

IMPLANTABLE ARTIFICIAL KIDNEY FOR FUTURE KIDNEY ON CHIP TECHNOLOGY

Overview

The importance of solving the life support problem for patients with chronic renal failure (CRF) from a medical, social and organizational point of view is due to the high mortality rate and the high complexity of technical support of modern methods of CRF treatment. Before a donor kidney transplant operation, patients undergo renal replacement therapy (RRT), during which excess fluid, metabolites and toxins are removed from the body. To date, the most common methods of renal replacement therapy are hemodialysis and its varieties, as well as peritoneal dialysis. Moreover, one of the most relevant areas in this subject is the development of wearable, portable and implantable systems of continuous blood purification that could improve the quality of renal replacement therapy procedures. This course provides an introduction to the development of implantable organ-on-chip blood purification devices. There will be provided a quick overview of chronic and terminal renal failure, a short introduction in existing conventional methods of renal replacement therapy including dialysis methods (hemodialysis, peritoneal dialysis and their modalities), and an overview of the current RRT devices development. The lectures will be organized to explain the main features of RRT methods from biomedical engineering point of view. A basic mathematical explanation of mass transfer during hemodialysis and peritoneal dialysis will be provided in order to achieve a better understanding of these methods. There will be a quick overview of the current status of wearable and implantable devices development; the main technical and medical challenges will be also explained in the process.

In the context of this course, the basic physical and chemical principles underlying the functioning of kidney-on-chip systems will be considered. The role of "digital twins" in the context of the development of implantable devices will be considered. We will also consider options for implementing this technology using various examples, such as implantable bioartificial and total artificial kidneys. This course will cover major aspects of implantable kidney development, such as digital twin technology, Model Based System Engineering approach, biocompatible membrane material selection and synthesis, modeling of feedbacks in biotechnical system of implantable total artificial kidney, AI integration in digital twin and artificial kidney development etc.

In order to mimic blood filtration in kidneys, the following issues have to be addressed. First, there should be a precise analysis and understanding of ultrafiltration and reabsorption

processes that take place in native nephrons (in particular, in Bowman’s capsules and proximal convoluted tubules). Thus, an analysis of mathematical modeling of reabsorption functions in proximal convoluted tubules (PCT) will be presented during this course; in particular there will be a description of solute transport in PCT-blood vessel system that can be potentially used in kidney-on-chip developing.

Second, in order to mimic a native nephron, a multilayered microfluidic organ-on-chip device must be developed. Such device must include a semipermeable membrane sandwiched between two channels in order to separate solutes on the basis of size. The device must also provide a selective ion transport between the solutes; therefore, electrode layers have to be also included into the organ-on-chip multilayered device. In that regard, it is necessary to develop a proper method of organ-on-chip manufacturing, including material and microfluidic device fabrication method selection. Thus, the main stages of implantable total artificial kidney developing will be also covered during this course. Step-by-step methods of microfluidic chip manufacturing will be reviewed during the course.

The knowledge that the participants will acquire from this course will provide a better understanding of the current worldwide trends of RRT and organ-on-chip development

Course Objectives

The key objectives for those who will attend this course are as follows:

- Presenting an overview of kidney physiology, kidney dialysis, blood filtration and reabsorption mechanism in a native nephron
- Explanation of the concept of renal replacement therapy
- Exposing the participants to conventional methods of dialysis
- Introduction to the concept of digital twins. Application of digital twins in biomedical engineering
- Summary of the main concepts of implantable artificial kidney and kidney-on-chip technology

Course Information	<p>Duration: 10th August 2025 – 14st august 2025</p> <p>Place: National Institute of Technology Silchar, Assam, India</p> <p>Total Contact Hours: 14 hours (12 hours lectures and 2 hours tutorials)</p>
Modules and schedules	<p>A: <u>Day 1: 10-08-2025</u></p> <p>Lecture 1 (1 hr): General introduction on natural kidney and nephron functions and</p>



chronic kidney failure.

Lecture 2 (1 hr): Treatment of kidney failure and renal replacement therapy.

Lecture 3 (1 hr): The main complications and issues of conventional methods of dialysis.

B: Day 2: 11-08-2025

Lecture 4 (1 hr): Possibilities of the future RRT methods development. Wearable and implantable artificial kidney technologies.

Lecture 5 (1 hr): Overview of the concept of implantable artificial kidneys: the cell based artificial kidneys and total artificial kidneys.

Tutorial 1 (1 hr): Ultrafiltration and reabsorption mechanisms in native nephron. Mathematical model of blood filtration in native nephron and its application in kidney-on-chip development.

C: Day 3: 12-08-2025

Lecture 6 (1 hr): Digital twin of implantable total artificial kidney as the essential step of the device development.

Lecture 7 (1 hr): Model Based System Engineering (MBSE) approach for developing digital twin of implantable total artificial kidney.

Lecture 8 (1 hr): Mimicking of Human Organs using MEMS and Microfluidic Technique

D: Day 4: 13-08-2025

Lecture 9 (1 hr): Concept of biofeedback design in the interaction of implantable total artificial kidney with the patient's body.

Tutorial 2 (1 hr): Fabrication of kidney-on-chip apparatuses. Microfluidic chip fabrication methods. Membrane material selection and achievement of biocompatibility of renal replacement therapy.

Lecture 10 (1 hr): Photonics sensors: A method to detect kidney diseases



	<p>E: <u>Day 5: 14-08-2025</u></p> <p>Lecture 11 (1 hr): AI integration in digital twin and implantable artificial kidney development.</p> <p>Lecture 12 (1 hrs): Prototypes of implantable total artificial and bioartificial devices for renal replacement therapy.</p>
Who can attend ...	<ul style="list-style-type: none">➤ Executives, engineers and researchers from manufacturing, service and government organizations including R&D laboratories.➤ Students at all levels (BTech/MSc/MTech/MBA/PhD).➤ Faculty from reputed academic and technical institutions.➤ Others who want to learn the basic and advanced concepts of future kidney on chip technology.
Fees	<p>The participation fees for taking the course are as follows:</p> <ul style="list-style-type: none">a. Participants from abroad: USD 250b. Participants from Industry/Research Organizations: Rs. 5000/-c. Participants from Academic Institutions:<ul style="list-style-type: none">i. Faculty member: Rs. 2000/-ii. External Students: Rs. 500/-iii. Internal PG & Ph.D. Students: Rs. 500/-iv. Internal UG Students: Nil <p>The above fee includes all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hours free internet facility. The participants may be provided with accommodation (single/sharing) on payment basis.</p>

The Faculty (Experts)

Dr. Boris Putrya
senior engineer, National
Research University of Electronic
Technology, Russia



Putrya Boris is a senior engineer in the Institute of Biomedical Systems, National Research University of Electronic Technology (Russia). He obtained Ph.D. (Engg.) degree from **Bauman Moscow State Technical University (BMSTU)**, Russia, in the year 2018. His research interests include dialysate regeneration, renal replacement therapy, wearable artificial kidney. Boris Putrya has good number of publications including peer reviewed journal and conference papers and holds two patents. At present, Dr. Putrya is a senior engineer and part-time Professor at the Institute of Biomedical Systems (National Research University of Electronic Technology MIET). His current research is focused on dialysate regeneration methods and wearable artificial kidney development.

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Course Coordinators

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About Silchar

Silchar is the second largest town of Assam. It was the kingdom of the Kachhari kings from 1755 to 1830. It was annexed to the British East India Company in 1833. The city has now attained a cosmopolitan status with inhabitants from all over India although Bengali speaking people constitute the majority. It is an educational and business hub in North East India next to Guwahati. During the month of August, the average temperature ranges between 25-35 degrees Celsius.



About NIT Silchar

In the late fifties, the Government of India decided to establish Regional Engineering Colleges (RECs) under the Quality Technical Education Policy – one each in every major state – with the prime objective of imparting quality technical education throughout the country and to foster national integration. These Regional Engineering Colleges were established as joint ventures of the Government of India and the respective State Governments. Assam is considered as the flag bearer of Northeast India and so in the year 1967 the 15th REC was officially established in Silchar. The first batch of students were admitted in 1977 in the BE program in 3 branches of engineering namely, Civil Engineering, Mechanical Engineering, and Electrical Engineering with a total intake of 60 students in each branch. The REC Silchar was upgraded to National Institute of Technology, Silchar with the status of Deemed University on 28th June 2002. The institute has been taken over by the Government of India and subsequently made into a fully funded Central Government Autonomous Institution. The institute has remodeled its curriculum and academic activities in line with that of the IITs. With its Deemed University status, the institute started awarding degrees from the year 2002 and the first convocation of the institute was held on 16 February 2004. The Government of India declared the Institute as an Institute of National Importance by enacting the National Institutes of Technology Act 2007.



How to reach NIT Silchar

The city is well connected by Road, Train and Air. There are direct flights from Kolkata and Guwahati and trains from New Delhi, Kolkata, Guwahati, and Agartala. Daily bus services are available from Agartala, Guwahati, Aizawl, and Imphal. The Institute is located around 35 kms from the Silchar airport, 10 kms from the Silchar railway station, 14 kms from ISBT Silchar, and 8 kms from the heart of the Silchar town. Prepaid taxi and auto services are available from Silchar.

Registration Guidelines (Step-by-Step):

1. Courses Registration for GIAN course may be done by paying the requisite fees as below through SBI collect.

SBI Collect Name: GIAN COURSE NIT SILCHAR, 2412143, Koushik Guha

- a. Participants from abroad: USD 250
- b. Participants from Industry/Research Organizations: Rs. 5000/-
- c. Participants from Academic Institutions:
 - i. Faculty member: Rs. 2000/-
 - ii. External Students: Rs. 500/-
 - iii. Internal PG & Ph.D. Students: Rs. 500/-
 - iv. Internal UG Students: Nil

2. Fill out the Registration form given below, sign it. Send the scan copy of the filled in form with scanned copy of course fee transaction slip obtained by SBI collect to the course coordinator e-mail address (koushik@ece.nits.ac.in , sktripathy@ece.nits.ac.in). This is for the Course Coordinator's record. Now, await the Course Coordinator's confirmation.



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GIAN: Global Initiative of Academic Network

**NAME OF THE COURSE: IMPLANTABLE ARTIFICIAL KIDNEY FOR FUTURE
KIDNEY ON CHIP TECHNOLOGY**

(Course ID: 2412143)

Dates: 10-14 August, 2025

**Department of Electronics and Communication Engineering,
NIT Silchar, Assam, India**

REGISTRATION FORM

GIAN Portal Application Number (if any):

Full Name: Category (Industry/Academic/Student):

Organization:

Address:

Email Id:

Mobile Number:

Highest Academic qualification:

SBI Collect payment details:

Transaction Id/Ref No	Date	Amount

Accommodation Required: Yes/No (please tick in the applicable field)

Date:

Place:

Signature of Applicant