Imperial College London

Nanotechnology in Consumer Electronics

Module Code	PHYS97053	FHEQ Level	Level 7
Pre-requisites	Light and Matter	Co-requisites	None
Primary Department	Physics		
Module Leader	Dr Will Branford, Prof Jing Zhang		
Additional Teaching Departments	None		
Teaching Staff	Dr Will Branford, Prof Jing Zhang + Course Associates		
Programmes on which the Module is delivered			Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)			Elective
Learning Outcomes	On completing the Nanotechnology course, students will: **Electronic device physics:** • Understand and be able to sketch the energy band edge diagram of a metal-semiconductor contact and a metal-oxide-semiconductor (MOS) capacitor. • Know and understand the operating principles and operating regimes of a metal-oxide-semiconductor capacitor and be able to calculate the capacitance of a MOS under different biasing regimes. • Know and understand standard the operating principles of a MOS field-effect transistor (MOSFET) and be able to derive the channel current equation using the gradual channel approximation. • Understand the role of the gate dielectric and channel geometry on the operating characteristics of a transistor. • Be able to calculate the unit-gain frequency for a planar transistor. • Understand and be able to explain the operation of a FinFET. • Understand and be able to explain the operation of a floating-gate memory MOSFET. • Know and be able to explain the operation of the logic NOT gate. • Understand and be able to explain the operation of a floating-gate memory MOSFET (flash memory). • Be able to draw the circuitry of passive and active matrix pixel elements used in displays. • Be able to explain the differences between unconventional semiconductors, such as organics and metal oxide based compounds, with conventional silicon. • Be aware of all basic photolithography steps used for the manufacturing of conventional silicon micro/nano-electronic elements. **Magnetic device physics:** • Understand the role of exchange in mediating magnetic interactions. • Know and understand the Magnetic Hysteresis loop in terms of simple energetics and key terms: coercive field, saturation and remanent magnetization. • Know what is meant by domain wall energy vs. single domain ferromagnetism.		

	• Calculate the superparamagnetic limit (minimum volume for ferromagnetism) from volume and anisotropy constant. • Be aware of types of anisotropy, stray field and demagnetization factors, dependence on size and shape. • Know that data storage (unpowered) requires history dependence of magnetization. • Know how read and write mechanisms work. • Be able to discuss challenges of scaling data storage and the superparamagnetic limit. • Be aware of: historic trends and the state of the art in data storage; perpendicular recording and patterned magnetic media; integrating storage and logic: MRAM. • Understand current in FM materials as two independent spin currents • Understand anisotropic magnetoresistance: Cosine dependence with angle between current and magnetization. • Understand transmission of spin currents across interfaces including the Jullière formula. • Be aware of: anisotropic, giant, colossal and tunnelling MR; hard disk read heads including GMR and TMR spin valves. • Be aware of current and future solid state data storage devices; flash memory and solid state drives, various random access memory devices such as Magnetic RAM, Resistive RAM and phase chase RAM.
Description of Content	To provide students with an understanding of the way physical properties can be manipulated at the nanoscale compared to bulk materials and how that underpins modern electronic devices.

Assessment		Assessment Type	Weighting
Written Exam		Exam	100%
Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
23.5	51.5	0	75
ECTS Credit	3	CATS Credit	6
Date of introduction	October 2016	Date of Last Revision	October 2019