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Department	School of Engineering and the Built Environment
Supervisors	DoS: Dr. Chan H. See, SS: Dr. Zhilun Lu, Dr. Dongyang Sun and Prof. Hongnian Yu
Funding Status	Funded PhD Project (Worldwide)
Application Deadline	14/04/2022
Project Title	PHD in Miniaturised Cellulose Nanomaterial-based Antennas and Arrays Design and Performance Evaluation for Internet of Things applications.

PROJECT DESCRIPTION

The advances in wireless networks and electronics have led to the emergence of Wireless Sensor networks (WSNs), which are considered to be one of the most important technologies that can revolutionize healthcare systems. This technology has impacted the medical devices field, replacing thousands of wires connected to traditional sensors as found in hospitals and providing enhanced mobility. However, miniaturization is one of the key requirements for both wearable and implantable devices.

Antenna is the key element in the wireless communication devices to transmit and receive radio signals. It acts as an omnipresent critical component in smart phones, tablets, implantable wireless biomedical devices, radio frequency identification systems, radars, etc. Compact antennas rely on an EM wave resonance, and therefore typically have a size of more than one-tenth of the EM wavelength. The limitation on antenna size miniaturization has made it very challenging to achieve compact antennas and antenna arrays, particularly at very-high frequency (VHF, 30–300 MHz) and ultra-high frequency (UHF, 0.3–3 GHz) with large wavelength, thus putting severe constraints on implantable medical devices and Internet of things (IoT) transceivers.

Implantable medical devices are at the centre of much academic and technical research in biomedical engineering, medicine and biology. Much of the work surrounding implantable technology has been a global initiative. With the advancement of MEMS structures, numerous devices are being designed and fabricated using silicon (Si) as the primary material. This is logical since Si is a very well-known and reliable material, has excellent mechanical and electronic properties, and has been used in many sensing applications. While Si will continue to be the material of choice for short-term biomedical applications, considerable work is needed to select a biocompatible device material suitable for long term implantation that is, at the same time, capable of efficient sensing. The increased demand of biomedical devices to solve medical problems has motivated the research *in vivo* antennas that would permit both interoperable communications between sensors as well as data transfer into and out of the human body. As a result, a biocompatible implantable antenna is a key component of an implantable device as many factors such as antenna dimensions, operation bandwidth, radiation performance, and so on should be considered within the overall framework of device requirements.

The aim of the proposed PhD research is to develop miniaturised antennas by using optimized structures/material combinations for biomedical wireless sensing and communication applications. By incorporating metamaterial inspired structures, cellulose nanomaterial, conductive polymer, carbon fibre and carbon nanotubes, the electromagnetic constitutive parameters of the host substrate can be enhanced and thus the size of the antenna reduced and the performances improved, i.e. impedance bandwidth, radiation characteristics, etc. The work proposed herein is novel and can be distinguished by its innovation to utilize new flexible, renewable, biodegradable materials as the device materials. With these, well-tailored magnetic and electric properties offer

great potential in realizing compact antennas with adequate bandwidth and efficiency. The outcomes of this research will provide the necessary leap within biomedical and wireless communication research to satisfy the ever-growing demands for miniaturised and "green" transceivers.

This project is a collaboration between two engineering subject areas, i.e. Material science and Electrical & Electronic Engineering within School of Engineering and the Built Environment (SEBE). It is suitable for applicants with interests and good background in electromagnetics and materials science and particularly in antenna and antenna arrays, metamaterial.

Academic qualifications
A first degree (at least a 2.1) ideally in Electronic and Electrical Engineering with a good fundamental knowledge of Electromagnetism, antenna, materials science and microwave theory.

English language requirement
IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

Essential attributes:

- Experience of fundamental antenna design and modelling
- Competent in Electromagnetics Theory and Fields
- Knowledge of material science, Microwave/millimetre wave transmission systems and devices, and wireless communication theory/principles
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:
This project is suitable for applicants with interests and good back ground in materials science, electromagnetic and electromagnetics design and particularly in electromagnetic wave propagation, antenna and antenna arrays for communications systems and energy harvesting systems.

Indicative Bibliography	C. M. Boutry, C.M. et al., "Towards Biodegradable Wireless Implants," Phil. Trans. *R. Soc. A 370*, pp.2418-2432, 2012 M. Irimia-Vladu, " Green electronics: biodegrable and biocompatible materials and devices for sustainable future," *Chem. Soc. Rev.*, vol.43, pp.588-610, 2014 M. Alibakshikenari et al., "High-Isolation Antenna Array Using SIW and Realized with Graphene Layer for Sub-Terahertz Wireless Applications," Scientific Reports, vol.11, Article no.10218, May 2021
Funding notes	This project may be funded by a scholarship of the School of Engineering and Built and Environment. Please see School-funded PhD scholarships -

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	RESEARCH AND INNOVATION (napier.ac.uk) for information on the scholarships and how to apply for them.
Enquiries	For informal enquiries about this PhD project, please contact Dr. Chan See (Email: c.see@napier.ac.uk
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process

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