 3.10%). Among them, when ^{28}Si or ^{29}Si atoms absorb a thermal neutron, they are changed into other stable silicon atoms. The absorption of a fast neutron leads to the direct or indirect (via decay) production of Al or Mg isotopes. The probability of this type of absorption, however, is lower by about two orders of magnitude. The absorption of fast neutrons disturbs the goal of Si doping. It is therefore desirable to suppress it by the provision of a well thermalized neutron spectrum for doping purposes. In the case of ^{30}Si, thermal neutron capture causes to the unstable isotope ^{31}Si, which undergoes beta decay. The product of this process is a phosphorous atom, ^{31}P, resulting in the n type impurity doping in silicon material:

$$^{30}Si + n \rightarrow {}^{31}Si \rightarrow (\beta^-) \rightarrow {}^{31}P \qquad (1.1)$$

The ^{31}P atom is a stable penta-valent impurity from group 15 in the periodic table. The component elements from this group have five electrons in their outermost shell, i.e. n type impurity doping is achieved through this process. The fact that the irradiation of Si with thermal neutrons results only in a single nuclear reaction and the short half-life of ^{31}Si of only 2.62 h are parameters of crucial importance with respect to the use of the NTD doping technique on an industrial scale. When natural germanium is being irradiated by thermal neutrons, gallium-31, arsenic-33 and selenium-34 atoms are produced by electron capture and some β^- decay. Among these products, the yield of gallium generated by the following reaction is the largest:

$$^{70}Ge + n \rightarrow {}^{71}Ge \rightarrow (EC)\ {}^{71}Ga \qquad (1.2)$$

Since ^{71}Ga is a stable trivalent impurity from group 13, p type impurity doping is possible by the neutron irradiation of germanium . The NTD method for germanium doping demonstrates its superiority in the micro-distribution of resistivity (0.7%) compared to resistances prepared by metallurgical techniques (4.3%). Germanium doped by the NTD method is used for the far-infrared p-Ge laser and several sensors, including extremely low temperature measurement devices like germanium cryogenic thermistors.

Gallium arsenide (GaAs) is an very important semiconductor material in the manufacture of devices such as microwave frequency integrated circuits, infrared light-emitting diodes, laser diodes and solar cells. GaAs has more superior electronic properties when compared with silicon. When GaAs is being irradiated by neutrons, germanium or selenium atoms are generated, and the amount of generated selenium is much larger than that of germanium. Thus, n type impurity doping in GaAs is possible by neutron irradiation.

Gallium nitride (GaN) can be produced as an n type semiconductor through two doping processes:

$$^{69}Ga + n \rightarrow {}^{70}Ga \rightarrow (\beta)\ {}^{70}Ge \tag{1.3}$$

While many significant commodities are produced from germanium, the main target of NTD is only silicon. A large commercial amount of NTD is applicable only for silicon because of the following reasons:

- Silicon is the most widely used semiconductor material;
- The demand for an extremely high quality silicon semiconductor useful for power devices and sensors has been significant and is still increasing;
- Unlike a pure silicon base, compound semiconductors in certain cases are more difficult to manufacture, primarily in the introduction of the dopant into the correct sub-lattice;
- NTD technology is far superior for the production of a semiconductor with an extremely uniform dopant concentration.

- Si ingots are available in the form of extremely pure perfect single crystals

1.4 Doping of a semiconductor

The process of adding impurities into the material in order to improve its one more properties is called as doping. Doping means the addition of impurities into a semiconductor crystal to the defined modification of conductivity. Two of the most important materials silicon can be doped with, as boron (3 valence electrons = 3-valent) and phosphorus (5 valence electrons = 5-valent). Other materials are aluminum, indium (3-valent) and arsenic, antimony (5-valent).The dopant is integrated into the lattice structure of the semiconductor crystals, the number of outer electrons defines the type of doping. Elements with 3 valence electrons are used for p-type doping, 5-valued elements for n-doping. The conductivity of a the contaminated silicon crystal can be increased by a factor of 10^6

1.5 Intrinsic semiconductors

The electrical conductivity of a semiconductor can be maintained over a wide range either permanently or drastically. Semiconductor devices are essential in modern technology. Silicon is significant as a matrix material to be doped in a majority of semiconductor devices, while other materials, although at lesser extent, are used as well.

An intrinsic semiconductor [14], also called an undoped semiconductor, is a pure material without any dopant species present. Elements from the group 14 in the periodic table such as silicon and germanium have four valence electrons, and they are called tetravalent elements. In their crystalline structure (diamond lattice), they form covalent bonds with adjacent atoms. The periodic lattice of a semiconductor crystalline structure establishes certain energy for electrons. The energy of an electron is confined to one of these energy bands. Figure 1 shows a simplified representation of the two uppermost bands in silicon. The lower lying energy bands are of not importance for the electrical conduction

The lower band is called the valence bond, in which outer shell electrons are bound to specific lattice sites by the covalent bonding that constitutes the interatomic forces within the crystal. The next higher band is called the conduction band, in which electrons are free to migrate through the crystal. Only these electrons and the corresponding holes (see below) contribute to the electrical conductivity of the material. The two bands are separated by the band-gap. Electrons in the valence band must cross the band-gap to reach the conduction band. It is similar to insulators, but the band-gap for an insulator is usually 5 eV or more, which is much higher than that of semiconductors.

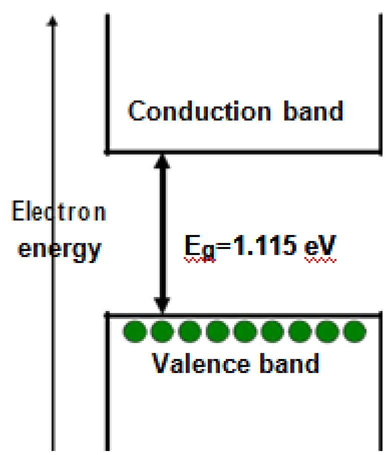

Fig 1.1.Energy band in semiconductors

In intrinsic semiconductors at room temperature, just as in insulators, very small amount of electrons gain enough thermal energy to leap over the band-gap. Therefore, intrinsic semiconductors and insulators have roughly the same conductivity at room temperature.

If an electron in the valence band leaps over the band-gap, the electron can have the specific bonding site and drift in the conduction band throughout the crystal. The excitation process not only creates an electron in the conduction band, but leaves a vacancy called a hole in the valence band, creating what is called an electron–hole pair.

The hole can also move under the influence of an applied electric field in the opposite direction of the electron. The mobility of both of these charges contributes to the observed conductivity of the material.

1.6 Doped semiconductors.

A semiconductor's intrinsic electrical properties are often modified by doping. The amount of dopant added to an intrinsic semiconductor measures the level of conductivity. Silicon is tetravalent and its normal crystalline structure forms covalent bonds with 4 adjacent atoms as shown in Figure1.2(a). In this figure, each dot represents a normal valence electron involved in the covalent bond. One of these covalent electrons can be lost by thermal excitation, leaving behind an unsaturated bond or hole. In silicon doped by an element in group 15, i.e. phosphorus, arsenic or antimony, some silicon atoms in the lattice are substituted by the dopant atoms as shown in Figure1.2 (b). Because there are five valence electrons surrounding a dopant atom, one electron is left over after all covalent bonds have been formed. This extra electron is only bound to the atom at the original site. From the perspective of the energy bands, it populates a level within the band gap but is separated by only a comparatively small energy (i.e. 44 meV for P in Si) from the conduction band and can be excited at moderate temperature easily into the conduction band to form a conduction electron without a corresponding hole. At normal temperature, virtually all such electrons are excited into the conduction band. Since excitation of these electrons does not result in the formation of holes, the number of electrons far exceeds the number of holes. In this case, the electrons are the majority carriers, and the holes are the negative charge of the majority charge carrier electrons. Note that each movable electron within the semiconductor has always been donated by an immobile positive dopantion, and the doped material has a net electric charge of zero.

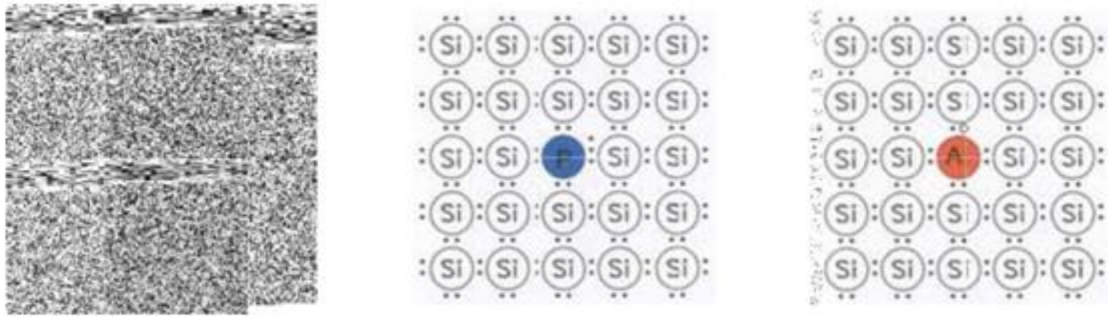

Fig1.2 Impurities in doped semiconductors

Semiconductors doped with donor impurities are called n type, while those doped with acceptor impurities are called as p type. The n- and p type designations indicate which charge carrier acts as majority carrier. The opposite carrier is called the minority carrier, which occurs due to thermal excitation at a much lower concentration than the majority carrier.

Degenerately, or very highly, doped semiconductors have conductivity levels comparable to metals. From the point of view of the energy bands, a degeneracy means the majority carrier levels interact and form a band on their own which merges with the conduction band in case of n type semiconductors or the valence band in case of p type semiconductors. Like in metals, in degenerate semiconductors occupied and un-occupied energy levels are no longer separated by a band-gap. Degenerate semiconductors are often seen in modern integrated circuits as a replacement for metal. Superscript plus and minus symbols are often used to denote relative doping concentration in semiconductors. For example, n^+ denotes an n type semiconductor with a huge, often degenerate, doping concentration. Similarly, p^- indicates a very lightly doped p type material.

Even at degenerate levels of doping, the concentration of dopant with respect to the base material is much lower. The doping concentration for silicon semiconductors may be in the range from 10^{13} cm^{-3} to 10^{18} cm^{-3}. Doping concentrations above 10^{18} cm^{-3} is considered degenerate at ambient temperature. Degenerately doped silicon contains dopant atoms in the order of parts per thousand of silicon.

1.7 Doping methods

Doping means the mixing of impurities into the semiconductor crystal to purposely alter its conductivity due to deficiency or excess of electrons. In contrast to the doping during the wafer fabrication, where the entire wafer is doped, this article describes the partial doping of silicon. The introduction of foreign substances can be achieved by diffusion, ion implantation (or alloy).

- Diffusion
- Ion implantation
- Neutron transmutation doping

1.7.1 Diffusion

Molecular diffusion, which is called simply diffusion, is a transport of molecules from a region of higher concentration to one of lower concentration by random molecular motion. The result of diffusion is a gradual addition of materials. To illustrate: a drop of ink in a glass of water is evenly spread after a certain amount of time. In a silicon crystal, one finds a solid lattice of atoms in which the dopant has to move. This can be done in different ways:

- **Empty space diffusion:** the impurity atoms can fill empty places in the crystal lattice which are present, even in perfect single crystals
- **Inter lattice diffusion:** the impurity of atoms move in-between the silicon atoms in the crystal lattice.
- **Changing of places:** the impurity of atoms are located in the crystal lattice and are exchanged with the silicon atoms.

1.7.2 Diffusion with an exhaustible source:

Diffusion with an exhaustible source is that the dopant is available in a limited quantity only. The longer the diffusion process occurs, the lower the concentration at the surface, and therefore the depth of penetration into the material increases. The diffusion coefficient of a substance indicates how fast it moves in the crystal. Arsenic with a low diffusion coefficient penetrates slower into the material, as for example phosphorus or boron.

1.7.3 Diffusion with an inexhaustible source:

In diffusion processes with an inexhaustible source the dopants are available in large quantity amount, and therefore the concentration at the surface remains unchanged during the process. Particles that have penetrated into the substrate are continually restored

1.7.4 Diffusion from the gas phase:

A carrier gas (nitrogen, argon, ...) is mixed with the desired dopant (also in gaseous form, e.g. phosphine PH_3 or diborane B_2H_6) and led to the silicon wafers, on which the concentration balance can take place.

1.7.5 Diffusion with solid source:

Slices which contain the dopants are placed in the wafers. If the temperature in the quartz tube is increased, the dopant from the source discs diffuses into the air. With a carrier gas, the dopant will be distributed uniformly, and thus reaches the wafers.

1.7.6 Diffusion with liquid source:

As liquid sources boron bromide BBr_3 or phosphoryl chloride $POCl_3$ can be used. A carrier gas is allowed to flow through the liquids and thus transporting the dopant in gaseous state. Since not the entire wafers should be doped, certain areas can be covered with silicon dioxide. The dopants can not penetrate through the oxide, and therefore no doping takes place at these areas. To avoid tensions or even fractions of the discs, the quartz tube is heated (e.g. +10 C per minute) till 900 C. Subsequent the dopant is allowed to the wafers. To set the diffusion process in motion, the temperature is changed to 1200 C.

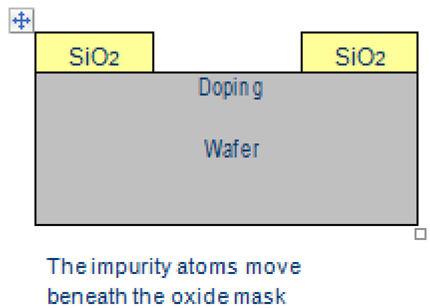

Fig 1.3.Diffusion doping of semiconductors.

1.8 Ion implantation

In the ion implantation charged dopants (ions) are accelerated in an electric field and irradiated in the wafer. The penetration depth can be set very precisely by reducing or adding the voltage needed to accelerate the ions. Since the process takes place at ambient temperature, previously added dopants can not move out. Regions that should not be doped, can be covered with a masking photo-resist layer.

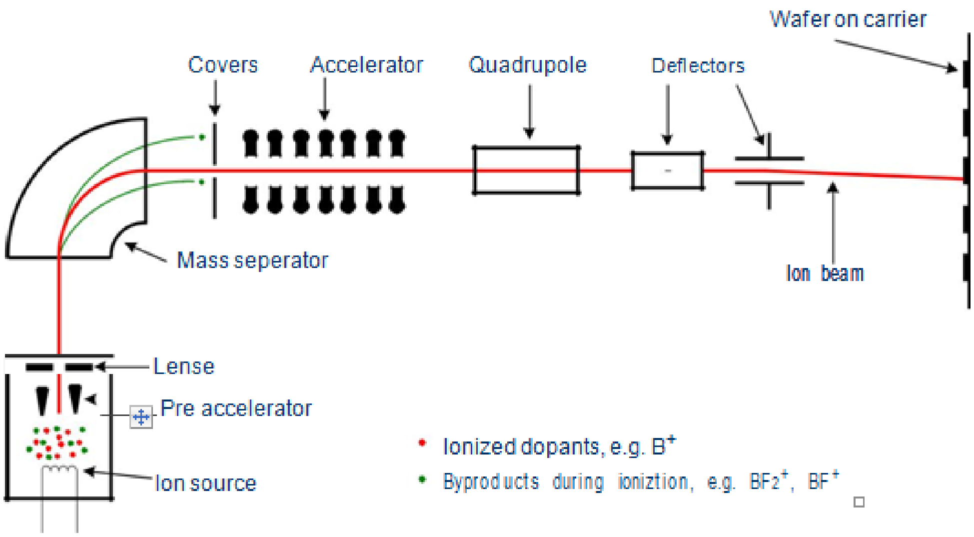

Fig 1.4 Ion implanter schematic diagram

An implanter consists of the following components:

a) **Ion source:** the dopants in gaseous state (e.g. boron trifluoride BF_3) are charged
b) **Accelerator:** the ions are drawn with approximately 30 kiloelectron volts out of the ion source
c) **Mass separation:** the charged particles are turned by a magnetic field by 90 degrees. Too light/heavy particles are deflected more/less than the desired ions and caught with screens behind the separator
d) **Acceleration lane:** several 100 keV accelerate the particles to their final velocity (200 keV accelerate bor ions up to 2.000.000 m/s)
e) **Lenses:** lenses are distributed inside the entire system to focus the ion beam
f) **Distraction:** the ions are deflected with electrical fields to irradiate the exact location
g) **Wafer station:** the wafers are placed on large rotating wheels and sent into the ion beam
h) **Penetration depth of ions in the wafer**: In contrast to diffusion processes the particles do not penetrate into the crystal due to their own movement, but because of their high velocity. Inside the crystal they are slowed down by collisions with

silicon atoms. The impact causes damage to the lattice since silicon atoms are knocked from their sites, the dopants themselves are mostly placed interstitial. There, they are not electrically active, because there are no bonds with other atoms which may give rise to free charge carriers. The displaced silicon atoms must be re-installed into the crystal lattice, and the electrically inactive dopants must be activate.

Table1.1 comparison of doping methods

Features	**NTD**	**Ion implantation**	**Diffusion**
state	Solid ingots can be doped	Solid and liquid as well	Gaseous and liquid
Cost	expensive	cheaper	cheapest
precision	Highly precise	Less precise	Not so accurate
uniformity	Can be achieved	Not so accurate	Requires more time

1.9 History, present status and future perspectives of NTD-SI

The possibility of producing silicon semiconductors with perfectly uniform phosphorus dopant distribution by neutron transmutation was first identified and described by Karl Lark-Horovitz in 1951. In 1961, Morris Tanenbaum and A.D. Mills at Bell Telephone Laboratories carried out the first NTD experiment, by irradiating small pieces of silicon with neutrons while measuring the phosphorus distribution.

While the NTD technique had been known and practiced for a decade in research laboratories, it was not commercially used to any significant extent until the mid-1970s. In 1973, a German high power device manufacturer used NTD-Si for the production of thyristors, which was a practical commercial breakthrough. Due to the superiority of the resulting device characteristics, between 1974 and 1976, NTD was offered by a number of research reactors in the USA, England and Denmark, and quickly the amount of irradiated silicon reached several tonnes.

At the Danish reactor DR2 of RISØ National Laboratory, the first industrial production of a 2 inch diameter silicon ingot began in 1974 in cooperation with the Danish company Topsil of Frederikssund [26]. They were called T-silicon, which was the registered trademark of commercial transmutation doped silicon. Two inch silicon ingots were irradiated in 53 mm diameter aluminum cans in a horizontal graphite stringer in the reactor's thermal column. Upon the final shutdown of DR2 in November 1975, about 100 kg silicon had been irradiated. Afterwards an irradiation facility for a 3 inch silicon crystal was constructed for the DR3 reactor, and its commercial service started in 1976. Additional irradiation facilities were constructed in 1977 and installed in the graphite reflector surrounding the heavy water tank. In 1997, they installed an additional 5 inch irradiation facility . DR3 continued irradiations of 3, 4 and 5 inch ingots and produced a large amount of the NTD-Si supply until it was permanently shut down in 2000 because of a small leak of heavy water.

In the United Kingdom, NTD was first undertaken by the Materials Test Reactors DIDO and PLUTO at the Harwell site of the United Kingdom Atomic Energy Authority (UKAEA) in 1975. Following the first successful trial for a silicon irradiation in 1975, the amount of NTD production increased from 2 t during 1976 to a level of around 30 t in 1985. According to the Harwell reactor's report in 1987, the demand for NTD had rapidly risen, and that the application fields of NTD Si had been extended. In order to satisfy an even higher demand in the future, the Harwell reactors had prepared for a capacity of about 35 t per annum. Then in early 1990, the DIDO and PLUTO reactors at the Harwell site were shut down. At that time, about 206 t of the silicon had been doped in these reactors over the course of 15 years. To compensate for the shutdown of the Harwell reactors, a joint venture was set up between AEA Technology (the trading name of the UKAEA) and the Centre for the Study of Nuclear Energy (SCK/CEN) involving silicon irradiation in the Centre's BR2 reactor in Mol, Belgium. A silicon irradiation facility named Silicon Doping by Neutron Irradiation Experiment

(SIDONIE) with an annual capacity of 28 t was designed and installed for this reactor in early 1992.

In Switzerland, the first irradiations in the SAPHIR reactor were carried out as early as 1975. The total annual quantities remained modest at less than 200 kg until about 1990, but in 1992, NTD activity was stepped up to about 2 t of silicon.

MURR, a 10 MW open pool reactor at the University of Missouri, USA, has performed NTD actively, starting with several test runs in 1975. It was reported that the reactor's capacity in 1978 was on the order of 15 t with 50 Ω•cm resistivity, and that it could be enhanced to 60 t with some modification.

In Japan, NTD tests began in 1975 in compliance with a local semiconductor company's request, and commercial service began in 1977. Irradiation rigs in the JRR-4 reactor were developed for 2.5, 4 and 5 inch silicon ingots of 45 cm length. JRR-2 had irradiated silicon up to 3 inch ingots from 1983 till its shutdown in 1996.

1.10 Advantages of NTD method

Since conventional techniques such as zone leveling and crystal growing require the simultaneous control of several kinetic processes including evaporation, segregation and vapor-liquid reaction, it can be done that their satisfactory implementation on a regular basis will require considerable ingenuity.

The NTD technique is a safe approach to the problem of preparation of uniform resistivity n-type silicon at any desired level. The major advantages of the ITTD process are:

- A real and spatial uniformity of dopant distribution.
- Precise control of doping level.
- Elimination of dopant segregation at grain boundaries in
- Polycrystalline silicon.

- Superior control of heavy atom contaminants
- Precision target doping (≈1% or better)
- Better axial and radial uniformity.
- No microresistivity structure.

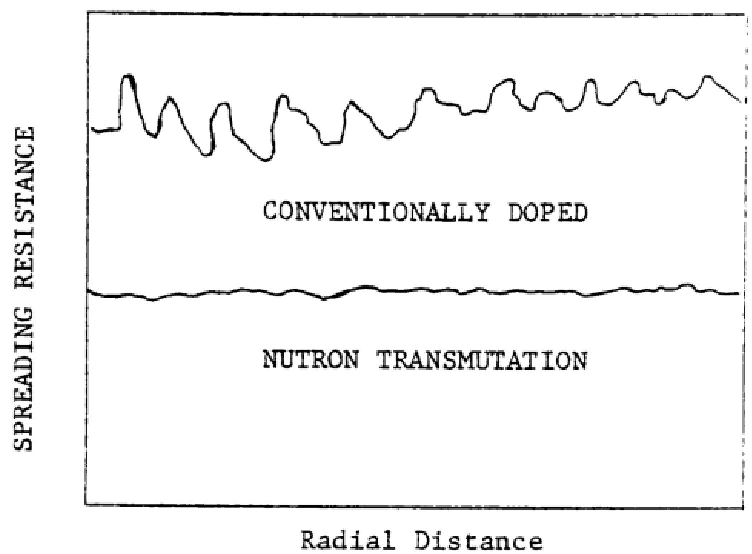

Fig1.5 Difference between conventional doping and NTD

Figure 1.5 is a schematic representation of spreading resistance traces across a wafer diameter for conventionally doped and NTD silicon. This shows that the homogeneity of resistance in NTD-Si is better than conventionally doped silicon. This homogeneity is a result of a homogeneous distribution of silicon isotopes in the target material and the long range of neutrons in silicon. Doping accuracy is a result of careful neutron flux integration

2. Practical part (Description of research)

2.1 Introduction to WIMS ANL

The Winfrith Improved Multigroup Scheme (WIMS) code has been used throughout the world for power and research reactor lattice physics analysis. There are many WIMS versions currently in use. The D4 version selected by the RERTR program was originally developed in 1980.1 It was chosen for the accurate lattice physics capability and for an unrestricted distribution privilege. The code and its 69-group library tape 166259 generated in Winfrith were obtained from the Oak Ridge National Laboratory, Radiation Safety Information Computational Center (RSICC) in 1992 Since that time the RERTR program has added three important features. The first was the capability to generate up to 20 broad-group burnup-dependent macroscopic or microscopic ISOTXS cross-sections for each composition of the unit cell3, an ENDF/B-V based nuclear data library4 (later updated to ENDF/B-VI), and a SUPERCELL option.3 As a result of these modifications and other minor ones, the code was named WIMS-D4M.5-6.

2.2 Overview of WIMS-ANL capabilities

WIMS uses transport theory to calculate the neutron flux as a function of energy and spatial location in a one-dimensional cell. Two main transport options that are most frequently used are DSN (discrete ordinates) and PERSEUS (collision probabilities). The transport solution can be performed with any user specified intermediate group to the number of library groups. This main transport solution is preceded by one or more SPECTROX flux spectra calculation(s) for few spatial regions in the full library group structure.

2.3 Selection of the filter material

The mail objective of filter (neutron flux) is to achieve axial uniformity of flux distribution to ensure uniform doping. So a proper filter should be fixed to flatten a neutron flux as shown in Figure 2.1 a uniform neutron irradiation can be achieved. The flux screen is composed of relatively strong neutron absorbers in a high neutron flux region and weak absorbers in a low flux region. This may be achieved by using different materials with different neutron absorption cross- sections or by desired thickness variation of the neutron absorbers. The choice of neutron absorbents depends on the available thickness for the neutron screen. If the thickness is a few millimetres, stainless steel or nickel can be used. As the neutron flux in a high flux region decreases, the flux at both ends of the screen decreases as well. In order to increase neutron efficiency, an effort to increase the flux at the both ends of screen should be given.

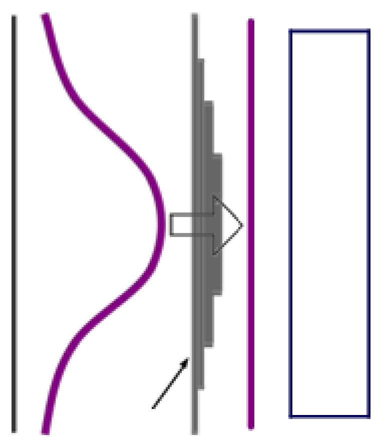

FIG.2.1. The uniform irradiation method using a neutron screen

2.4 Europium

The first material which we can consider is europium. It is a chemical element with symbol **Eu** and atomic number 63. It was founded in 1901 and is named after the continent of Europe. It is hard, silvery metal which easily oxidizes in air and water. It is member of the lanthanide series, europium usually recieves the oxidation state +3, but the oxidation state +2 is also seen. All europium compounds with oxidation state +2 are slightly reducing. Europium has no important biological role and is relatively non-poisonous compared to other heavy metals. Most applications of europium exploit the phosphorescence of europium compounds. Europium is one of the least widely spread elements in the universe; only about 5×10^{-8}% of all matter exist is europium.

2.5 Physical properties

Europium is a hard ductile metal with hardness similar to that of lead. It crystallizes in a BCC cubic lattice. Some properties of europium are strongly influenced by its half-filled electron shell. Europium has the lowest melting point and the lowest density of all lanthanides. Europium becomes a superconductor when it is cooled below 1.8 K and compressed to above 80 GPa. This is because europium has 2 valence in the metallic state, and is converted into the 3 valency state by the applied pressure. In the divalent state, the strong local magnetic moment ($J = {}^{7}/_{2}$) suppresses the superconductivity, which is induced by eliminating this local moment ($J = 0$ in Eu^{3+}).

2.6 Isotopes of Europium

Naturally existing europium is composed of 2 isotopes, ^{151}Eu and ^{153}Eu, with ^{153}Eu being the most abundant (52.2% natural abundance). While ^{153}Eu is stable, ^{151}Eu was recently found to be unstable to alpha decay with half-life of 3×10^{18} years giving about 1 alpha decay per two minutes in every kilogram of natural europium. This value is in agreement with theoretical assumtions. Besides the natural radioisotope ^{151}Eu, 35 artificial radioisotopes have been characterized, the most stable being ^{150}Eu with a half-life of 36.9 years, ^{152}Eu with a half-life of 13.516 years, and ^{154}Eu with a half-life of 8.593 years. All the other radioactive isotopes have half-lives shorter than 4.7612 years, and the majority of these have half-lives shorter than 12.2 seconds. They also has 8 meta states, with the most stable being ^{150m}Eu ($t_{1/2}$=12.8 hours), ^{152m1}Eu ($t_{1/2}$=9.3116 hours) and ^{152m2}Eu ($t_{1/2}$=96 minutes).

The primary decay for isotopes lighter than ^{153}Eu is electron capture, and the primary mode for heavier isotopes is beta minus decay. The primary decay products before ^{153}Eu are isotopes of samarium (Sm) and the primary products after are isotopes of gadolinium (Gd).

Table 2.1 Microscopic cross section of Europium isotopes.

Isotope	151Eu	152Eu	153Eu	154Eu	155Eu
Yield	~10	low	1580	>2.5	330
Barns	5900	12800	312	1340	3950

The Table 2.1 shows the absorption cross section of Europium isotopes which is very high the element is suitable for neutron filters

2.7 Gadolinium

Gadolinium hard metal with symbol **Gd** and atomic number 64. Gadolinium is a silvery-white, malleable, and ductile rarely seen earth metals It is found in nature only in oxidized form, and even when separated, it usually has impurities of the other rare earths. Gadolinium was found in 1880 by Jean Charles de Marignac, who detected its oxide by using spectroscopy.They were called after the mineral gadolinite, which is one of the minerals in which it is found, itself named for the chemist Johan Gadolin. Pure gadolinium was first found by the chemist Paul Emile Lecoq de Boisbaudran in about 1886.

Gadolinium contains unusual metallurgical properties, to the extent that as little as 1.0 percent of gadolinium can significantly improve the workability and resistance to oxidation at high temperatures of iron, chromium, and related metals. Gadolinium as a metal or a salt absorbs neutrons, and it is, therefore, used sometimes for shielding in neutron radiography, and also in nuclear reactors.

2.8 Physical properties

Gd is a silvery-white malleable and ductile rare metal. It crystallizes in hexagonal, in the close-packed α-form at ambient temperature, but, when heated to temperatures above 1235 °C, it transforms into its β-form, which has a BCC structure.

The isotope gadolinium-157 has the highest thermal neutron absorption cross-section about 259,000 barns. Only xenon-135 has a higher capture cross section, about 2.0 million barns, but this isotope is radioactive.

Gadolinium is believed to be ferromagnetic at temperatures below 20 °C (68 °F) and it is paramagnetic above this temperature. There is evidence that gadolinium is a helical anti-ferromagnetic, rather than a ferromagnetic, below 20 °C (68 °F). Gadolinium shows a magneto caloric effect whereby its temperature increases when it enters a magnetic field, and decreases when it leaves the magnetic field. The temperature is lowered to 5 °C (41 °F) for the gadolinium alloy $Gd_{85}Er_{15}$, and this effect is considerably stronger for the alloy $Gd_5(Si_2Ge_2)$, but at a much lower temperature (<85 K (−188.2 °C; −306.7 °F)).[1] A magneto-caloric effect is observed at higher temperatures, up to about 300 kelvin, in the compounds $Gd_5(Si_xGe_{1-x})_4$.

Individual Gd atoms can be isolated by encapsulating them into fullerene molecules, where they can be seen with transmission electron microscope. Individual Gd atoms and small Gd clusters can be incorporated into carbon nanotubes.

2.9 Commercial Filters

If a proper filters is installed to flatten a neutron flux as shown in Figure 11, a uniform neutron irradiation can be achieved. The flux screen is composed of relatively strong neutron absorbers in a high neutron flux region and weak absorbers in a low flux region. This may be accomplished by using different materials with different neutron absorption cross- sections or by appropriate thickness variation of the neutron absorbers. The choice of neutron absorbents depends on the available thickness for the neutron screen. If the thickness is a few millimeters, stainless steel or nickel can be used. As the neutron flux in a high flux region decreases, the flux at both ends of the screen decreases as well. In order to increase neutron efficiency, an effort to increase the flux at the both ends of screen should be given.

The irradiation procedure of this method is relatively simple compared to other methods, since the axial neutron flux distribution varies especially according to the control rod position, significant planning should be considered before undertaking this method. An appropriate methodology in the development of a suitable flux screen is to irradiate a batch of Si ingots which had been equipped with flux monitors in small holes, drilled into the ingots. The analysis of such experiment would typically follow by complementary modeling by means of MCNP calculations. If the location of the flux screen can be adjusted to compensate for a change of control rod position, rather consistent axial uniformity can be achieved regardless of rod height. This method has already in the 1990s been used at the ASTRA reactor in Austria and has more recently been adopted at OPAL, HANARO and FRM II.

2.10 Description of a Model in WIMS ANL

A numerical model is created using WIMS ANL computer code. A model geometry consist of UO_2 is at the centre. Silicon ingot is surrounded with europium 151 and water. A numerical created model is taken under consideration the model consist of silicon with the thickness of 6.35 cm and the europium which taken as filter material with desirable thickness and uranium is taken as fuel material and the arrangement is made concentrically as shown in the fig 2.1 a simulation is done is done using WIMS

ANL and the following outputs is obtained. The dimensions and concentration are listed in Table 2.2

Table 2.2 Dimensions and concentration of materials used in model

Material	Radius cm	Concentration nuclides/cm^3
Silicon	6.35	0.0224921
Europium	6.75	0.0207
Uranium	9.4	0.0499
Water	12.7	0.052754

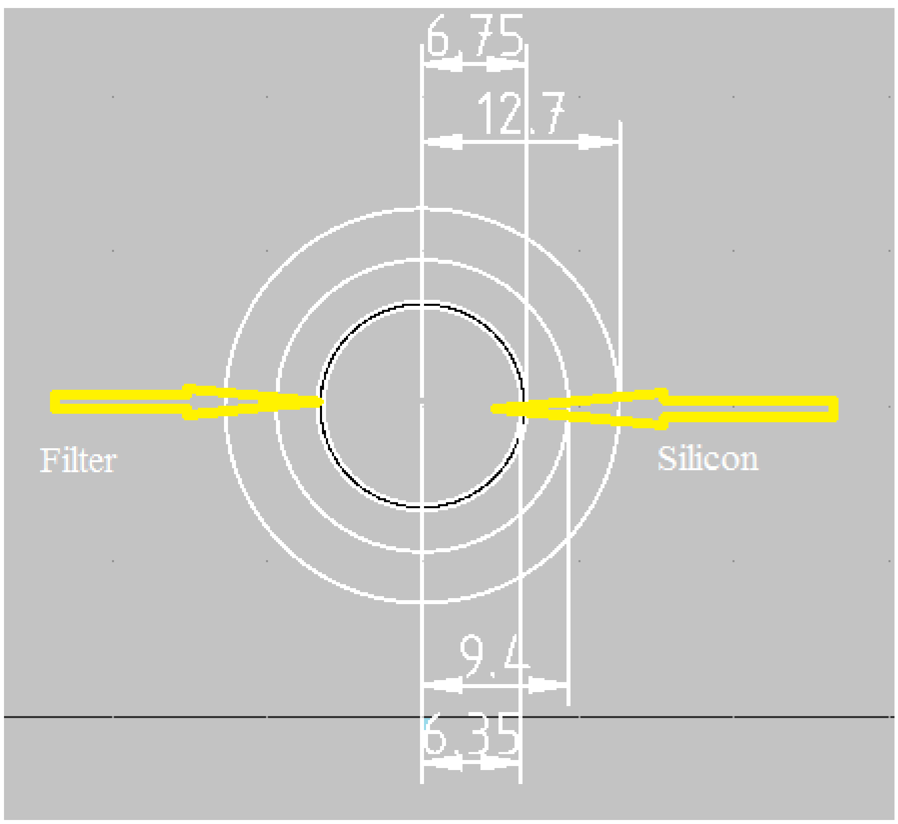

Fig. 2.2. Model taken under consideration.

3. Modeling Results

The model consist of silicon ingot with desirable thickness covered with europium metal as shown in figure now a numerical simulation is created with help of WIMS ANL computer code Fig 2.2

Table3.1 Obtained results the simulation.

Thickness cm of Eu	Average flux Of silicon	(Maximum flux by average flux) of silicon
0.001	$6.11 \cdot 10^{-4}$	1.091083
0.005	$6.11 \cdot 10^{-4}$	1.08680
0.01	$6.11 \cdot 10^{-4}$	1.08234
0.015	$6.13 \cdot 10^{-4}$	1.081489
0.020	$6.11 \cdot 10^{-4}$	1.079255
0.025	$6.11 \cdot 10^{-4}$	1.091083
0.030	$6.11 \cdot 10^{-4}$	1.08680
0.04	$6.11 \cdot 10^{-4}$	1.08234
0.05	$6.13 \cdot 10^{-4}$	1.081489
0.06	$6.11 \cdot 10^{-4}$	1.079255
0.07	$6.11 \cdot 10^{-4}$	1.091083
0.08	$6.11 \cdot 10^{-4}$	1.08680
0.09	$6.11 \cdot 10^{-4}$	1.08234
0.10	$6.13 \cdot 10^{-4}$	1.081489

0.2	$6.15 \cdot 10^{-4}$	1.079255
0.3	$6.18 \cdot 10^{-4}$	1.079255
0.4	$6.18 \cdot 10^{-4}$	1.079255
0.5	$6.18 \cdot 10^{-4}$	1.079255

The dependence between the flux and mesh points is obtained by means of a graph the coefficient of irregularity should be not greater than 7% since we accurate results are not obtained. By using filter it is possible to obtain radial uniformity.

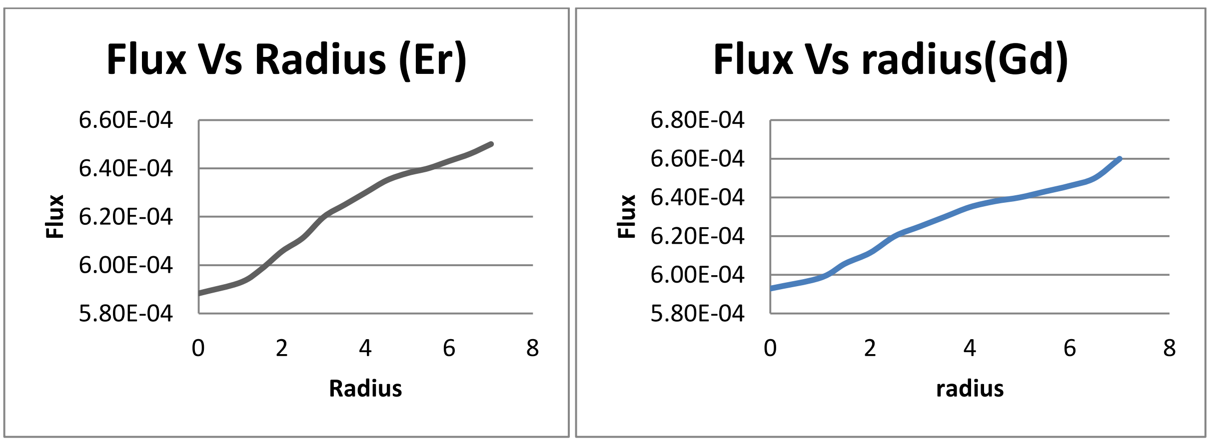

Fig 3.1 Flux distribution in silicon for given thickness of filter

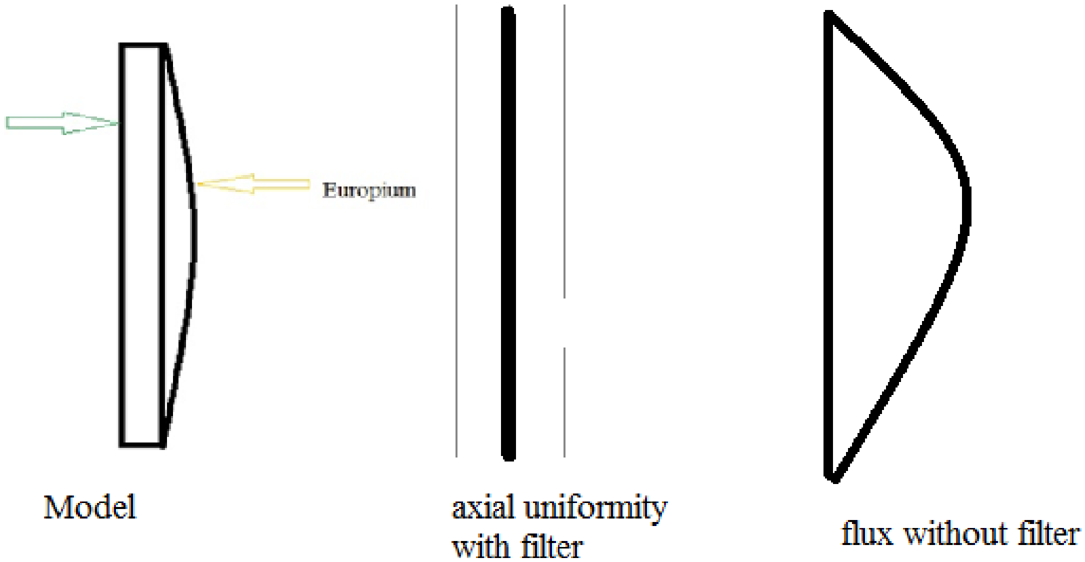

Fig 3.2 Axial uniformity is obtained by means of filter shown graphically

The flux which is obtained by using filter is uniform with respect to the radius of the silicon ingot as shown in the Fig 3.2 as you the axial uniformity is achieved through optimization of filter thickness.

3.1 Heat transfer in nuclear reactors

From the rules of thermodynamics, it is known that energy cannot be created nor be destroyed but energy can be transferred from interactions. There are two methods in which energy can be transferred: work and heat. Specifically this project focuses on energy transferred as heat. Heat transfer is thermal energy transferred due to a temperature difference differences at different points. There are three modes in which heat can be transferred. Heat is transferred by one or more of the following modes: conduction, convection, and radiation. In conduction, heat moves through either a solid or a liquid due to a temperature gradient across the solid or liquid. This mode of heat transfer is modeled by the expression called Fourier's Law, where the rate of heat transfer per unit area, q, is equal to represents the material-specific thermal conductivity.

$$Q = -kA \cdot \frac{dT}{dx} \tag{3.1}$$

Where k- specific thermal conductivity W ·m · K;

$\frac{dT}{dx}$ - the rate of heat transfer per unit area K/m;

A - cross sectional area m^2.

Convective heat transfer occurs between a moving fluid and a surface body at different temperatures. In this mode of heat transfer, the hotter portions of the fluid move and the rest of the body which circulates and mixes hot and cold portions of the fluid. Convection tends to transfer heat faster than conduction. Newton’s Law of Cooling expresses the rate of convective heat transfer as KJ in units is the convective heat transfer coefficient, dependent on boundary layer conditions and surface geometry.

$$Q = m \cdot C_p \cdot \Delta T \tag{3.2}$$

Where Q = heat content in Joules

m = mass flow rate.

C_p = specific heat, J/g °C

ΔT = change in temperature

Radiation is the simplest mode of heat transfer that does not require solids or fluids to achieve the energy transfer; instead, heat travels by electromagnetic waves. For the purposes of this experiment, only convection and conduction were taken into the account, due to negligible effects of radiation.

3.2 Overall Heat Transfer Coefficient

An overall heat transfer coefficient, U, can be used to take into account the total thermal resistance of the system. The overall heat transfer coefficient has the same units as the convective heat transfer coefficient h. The overall heat transfer coefficient is used for composite systems and takes into account the heat transfer inside the medium, through the walls of the system, and the heat transfer on the outside of the system. Where hi is the inside heat transfer coefficient, tw is the wall thickness, k is the thermal conductivity, and ho is the outside heat transfer coefficient. As the overall heat transfer coefficient includes the inside and outside heat transfer coefficients, any factors that affect the inside and outside heat transfer coefficients will also affect the overall heat transfer coefficient. The inside heat transfer coefficient hi is affected by the stirring of the fluid and will increase with better mixing. The outside heat transfer coefficient is affected by the cooling jacket flow-rate and will also increase with higher flow-rates. Thermal conductivity is a property of the material of the reactor and wall thickness varies from reactor to reactor.

$$\frac{1}{UA} = \frac{1}{Ah_1} + \frac{t}{KA} + \frac{1}{Ah_2} \tag{3.3}$$

Where
U = overall heat transfer coefficient (W/m^{2}K)
A = contact area for each fluid side (m^2)
k = thermal conductivity of the material (W/mK)
h_1, h_2 = individual convection heat transfer coefficient for each fluid (W/m^{2}K)
t_w = wall thickness (m)

3.3 Rate of Heat Production

There are several major contributors to the changing rate of heat production during scale up, such as concentration of reactants and catalysts, reactor size and starting temperature. While chemists tend to only consider the stoichiometry given for a particular chemical reaction, where a certain number of moles of each reagent produce a set number of moles of a reactant, the chemistry is not so simple on a larger scale. For example, mixing affects the stoichiometry of a reaction over time in a stirred tank reactor. Additionally, rates of addition, reaction, and removal affect overall production and the physical conditions within the reactor. Primarily, with the decrease in heat transfer area per unit volume, longer reagent addition times are required to prevent runaway reactions. However, this often affects the yield and quality of the product. Therefore, factors that contribute the most to changing the rate of heat production are reactant concentration and the starting temperature of the reaction.

3.4 Power distribution in silicon

To calculate the power distribution in silicon we must calculate the Q value of the beta decay in the reaction.

$^{30}Si + n \rightarrow {}^{31}Si \rightarrow (\beta^-) \rightarrow {}^{31}P$

The Q value of the reaction is found out to be 4.34 Mev. The power distribution in filter material is plotted as shown in fig 2.7.

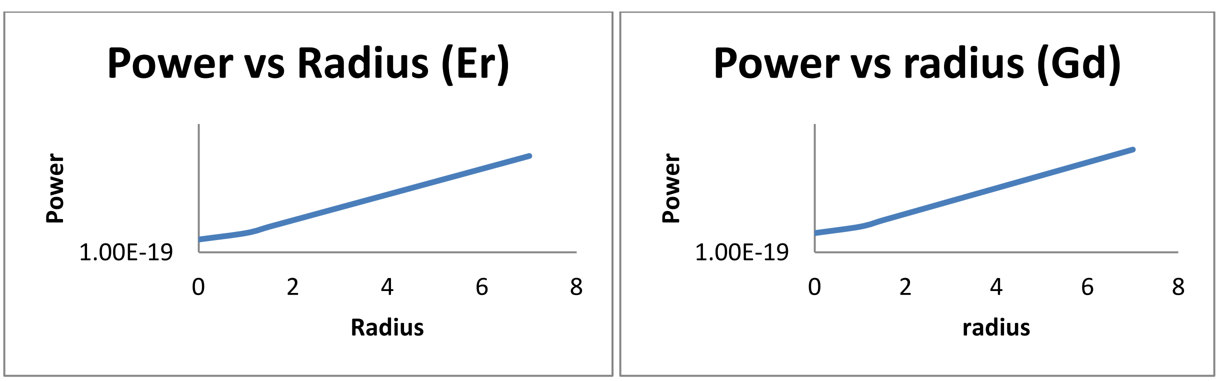

Fig 3.3 Power distribution in silicon.

After calculating the power distribution the heat transfer coefficient is calculated. The temperature of the silicon is found out to be 105 C

$$Q = m \cdot C_p \cdot \Delta T$$

$$Q=0.1666 \cdot 4.18 \cdot (105-60)$$

$$=31337.46 \text{ KJ}$$

The heat transfer in the coolant is found to be 31337.46KJ.

The power distribution in the filter is given by means of graph

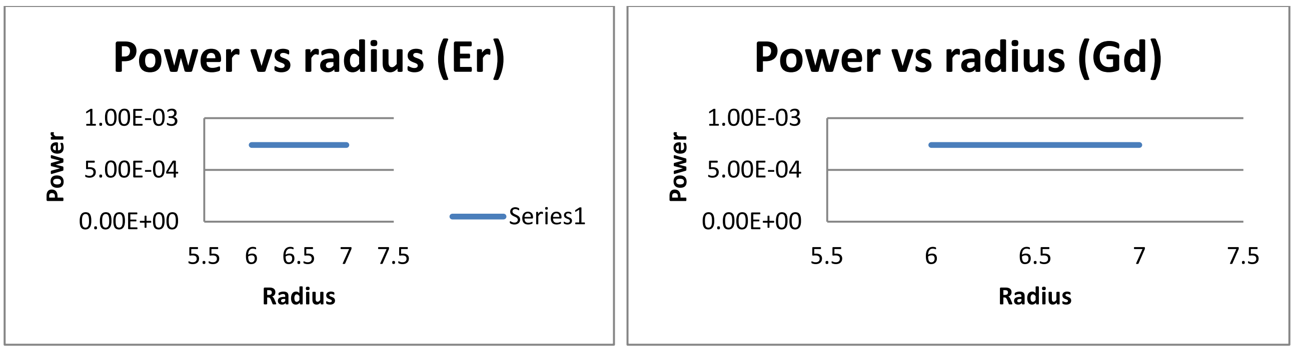

Fig.3.4 Power Distribution in filter material.

From the graph we come to know about the power distribution in the filter material since the ultimate goal of the project is to provide radial uniformity in doping process the function of the filter material gives you the exact uniformity process in the doping since flux is uniform the power distribution is form and the power distribution is uniform the doping process is uniform from the graph it is very evident that the flux is radially distributed.

3.5 Conclusion.

This dissertation is carried out by step by step systematic analysis of the objectives. The main goal of the dissertation is find out the optimum thickness of the filter in order to achieve axial uniformity so that doping process is more uniform and reliable. In the process of achieving this goal we need to select the proper filter materials by studying the neutron characteristics of various materials we arrived at the conclusion that we must choose material which as more absorption cross section therefore the two elements which are chosen for studies is Europium and Gadolinium after choosing the material a computer model is created and the following analysis is done firstly the flux distribution is found out without the filter and from the Fig 2.5 we found out that the flux keeps on increases and we move axially across the silicon ingot and different thickness of the filter material is used and the results are obtained. Simultaneously power distribution in the filter and silicon is found out for optimum thickness and the following results are obtained the optimum thickness of the filter is found out to 6.370 cm and the radial and axial uniformity is obtained through this thickness so the doping process is uniform. With the help of this thickness the energy stored in silicon and europium is obtained and the graph is drawn in Fig 2.8 and Fig 2.9 as the next step in the dissertation the amount of heat transfer in the coolant is calculated for the given model and the amount of heat transfer in the coolant is obtained. The heat transfer in the coolant is found to be 31337.46KJ.

4. Financial management, resource efficiency and resource conservation.

4.1 Introduction to SWOT

The process of analysing Strengths, Weaknesses, Opportunities and Threats in a given project is called as SWOT analysis. Strengths (S) and Weaknesses (W) are factors within the project which is controllable and Opportunities (O) and Threats (T) are factors outside the project which cannot be controlled.

SWOT is tool to determine the strategic position of the project and its environment. Its target is to identify the methodologies that will make a project profitable and that will best arrange a raw materials and labour potentials to the specification of the environment in which the project works.

It is used for identifying the inner potential and drawbacks and the probable opportunities and threats from the external environment. It sees all positive and negative factors inside and outside the project that affect the success. The environment in which the project operates helps in forecasting the changing trends and in the decision-making process of the project.

The four factors (Strengths, Weaknesses, Opportunities and Threats) is given below-

Strengths - Strengths are the qualities that enable us to accomplish the project's mission. A detailed strength analysis is done for the project. While doing the project in order to achieve the goal it is necessary to produce a detailed strength of the project. The person who is carrying out the project must posses the adequate skills for the objective and immense technical knowledge which gained through the academic activities and course works and research work will play a crucial role in deciding the positive outcome of the project.

Weaknesses - Weaknesses are the attributes that stop us from accomplishing our outcomes and achieving our full potential. These weaknesses hinder influences on the project success and growth. Weaknesses are the factors which do not meet the standards of the projects which the project should meet. Weaknesses in the project may be lack of infrastructure socio cultural differences, insufficient research and development facilities, lack of decision-making, etc. But these weaknesses are controllable. They must be minimized and removed. For instance - to overcome faulty machinery, new machinery can be purchased. Other examples of project weaknesses language and bureaucratic barriers, complex decision making process, narrow product range, large wastage of raw materials, etc.

Opportunities - Opportunities can be shown the environment within which our project operates. They arise when a project can take benefit of conditions in its environment to plan and execute strategies that enable it to become more profitable. Projects can gain competitive advantage by making use of opportunities. During the course of undertaking the project being innovative is an opportunity to improve the efficiency of the operation thereby reducing the hughe capital cost of the project.

Threats - Threats are conditions in external environment which jeopardize the reliability and profitability of the project. They increase the vulnerability when they relate to the weaknesses. Threats are uncontrollable. When a threat comes, the stability and survival can be at huge risk. Examples of threats are – stress and unrest among employees; inability in adapting to changing technology; increasing competition leading to excess capacity, and reducing industry profits; etc.

The process must ask and answer questions that give meaningful information of (strengths, weaknesses, opportunities, and threats) to make the analysis useful and find their competitive advantage. The process aims to identify the key internal and external factors seen as

1. Internal factors – the *strengths* and *weaknesses* internal to the project
2. External factors – the *opportunities* and *threats* presented by the environment external to the project.

ANALYSIS OBJECTIVES

Achieving axial uniformity in silicon doping by optimization of filter materials and calculating the power distribution in filter material and heat transfer in the coolant

INTERNAL FACTORS

STRENGTHS (+)	WEAKNESSES (-)
• Knowledge • Experience • Skills • Ability to work under pressure • Team work • Self confidence • Proven academic credentials	• Lack of guidance • Lack of access into facility • Lack of exposure • Language barrier • Lack of study materials • Lack of funds • Difficulties in transporting raw materials.

EXTERNAL FACTORS

OPPORTUNITIES (+)	THREATS (-)
• Innovate • Improving efficiency • Exposure to new language and culture • Developing sustainability • Developing eco friendly technology • Adaptability	• Restrictions • Language barrier • Absence of infrastructure • Lack of training

EVALUATION OF OBJECTIVES

Improving the condition of work to increase the efficiency of the project thereby eliminating the threats and improving the opportunities.

Fig 4.1 Swot analysis schematic representation.

4.2 Internal Factors: Strengths and Weaknesses(S, W)

- Human factors - staff, target population
- Physical factors - location,infrastructure
- Financial factors - grants, funding agencies, other sources of income
- Experience - building blocks for learning and success, the reputation in the community

The strengths and weakness of the project are the internal factors, don't overlook the perspective of people outside the group. Identify strengths and weaknesses from both the own point of view and that of others, including those you serve or deal with.

4.3 External Factors: Opportunities and Threats (O, T)

Cast a wide net for the external part of the assessment. No project, group, program, or neighborhood is immune to outside events and forces. Consider the connectedness, for better and worse, as you compile this part of the SWOT list.

- Lack of guidance – without advisors very difficult to work
- Lack of access into facility- no access into facility
- Lack of exposure- without exposure
- Language barrier- not communicating
- Lack of study materials- materials for preparation
- Lack of funds- no grants
- Difficulties in transporting raw materials.

4.4 Raw materials, purchased products and semi-finished products

This item includes the cost of all kinds of purchasing materials, components and semi-finished products necessary for the implementation of works on the subject. Number of required material values determined by the norms of consumption.

where:

$$\text{Additional salary} = \text{basic salary} \times (12\text{-}15\%); \quad (3.1)$$

$$\text{Benefit expenses} = (\text{basic salary} + \text{additional salary}) \times 30{,}01\%; \quad (3.2)$$

$$\text{Overhead cost} = \text{basic salary} \times (60\text{-}70\%). \quad (3.3)$$

Calculating the expenses of material costs based on the current price list or negotiated prices. The expenses of material costs include transportation and procurement costs (3 – 5% of the price). In the same item includes the expenses of paperwork (stationery, copying materials). The results of this term are presented in the Table 3.1 below.

Table 4.1 – Raw materials, components and semi-finished products

Title	Mark, size	Quantity	Price per each, rupees	The sum, rupees
Computer	Hp	1	23 000	23 000
Notebook	Nataraj	5	30	150
Pen	reynolds	10	15	150
Printing		10	500	5000
Total of materials				28 300
Transportation and procurement expenses (3.5%)				990,5
Total items $C_{м}$				29 290,5

Table 4.2 – The calculation of the basic salary

№ п/п	Stage	Performers by Category	Laboriousness, Number of people×days	Salary per one person×days, thousand rupees	Total salary under the tariff (wage), thousand rupees
		Supervisor 1/Docent	1×30	1,05711×30	31,7133
		Supervisor 2/Scientific staff	1×26	0,79782×26	20,7434
Total: 52,4567					

4.5 Social Insurance

Social insurance, public insurance program that provides protection against various economic risks (*e.g.*, loss of income due to sickness, old age**,** unemployment**)** and in which participation is compulsory. Social insurance is considered to be a type of social security, and in fact the two terms are sometimes used interchangeably. Usually it is calculated 30% of the labor wages.

4.6 Overhead Expenses

Overhead is an accounting term that refers to all ongoing business expenses not including or related to direct labor, direct materials or third-party expenses that are billed directly to customers. A company must pay overhead on an ongoing basis, regardless of whether the company is doing a high or low volume of business. It is important not just for budgeting purposes but for determining how much a company must charge for its products or services to make a profit. For example, a service-based business that operates in a traditional white-collar office setting has overhead expenses such as rent, utilities and insurance**.**

Table 4.3 Estimation of overall expenses.

S.No	**Type of expenses**	**Budget Rupes**	**Citation**
1	Labor wages	52,456	3.1
2	Raw materials and resources	29,290	-
3	Social insurance	15,736	3.2
4	Over head	16,349	3.3
5	Total	**1,13,831**	

4.7 Conclusion

The process of completion of the project started with doing a systematic SWOT analysis the step by step analysis of strength weakness and opportunities and threats were critically analyzed and after performing these analysis the methodology how to overcome the weakness and threats and how to achieve the objective.

The payment for achieving the project is evaluated and total number of days required are found out and along with the expenses to carry out the project the overload expenses and social funding is also evaluated.

The dissertation was done in a period 632 days totally with the participation of master's student and the support of two supervisors. In which, the researcher, i.e. the student, who carried out this thesis spending 567 days for working on, the supervisor 1 is 30 days and supervisor 2 is 26 days.

The amount of money had been spent for doing this dissertation is 137 702 ruble totally. Particularly, 41119 rupees is the salary, which had to pay for the supervisor 1; 31 034 rupees is the wage, which had to pay for the supervisor 2. Overhead cost – 33 759 rupees.

In addition, there are some money also paid for some necessary equipment, which had been used for doing this research, such as computer, notebooks, pen, printing, specific textbook. Totally, it costs 31 790 rupees for all.

5 SOCIAL RESPONSIBILITY

In modern conditions, one of the main directions of radical improvement of all preventive work to reduce occupational traumatism and occupational morbidity is the widespread implementation of an integrated OSH management system. That means combining isolated activities into a single system of targeted actions at all levels and stages of the production process. Occupational safety is a system of legislative, socio-economic, organizational, technological, hygienic and therapeutic and preventive measures and tools that ensure the safety, preservation of health and human performance in the work process [1].

Rules for labor protection and safety measures are introduced in order to prevent accidents, ensure safe working conditions for workers and are mandatory for workers, managers, engineers and technicians.A dangerous production factor is a manufacturing factor whose impact under certain conditions leads to trauma or other sudden, severe deterioration of health [1]. A harmful production factor is a production factor, the effect of which on a worker under certain conditions leads to a disease or a decrease in working capacity.

5.1 Analysis of hazardous and harmful production factors

The working conditions in the workplace are characterized by the presence of hazardous and harmful factors, which are classified by groups of elements: physical, chemical, biological, psychophysiological. The main elements of the production process that form dangerous and harmful factors are presented in Table 5.1

Table 5.1 - The main elements of the production process, forming hazardous and harmful factors

Table5.1 Parameter of working process.

Name of the types of work and the parameters of the working process	FACTORS GOST 12.0.003-74 Occupational safety standards system		Normative documentation
	harmful	Dangerous	
Work with PC	Chemical Toxic		GOST 12.1.007-76 Occupational safety standards system.Harmful substances.
		Electricity	GOST 12.1.038-82 Occupational safety standards system.electrical safety
	The impact n (HF, UHF,		SanPiN 2.2.2 / 2.4.1340-03 Sanitary-epidemiological rules and regulations. "Hygienic requirements for

			personal computers and organization of work"

The following factors effect on person working on a computer:

Physical:

- temperature and humidity;
- noise;
- static electricity;
- electromagnetic field of low purity;
- illumination;
- presence of radiation;

Human:

- physical overload (static, dynamic)
- mental stress (mental overstrain, monotony of work, emotional overload).

5.2 Organizational arrangements

All personnel are required to know and strictly observe the safety rules. The training of personnel in occupational safety and industrial sanitation consists of introductory briefing and briefing at the workplace by the responsible person.

The knowledge of safety rules is checked by the qualification commission or by the person responsible for the workplace after training at the workplace. After that, commission assign the qualification group on safety corresponding to the employee's knowledge and experience of work and issue a special certificate.

Persons serving electrical installations must not have injuries and illnesses that interfere with production work. The state of health is established by medical examination before being employed.

5.3 Technical Activities

The rational layout of the workplace provides for a clear order and permanent placement of objects, means of labor and documentation. Object, what is required to perform the work more often, should be located in the easy reach of the workspace, as shown in Fig. 5.1

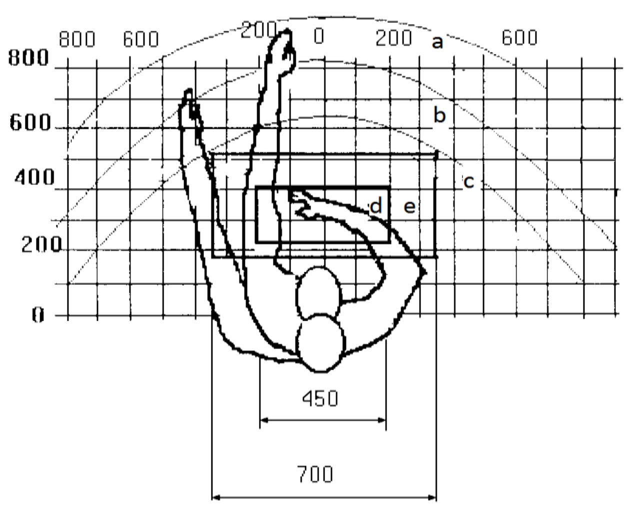

Figure 5 1 - Hand reach zones in the horizontal plane

a - Zone of maximum reach of hands;

b - reach zone of fingers with outstretched arm;

c - easy reach zone of the palm;

d. Optimum space for fine handmade work

e. the optimum space for rough manual work;

Optimal placement of objects of labor and documentation in the reach of hands:the display is located in zone a (in the center);keyboard - in the area of e / d;the system unit is located in zone b (on the left);the printer is in zone a (right);The documentation is placed in the easy reach of the palm - in (left) - literature and documentation necessary for work; In the drawers of the table - literature that is not used constantly.When designing a desk, the following requirements must be taken into account.

The height of the working surface of the table is recommended within 680-800 mm. The height of the working surface, on which the keyboard is installed, should be 650 mm. The working table must be at least 700 mm wide and at least 1400 mm long. There should be a legroom of not less than 600 mm in height, a width of at least 500 mm, a depth at the knee level of at least 450 mm and at the level of elongated legs - not less than 650 mm.The work chair must be liftable and adjustable in height and angle of inclination of the seat and backrest, as well as the distance of the backrest to the front edge of the seat. It is recommended that the height of the seat be above the floor level of 420 to 550 mm. The design of the working chair should ensure: the width and depth of the seat surface is not less than 400 mm; Seat surface with recessed front edge.

The monitor should be located at the eye level of the operator at a distance of 500 - 600 mm. According to the norms, the viewing angle in the horizontal plane should be no more than 45º to the normal of the screen. It is better if the viewing angle is 30 °. In addition, it should be possible to select the level of contrast and brightness of the image on the screen. It should be possible to adjust the screen: Height +3 cm;on a slope from 10 to 20 degrees with respect to the vertical;in the left and right directions.The keyboard should be placed on the surface of the table at a distance of 100 - 300 mm from the edge. The normal position of the keyboard is its placement at the elbow level of the operator with an angle of inclination to the horizontal plane of 15º. It is more convenient to work with keys that have a concave surface, a quadrangular shape with rounded corners. The key design should provide the operator with a click sensation. The color of the keys should contrast with the color of the panel.It is recommended to choose soft, low-contrast floral shades that do not disperse attention (low-saturated shades of cold green or blue colors) in the case of monotonous mental work requiring considerable nervous tension and great concentration. Shades of warm tones are recommended at work, which requires intense mental or physical tension, due to they excite human activity.

5.4 Safe work conditions

The main parameters characterizing the working conditions are microclimate, noise, vibration, electromagnetic field, radiation, illumination.

The air of the working area (microclimate) is determined by the following parameters: temperature, relative humidity, air speed. The optimum and permissible values of the microclimate characteristics are established in accordance with [2] and are given in Table 5.2.

Table5.2 - Optimal and permissible parameters of the microclimate

Period of the year	Temperature, ^{C}	Relative humidity,%	Speed of air movement, m / s
Cold and changing	23-25	40-60	0.1

of seasons			
Warm	23-25	40	0.1

The measures for improving the air environment in the production room include: the correct organization of ventilation and air conditioning, heating of room. Ventilation can be realized naturally and mechanically. In the room the following volumes of outside air must be injected:

at least 30 m^3 per hour per person for the volume of the room up to 20 m^3 per person;

natural ventilation is allowed for the volume of the room more than 40 m^3 per person and if there is no emission of harmful substances.

The heating system must provide sufficient, constant and uniform heating of the air. Water heating should be used in rooms with increased requirements for clean air.

The parameters of the microclimate in the laboratory regulated by the central heating system, have the following values: humidity 40%, air speed 0.1 m / s, summer temperature 20-25 ° C, in winter 13-15 ° C. Natural ventilation is provided in the laboratory. Air enters and leaves through the cracks, windows, doors. The main disadvantage of such ventilation is that the fresh air enters the room without preliminary cleaning and heating.

Noise and vibration worsen working conditions, have a harmful effect on the human body, namely, the organs of hearing and the whole body through the central nervous system. As a result, attention is weakened, memory deteriorates, the response decreases, and the number of errors in work increases. Noise can be generated by operating equipment, air conditioning units, daylight illuminating devices, as well as penetrating from the outside. When working on a PC, the noise level in the workplace should not exceed 50 dB.

The screen and system blocks produce electromagnetic radiation. Its main part comes from the system unit and the video cable. According to [2], the intensity of the electromagnetic field at a distance of 50 cm around the screen along the electrical component should be no more than:

- in the frequency range 5 Hz - 2 kHz - 25 V / m;
- in the frequency range 2 kHz - 400 kHz - 2.5 V / m.

The magnetic flux density should be no more than:

- in the frequency range 5 Hz - 2 kHz - 250 nT;
- in the frequency range 2 kHz - 400 kHz - 25 nT.

There are the following ways to protect against EMF:

increase the distance from the source (the screen should be at least 50 cm from the user);

the use of pre-screen filters, special screens and other personal protective equipment.

When working with a computer, the ionizing radiation source is a display. Under the influence of ionizing radiation in the body, there may be a violation of normal blood coagulability, an increase in the fragility of blood vessels, a decrease in immunity, etc. The dose of irradiation at a distance of 20 cm to the display is 50 μrem / hr. According to the norms [2], the design of the computer should provide the power of the exposure dose of x-rays at any point at a distance of 0.05 m from the screen no more than 100 μR / h.Fatigue of the organs of vision can be associated with both insufficient illumination and excessive illumination, as well as with the wrong direction of light.

5.5 Electrical safety

Depending on the conditions in the room, the risk of electric shock to a person increases or decreases. Do not operate the computer in conditions of high humidity (relative air humidity exceeds 75% for a long time), high temperature (more than 35 ° C), the presence of conductive dust, conductive floors and the possibility of simultaneous contact with metal components connected to the ground and the metal casing of electrical equipment. The computer operator works with electrical devices: a computer (display, system unit, etc.) and peripheral devices. There is a risk of electric shock in the following cases: with direct contact with current-carrying parts during computer repair; when touched by non-live parts that are under voltage (in case of violation of insulation of current-carrying parts of the computer);when touched with the floor, walls that are under voltage; short-circuited in high-voltage units: power supply and display unit. Measures to ensure the electrical safety of electrical installations: disconnection of voltage from live parts, on which or near to which work will be carried out, and taking measures to ensure the impossibility of applying voltage to the workplace; posting of posters indicating the place of work; electrical grounding of the housings of all installations through a neutral wire; coating of metal surfaces of tools with reliable insulation; inaccessibility of current-carrying parts of equipment (the conclusion in the case of electro orating elements, the conclusion in the body of current-carrying parts) [3].

5.6 . Fire and explosive safety

According to [4], depending on the characteristics of the substances used in the production and their quantity, for fire and explosion hazard, the premises are divided into categories A, B, C, D, E. The room belongs to category B according to the degree of fire and explosion hazard. It is necessary to provide a number of preventive measures.

Possible causes of fire: malfunction of current-carrying parts of installations; work with open electrical equipment; short circuits in the power supply; on-compliance with fire safety regulations; presence of combustible components: documents, doors, tables, cable insulation, etc. Activities on fire prevention are divided into: organizational, technical, operational and regime. Organizational measures provide for correct operation of equipment, proper maintenance of buildings and territories, fire instruction for workers and employees, training of production personnel for fire safety rules, issuing instructions, posters, the existence of an evacuation plan. The technical measures include: compliance with fire regulations, norms for the design of buildings, the installation of electrical wires and equipment, heating, ventilation, lighting, the correct placement of equipment. The regime measures include the establishment of rules for the organization of work, and compliance with fire-fighting measures. To prevent fire from short circuits, overloads, etc., the following fire safety rules must be observed: elimination of the formation of a flammable environment (sealing equipment, control of the air, working and emergency ventilation);use in the construction and decoration of buildings of non-combustible or difficultly combustible materials; the correct operation of the equipment (proper inclusion of equipment in the electrical supply network, monitoring of heating equipment);correct maintenance of buildings and territories (exclusion of the source of ignition - prevention of spontaneous combustion of substances, restriction of fire works);training of production personnel in fire safety rules; the publication of instructions, posters, the existence of an evacuation plan;

compliance with fire regulations, norms in the design of buildings, in the organization of electrical wires and equipment, heating, ventilation, lighting; the correct placement of equipment; well-time preventive inspection, repair and testing of equipment.

In the case of an emergency, it is necessary to:

- inform the management (duty officer);
- call the Emergency Service or the Ministry of Emergency Situations tel. 112;
- take measures to eliminate the accident in accordance with the instructions.

5.7 Conclusion

This dissertation is carried out by step by step systematic analysis of the objectives. The main goal of the dissertation is find out the optimum thickness of the filter in order to achieve axial uniformity so that doping process is more uniform and reliable. In the process of achieving this goal we need to select the proper filter materials by studying the neutron characteristics of various materials we arrived at the conclusion that we must choose material which as more absorption cross section therefore the two elements which are chosen for studies is Europium and Gadolinium after choosing the material a computer model is created and the following analysis is done firstly the flux distribution is found out without the filter and from the Fig 2.5 we found out that the flux keeps on increases and we move axially across the silicon ingot and different thickness of the filter material is used and the results are obtained. Simultaneously power distribution in the filter and silicon is found out for optimum thickness and the following results are obtained the optimum thickness of the filter is found out to 6.370 cm and the radial and axial uniformity is obtained through this thickness so the doping process is uniform. With the help of this thickness the energy stored in silicon and europium is obtained and the graph is drawn in Fig 2.8 and Fig 2.9 as the next step in the dissertation the amount of heat transfer in the coolant is calculated for the given model and the amount of heat transfer in the coolant is obtained. The heat transfer in the coolant is found to be 31337.46K.To execute this dissertation it is necessary for us to produce and denominate the resources and finance and budget for the following project. Systematic analysis is been carried out for the following project the amount of resource and managing them is a serious problem to overcome this problem we need to perform a SWOT analysis in the this analysis a strength and opportunities are studied carefully these are internal factors which become a big threat to the project when not properly carried out access to the facility is being neglected and the real values are not found out and project is being carried out under scientific assumption and based on these the weakness of the project is being determined and the solution for these weakness is found out and rectification process is a big challenge. The dissertation was done in a period 632 days totally with the participation of master's student and the support of two supervisors. In which, the researcher, i.e. the student, who carried out this thesis spending 567 days for working on, the supervisor 1 is 30 days and supervisor 2 is 26 days.

The amount of money had been spent for doing this dissertation is 1,13,831 ruppes totally. Particularly, supervisor 1and 2 is 52,510 rupees on wage. Overhead cost – 16,349 rupees. And on social insurance 15,736

In addition, there are some money also paid for some necessary equipment, which had been used for doing this research, such as computer, notebooks, pen, printing, specific textbook. Totally, it costs 1,13,831 rupees for all

The final part of the dissertation is social responsibility the project has to be done as per the rules and regulation in-order to achieve that it is necessary to produce a systematic analysis of the safety factors the numerous amount of threat is involved in achieve the goal of the project fire safety radiation safety electrical safety in order to achieve the success of the project the people who are involved in the project as to trained properly and so ultimate safety is achieved and among this is most important is radiation safety the personnel's who are involved in the project as to be shielded from radiation proper radiation shielding methods as to be used regarding the fire safety all inflammable materials should be kept away from the fire reachable area and thus fulfilling all these safety measure the project can be executed safely and smoothly thus allowing us to perform all necessary safety precaution during course of the project and regarding the electrical safety proper voltage as to maintained properly and smooth function of the project as to be ensured.

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Tomsk, May 13, 2017

Kumar Ashok

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