PROGRAMME SPECIFICATION

Awarding body/institution	Glyndŵr University
Teaching institution	
Details of accreditation by a professional, statutory or regulatory body	The programme will look to apply for the following accreditations after one year of delivery; Royal Society of Chemistry (RSC), Solar Trade Association and Institute of Materials (IOM). The Programme team may extend this to other PSRB.
Final award/s available	MSc, PGDip and PGCert
Award title	MSc in Photovoltaics (Materials), MSc in Photovoltaics (Advanced Manufacturing) MSc in Photovoltaics (System Design) PGDip in Photovoltaics PGCert in Photovoltaics
UCAS code	
Relevant QAA subject benchmark statement/s	The QAA Chemistry Benchmark Statement 2007
Other external and internal reference points used to inform the programme outcomes	FHEQ 2008, CQFW, KIS Fields – Teaching, Learning and Assessment, The Framework for Qualifications of the European Higher Education Area
Mode/s of study	Full Time, Part Time
Language of study	English
Date at which the programme specification was written or revised	August 2013

Criteria for admission to the programme

Normally, applicants will be required to attend an interview. This is not always possible, e.g. overseas students, in which case the application form and interview via phone, internet and video conferencing may also be used.

Normal entry requirements will be one of the following:

1) A good first degree in Chemistry, Physics, Materials Science, Engineering or other subjects deemed relevant by the programme team, with a 1st or 2nd class award.

2) A non-graduate can be admitted for candidature provided that:

i. he/she has a non-graduate qualification which Glyndŵr University has deemed to be of a satisfactory standard for the purpose of post-graduate admission,

or

ii. He/she has held, for a minimum of two years, a reasonable position relevant to the scheme to be pursued deemed relevant by the programme team.

3) Equivalent qualifications of another overseas country which are deemed satisfactory by the programme team. The equivalence of overseas qualifications will be checked by the International Office.

In addition to the academic entry requirements, international students whose first language is not English require a TOEFL score of 575 (paper) or 232 (online), or an IELTS score of 6.5. Details of additional support for International Students are detailed in the Particular Support for Learning and Equality and Diversity sections including:

Language provision designed to ensure that the international students have achieved a minimum level of language skills before they embark on their chosen degree programme. This is a six-week pre-sessional intensive English Language for Academic Study course that aims to bring students to an IELTS (International English Language Testing System) level of 6.5 – the standard demanded for entry into the Masters Degree programme. Irrespective of a candidate's entry qualifications, the student must provide evidence to the satisfaction of the interview panel of his/her ability to complete academic work to the required standard in order to successfully complete the scheme of study proposed.

AP(E)L:
Students who wish to claim AP(E)L will be considered on an individual basis in line with University and Department policies (supporting evidence). AP(E)L will only be granted for a maximum of 4 modules excluding the research project.

Aims of the programme

The world is moving towards green and renewable energies and it is important to ensure that the next generation of scientist and engineers have the adequate skills and understanding, at postgraduate level, to innovate, develop, install and maintain technologies of the future and meet the rapidly changing needs of this highly interdisciplinary field. Converting the abundant energy from the sun to a useful energy (electricity) is a fascinating field of research, referred to as Photovoltaics (PV). The Department of Chemistry at Glyndŵr University carry out leading research in PV which aims to provide students with postgraduate teaching focused on depth of study, critical awareness and evaluation. The student will also be taught more general all round abilities related to Sciences. The postgraduate programme in Photovoltaics, including materials on the theory, design and implementation of PV, aims to prepare students effectively for professional employment or doctoral studies in the chemical sciences related to PV. It will extend the students' comprehension of key chemical concepts and provide them with an in-depth understanding of photovoltaic materials, processes, manufacturing and testing. The programme also

aims at providing the students with a tailored outcome by providing 3 specialisms, within the field of PV.

The programme aims to apply for accreditation from the Royal Society of Chemistry (RSC), Solar Trade Association and/or Institute of Materials after a year of delivery.

Distinctive features of the programme

This programme is intended to provide an in-depth study centred on photovoltaic materials, deposition techniques and an introduction to new technologies especially in solar cell design and light management. The programme is the only dedicated solar PV masters course in the UK and takes advantage of the world class research facilities and experienced research team of Prof Stuart Irvine and the Centre for Solar Energy Research (CSER) in thin film photovoltaic materials to deliver a programme combining tuition, discovery and research. The use of the facilities and capabilities at Glyndŵr University's CSER, including the Solar Wall at Glyndŵr University St Asaph will play a central role in the delivery of this programme. The students will be based at the St Asaph campus but will be able to take advantage of the wider resources of the Chemistry Department where 2 of the modules will be shared with the Formulation Science MSc programme.

Rationale for chosen design of the curriculum:
This programme is the only MSc in Photovoltaics available in the UK and will be based on the world class research activity of the Centre for Solar Energy Research (CSER). Other universities have renewable MSc's with a module(s) in solar, but not a dedicated MSc programme. The Fraunhofer Institute in Germany offer an on-line Masters in Photovoltaics highlighting that there is a market for this programme.

This programme has been developed in conjunction with the Photovoltaic Industry Advisory Group on the Welsh Energy Sector Training (WEST) project for which Glyndŵr University is leading the Solar (Photovoltaic) activity. Hence it will provide an in-depth study in photovoltaics with three specialist areas (Materials, Advanced Manufacturing and System Design) with an emphasis on recent and emerging PV technologies, aimed at meeting the demands of employers and market needs for advanced skills within photovoltaics.

Benefits of studying the Programme:
This programme covers knowledge essential both for a student wanting to work in research and development in photovoltaics, in industry and for a student planning an academic research career. The course gives the student an advanced and comprehensive coverage of the specialist practical skills required by working in a dynamic research group. This course prepares students for careers in the rapidly evolving PV market driven by advanced technology.

The MSc programme is designed to provide progression from existing Bachelor Degrees (Chemistry and Engineering) and for qualified entrants who studied in universities in the UK or other countries. Each module has the same structure and a problem solving approach to foster independent learning and critical thinking. In addition the learning experience will be enhanced by guest lecturers/seminars from industry speakers where possible.

A typical module delivery might incorporate:

25 hrs. Lectures
10 hrs. Laboratory Sessions
5 hrs. Tutorials
2 hrs. Industry Speakers
42 hrs. Contact Time and 158 hrs. directed and self-study

Benchmarking:
The QAA Chemistry Benchmark Statement 2007 was referenced when making this proposal, in order to achieve the academic standard for Masters degrees as set out in this subject benchmark statement. The methods of teaching, learning and assessment are constructed so that the learning activities and assessment tasks are aligned with the learning outcomes that are intended in the programme and therefore to enhance and reinforce the student learning experience. The methods of delivery and the design of the curriculum are in response to generic and discipline-specific developments, taking into account educational research, changes in national policy, social and economic factors, industrial practice and the needs of employers.

The QAA subject benchmark statements have informed the curriculum design. Research, scholarship and an understanding of the potential destinations of graduates and the use of industrially-relevant applications of chemistry are included. For students to achieve a satisfactory understanding of Photovoltaics the curriculum design will ensure students have significant exposure to laboratory problem solving tasks and substantial individual project work. The curriculum also includes both design and research-led projects, to enable students to develop in both independence of thought and the ability to work effectively in a team.

The Masters programme in this proposal includes deepening of technical understanding, emphasis on problem solving and team/group working, an increase in the use of industrially-relevant applications of photovoltaics and an enhanced capability for independent learning and work through case studies and projects. These will encourage Masters students to accept responsibilities, formulating ideas proactively, dealing with open-ended and unfamiliar problems, planning and developing strategies, implementing and executing agreed plans, leading and managing teams where required, evaluating achievement against specification and plan and decision making. The elements within the curriculum of this programme are to prepare students for their future in technical and/or managerial activities in the rapidly expanding PV industry.

This proposal also referenced the Descriptor for a higher education qualification at level 7: Masters Degree in the Framework for Higher Education Qualifications in England, Wales and Northern Ireland August 2008, the FHEQ (2008) and the QAA's Quality Code for HE which gives all higher education providers a shared starting point for setting, describing and assuring the academic standards of their higher education awards and programmes and the quality of the learning opportunities they provide. The benchmarking standards for Masters Degrees are regarded as minimal standards required of a course leading to the award of Masters Degree as outlined below.

Masters Degrees are awarded to students who have demonstrated:

- A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of their academic discipline, field of study or area of professional

practice.

- A comprehensive understanding of techniques applicable to their own research or advanced scholarship.
- Originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline.
- Conceptual understanding that enables the student:
  - To evaluate critically current research and advanced scholarship in the discipline.
  - To evaluate methodologies and develop critiques of them and, where appropriate, to propose new hypotheses.

Programme structures and requirements, levels, modules, credits and awards

The structure of the programme is shown in the table below.

DELIVERY	PART 1 (Trimester 1 & 2)	PART 2 (Trimester 3)
F/T (Yr1)	120 Credits	60 Credits
P/T (Yr1)	60 Credits	-
P/T (Yr2)	60 Credits	-
P/T (Yr3)	60 Credits	-

The levels and credit ratings and the awards that can be gained are detailed below. Personal Development Planning is an integral part of the learning process of each element of the programme. The programme has been designed in accordance with the Regulations for Glyndŵr University: 'Taught Masters Degrees'.

1. Full-time students starting the MSc programme in the autumn semester follow a one year programme which consists of two trimesters of taught modules, and a dissertation/project which takes place over the third trimester, requiring approximately 40 hours of study per week.

2. Part-time students on the MSc programme undertake the equivalent overall workload over a longer period of study, normally three years, and will start in September.

The MSc award requires 180 credits at level 7: 120 credits for the taught elements and 60 credits for the Dissertation/Project. Modules are equivalent to 20 credits. Typically a full-time student studies modules equivalent to 60 credits per semester (normally 3 modules) with 15 weeks of teaching, revision and assessment activities for each module.

The full degree scheme, including submission of the dissertation in the prescribed form, shall normally be completed within the following periods from date of registration:

Full-time candidates One year
Part-time candidates Three years

All taught modules and the dissertation or project module are marked on a percentage scale with a pass/fail threshold of 40%. While most students will aim to achieve the full Masters qualification, all Masters programmes offer the awards of Postgraduate Certificate (PGCert) or Postgraduate Diploma (PGDip) for students unable to complete their full programme of study. The full list of awards and their requirements are:

Award	***Credits at level 7***
MSc	180
Postgraduate Diploma	120
Postgraduate Certificate	60

Available Awards:

- MSc in Photovoltaics (Materials)
- MSc in Photovoltaics (System Design)
- MSc in Photovoltaics (Advanced Manufacturing)
- PGDip in Photovoltaics
- PGCert in Photovoltaics

Students will gain experience across the three specialisms in the first trimester by completing a variety of case studies and self-taught laboratory challenges from each specialism to allow them to make an informed decision at the start of the second trimester for FT and start of second year for PT, on which specialism they wish to pursue. During the second trimester students will undertake case studies and self-taught laboratory challenges only within their chosen specialism. At the start of the third trimester for FT and third year for PT, students must confirm specialisms in which to undertake the research project. A variety of research projects are available in the three different specialisms.

To obtain a PGCert students must have achieved 60 credits, including the Fundamentals in Photovoltaics module.

To obtain a PGDip students must have achieved 120 credits.

An example of possible exit pathway is shown below:

- Fundamentals in Photovoltaics
- Research Methods
- Energy and the Environment: Economics and Policies

Exit 1: PGCert (60 Credits)

- Advanced Photovoltaics
- Processes at Interfaces
- Advanced Materials Science

Exit 2: PGDip (120 Credits)

- Research Project

Exit 3: MSc (180 Credits)

All modules will also be offered as credit bearing CPD courses which on completion will award students a Glyndŵr University Certificate of Continuing Education. The titles of GU certificates in Continuing Education available are given in Appendix A

Progression:

- Detailed information relating to progression and awards are outlined in the Regulation for Glyndŵr University: 'Taught Masters Degrees'.

- Each student follows a course of study which will enable the successful candidate to attain either an exit award of Postgraduate Certificate or the exit award Postgraduate Diploma or to progress to the MSc.

- Progression to the MSc stage is determined by the Assessment Board and requires the successful student to have acquired 120 credit points in the previous PGD stage.

Delivery Schedule
Details of the delivery schedule for both Full Time (FT) and Part Time (PT) students is outlined below.

Full Time:
The table below shows the planned trimester in which each module will be delivered.

It is anticipated that Full Time students would be expected to attend 3 days a week, with all lectures held on one day a week and laboratory sessions and tutorials held on the other two days. Trimester 1 module lectures will be delivered on the Wrexham campus and Trimester 2 lectures will be delivered on the St Asaph campus. All modules are CORE, Level 7.

Code	Module Title	Credits	Module Leaders	Trimester
SCI706	Fundamentals of Photovoltaics	20	S. Irvine	1
ENG705	Energy and the Environment: Economics and Policies	20	D. Sprake	1
SCI707	Research Methods	20	I. Ratcliffe	1
SCI708	Advanced Photovoltaics	20	V. Barrioz	2
SCI709	Advanced Material Science	20	J. Yang	2
SCI710	Processes at Interfaces	20	S. Irvine	2
SCI711	Research Project	60	V. Barrioz	3

Indicative Delivery Schedule (Part Time):
The table overleaf shows the planned trimester in which each module will be delivered.

It is anticipated that Part Time students would be expected to attend 1 day a week for lectures for one trimester and 1 day a week for laboratory sessions in the other trimester, video demonstrations will be utilised to aid delivery of lab sessions.

Trimester 1 module lectures will be delivered on the Wrexham campus and Trimester 2 lectures will be delivered on the St Asaph campus. All modules are CORE, Level 7.

Code	Module Title	Credits	Module Leaders	Trimester
SCI706	Fundamentals of Photovoltaics	20	S. Irvine	Yr1 (Lectures1 & Labs 2)
ENG705	Energy and the Environment: Economics and Policies	20	D. Sprake	Yr1 (Lectures1& Labs2)
SCI707	Research Methods	20	I. Ratcliffe	Yr1 (Lectures1& Labs 2)
SCI708	Advanced Photovoltaics	20	V. Barrioz	Yr2 (Labs 1& Lectures 2)
SCI709	Advanced Material Science	20	J. Yang	Yr2 (Labs 1& Lectures2)
SCI710	Processes at Interfaces	20	S. Irvine	Yr2 (Labs 1& Lectures 2)
SCI711	Research Project	60	V. Barrioz	Yr3 (1&2)

The Research Project (60 Credits) can be undertaken at a work placement within a suitable company. Work placement is not compulsory for achievement of the award, but students will be encouraged to capitalise on this unique opportunity to gain valuable experience of the solar industry.

Intended learning outcomes of the programme

This programme will equip students to work as leaders in the rapidly developing PV solar industry or as researchers in emerging PV technologies. The context of the learning environment in CSER will challenge students to utilise an in-depth knowledge of the underpinning science and engineering to solve complex problems in PV materials devices and systems. Their problem solving skills will draw on their ability to cope with conflicting information and synthesise appropriate solutions. The students will be capable of designing and undertaking a substantial investigation making appropriate use of theory, modelling and practice. The course recognises that the students will be working in team situations where skills of communication and negotiation will be essential for them to be effective and bring about creative solutions. The students will become competent in the use of a wide range of modern technologies to achieve effective solutions and research outcomes within an economic, social and environmental context.

The programme emphasises emerging and state-of-the-art techniques and technologies within the field of photovoltaics and will deliver a range of course materials to cover technical, environmental and energy issues. It will provide an opportunity for students to gain a comprehensive theoretical knowledge of PV materials, devices and systems, while developing advanced analytical and practical skills. Their knowledge will cover the existing main stream crystalline silicon technologies and more specialist thin film and organic PV materials. Critical abilities will be developed in bringing together different components of a PV system and

interpreting its performance in complex settings. Beyond the MSc course the students will be equipped to continue to develop skills and knowledge and to have the ability to investigate areas of interest in more depth.

Aims and outcomes were derived as a result of consultation within the programme team and having reference to the Credit and Qualifications Framework for Wales (CQFW, 2009), The Qualifications and Credit Framework (2008), Chemistry Benchmark Statement (2007) and the requirements of professional institutions/bodies defined in the RSC Accreditation of Degree Programmes document, and Framework for Higher Education Qualifications (FHEQ, 2008 defined in section 4). The programme provides opportunities for the learners to achieve the outcomes described in the specific learning outcomes defined below.

Please note that programme learning outcomes differentiated by award are shown overleaf:

Specific Programme and Award Outcomes

Postgraduate Certificate (PGC) in Photovoltaics (60 Credits)	**Postgraduate Diploma (PGD) in Photovoltaics** (120 Credits)	**Masters (MSc) in Photovoltaics (Materials, Advanced Manufacturing or System Design)** (180 Credits)
A. Knowledge and Understanding of: **A.1** Essential facts, concepts, principles and theories relevant to advanced photovoltaics; **A.2** Theoretical photovoltaic principles (materials, advanced manufacturing and system design) and application of relevant techniques; **A.4** Current photovoltaic problems, including materials, advanced manufacturing and system design; **A.5** Current research and recent developments in chemistry and other sciences within which PV (materials, advanced manufacturing or system design) is applied.	A. Knowledge and Understanding of: **A.1** Essential facts, concepts, principles and theories relevant to advanced photovoltaics; **A.2** Theoretical photovoltaic principles (materials, advanced manufacturing and system design) and application of methodological approaches; **A.3** A systematic understanding of methodologies and techniques available for materials and devices and chemical analysis relevant to Photovoltaics; **A.4** Current photovoltaic problems, including materials, advanced manufacturing and system design, treated in a critical and evaluative manner; **A.5** Current research and recent developments in chemistry and other sciences within which PV (materials, advanced manufacturing or system design) is applied, including social and environmental considerations.	A. Knowledge and Understanding of: **A.1** Essential facts, concepts, principles and theories relevant to advanced photovoltaics and its interrelationship with other renewable energy systems; **A.2** Theoretical photovoltaic principles (materials, advanced manufacturing and system design) and application of methodological approaches; **A.3** A systematic understanding of methodologies and techniques available for materials and devices and chemical analysis relevant to Photovoltaics and critical application in research; **A.4** Current photovoltaic problems, including materials, advanced manufacturing and system design, treated in a systematic, critical and evaluative manner; **A.5** Current research and recent developments in chemistry and other sciences within which PV (materials, advanced manufacturing or system design) is applied, and critically evaluate in the context of social and environmental considerations.
B. Intellectual Skills - able to: **B.1** Apply advanced principles to the solution of Photovoltaics, including in-depth consideration of materials, advanced manufacturing and system design issues, and the investigation of new and emerging technologies; **B.3** Analyse complex Photovoltaic issues, including materials, advanced manufacturing and system design issues, in both a systematic and creative way;	B. Intellectual Skills - able to: **B.1** Apply advanced principles and develop creative solutions to Photovoltaics, including in-depth consideration of materials, advanced manufacturing and system design issues, and the investigation of new and emerging technologies; **B.3** Analyse complex Photovoltaic issues, including materials, advanced manufacturing and system design issues, in both a systematic and creative way;	B. Intellectual Skills - able to: **B.1** Apply advanced principles and develop creative solutions in complex situations to Photovoltaics, including in-depth consideration of materials, advanced manufacturing and system design issues, and the investigation of new and emerging technologies; **B.2** Design, conduct and report on a substantial and original programme of work (dissertation) relevant to Photovoltaics (Materials, Advanced Manufacturing or System Design);

B.4 Evaluate data sources and make sound judgements in the absence of complete data; **B.5** Make sound decisions in complex and unpredictable situations;	**B.4** Evaluate data sources and make sound judgements in the absence of complete or contradictory data; **B.5** Make sound decisions in complex and unpredictable situations, both familiar and unfamiliar; **B.6** Apply project planning and team management techniques, with an evaluation of commercial, financial and environmental context, in the conduct and management of a Photovoltaics project.	**B.3** Analyse complex and unfamiliar Photovoltaic issues, including materials, advanced manufacturing and system design issues, in both a systematic and creative way; **B.4** Evaluate complex data sources and make sound judgements in the absence of complete or contradictory data; **B.5** Make sound decisions in complex and unpredictable situations, both familiar and unfamiliar and argues the case for alternative approaches; **B.6** Master project planning and team management techniques, with an evaluation of commercial, financial and environmental context, in the conduct and management of a Photovoltaics project.
C. Practical Skills - able to: **C.1** Demonstrate self-direction and originality in tackling and solving Photovoltaics problems, competence in the planning, design and execution of experiments; **C.2** Act autonomously in planning and implementing experiment design and evaluative testing; **C.3** Prepare in-depth reports at a professional level; **C.4** Specify and use laboratory and workshop equipment competently and safely with understanding of risk assessment.	C. Practical Skills - able to: **C.1** Demonstrate ability to work autonomously and display originality in tackling and solving Photovoltaics problems, display critical skills in the planning, design and execution of experiments; **C.2** Act autonomously in planning and implementing experiment design and evaluative testing; **C.3** Prepare in-depth reports at a professional level achieving consensus of the presentation and findings across team members; **C.4** Specify and use unfamiliar laboratory and workshop equipment competently and safely and carry out full risk assessment.	C. Practical Skills - able to: **C.1** Demonstrate ability to work autonomously and display originality in tackling and solving more unpredictable Photovoltaics problems, competence in the planning, design and execution of experiments; **C.2** Act autonomously in planning and implementing experiment design and evaluative testing in complex situations; **C.3** Prepare in-depth and critical reports at a professional level of a complex topic where findings may be uncertain; **C.4** Specify and use laboratory and workshop equipment competently in complex situations and carry out full risk assessment to include alternative approaches
D. Transferable/key skills - able to: **D.1** Exercise initiative and personal responsibility;	D. Transferable/key skills - able to: **D.1** Exercise initiative and personal responsibility in more complex situations;	D. Transferable/key skills - able to: **D.1** Exercise initiative and personal responsibility in managing a research project;

D.2 Communicate and interact with professionals and non-specialists from this and other disciplines; **D.3** Select and apply methodologies in the interpretation of problems and evaluation of solutions; **D.4** Exercise judgement in the use of information technology, to source information and model performance of Photovoltaics, with awareness of limitations of computer models; **D.5** Apply Independent learning ability required for continuing professional development	**D.2** Communicate and interact with professionals and non-specialists on unfamiliar topics in PV; **D.3** Select and apply methodologies in the interpretation of complex problems and evaluation of solutions; **D.4** Exercise judgement in the use of information technology, to source information and model performance of Photovoltaics in more complex and less standard situations, with awareness of limitations of computer models; **D.5** Apply Independent learning ability in unfamiliar circumstances required for continuing professional development **D.6** Exercise autonomy and self-direction regarding own performance and self-management	**D.2** Communicate and interact with professionals and non-specialists complex research results; **D.3** Select and apply methodologies in the interpretation of complex problems and evaluation of solutions where there are likely to be alternative solutions; **D.4** Exercise judgement in the use of information technology, to source information and model performance of Photovoltaics in a research context, with awareness of limitations of computer models; **D.5** Apply Independent learning ability in research situations required for continuing professional development; **D.6** Exercise autonomy and self-direction regarding own performance and self-management in a research environment.

CURRICULUM MATRIX demonstrating how the overall programme outcomes are achieved and where skills are developed and assessed within individual modules.

	MSc in Photovoltaics (Materials, Advanced Manufacturing or System Design) A. Knowledge and Understanding C. Practical skills B. Intellectual Skills D. Transferable/Key Skills																				
	A					**B**						**C**				**D**					
Module Title	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**	**6**
Research Methods	*			*		*	*	*		*	*			*		*	*			*	*
Fundamentals of Photovoltaics	*	*	*	*	*	*		*	*				*		*		*	*	*		
Advanced Photovoltaics		*		*	*	*	*	*	*	*	*	*	*	*	*	*				*	*
Processes at Interfaces		*	*	*	*	*		*		*	*	*		*	*	*	*	*	*	*	
Advanced Materials Science	*	*	*	*	*	*		*	*			*			*			*		*	
Energy & Environment Economics and Policies		*	*	*	*	*		*		*	*	*		*	*	*	*		*	*	
Research Project	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

	PGD in Photovoltaics A. Knowledge and Understanding C. Practical skills B. Intellectual Skills D. Transferable/Key Skills																			
	A					**B**					**C**				**D**					
Module Title	**1**	**2**	**3**	**4**	**5**	**1**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**	**6**
Research Methods	*			*		*	*		*	*			*		*	*			*	*
Fundamentals of Photovoltaics	*	*	*	*	*	*	*	*				*		*		*	*	*		
Advanced Photovoltaics		*		*	*	*	*	*	*	*	*	*	*	*	*				*	*
Processes at Interfaces		*	*	*	*	*	*		*	*	*		*	*	*	*	*	*	*	
Advanced Materials Science	*	*	*	*	*	*	*	*			*			*			*		*	
Energy & Environment Economics and Policies		*	*	*	*	*	*		*	*	*		*	*	*	*		*	*	

	PGC in Photovoltaics A. Knowledge and Understanding C. Practical skills B. Intellectual Skills D. Transferable/Key Skills																
	A				**B**				**C**				**D**				
Module Title	**1**	**2**	**4**	**5**	**1**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
Research Methods	*		*		*	*		*			*		*	*			*
Fundamentals of Photovoltaics	*	*	*	*	*	*	*			*		*		*	*	*	
Advanced Photovoltaics		*	*	*	*	*	*	*	*	*	*	*	*				*
Processes at Interfaces		*	*	*	*	*		*	*		*	*	*	*	*	*	*
Advanced Materials Science	*	*	*	*	*	*	*		*			*			*		*
Energy & Environment Economics and Policies		*	*	*	*	*		*	*		*	*	*	*		*	*

Learning and teaching strategy used to enable outcomes to be achieved and demonstrated

The Department seeks to assist the student to become an independent learner whilst still supporting the students in their transition to postgraduate work. The curriculum is designed to encourage an appreciation for learning. Learning is enriched by appropriate underpinning, current research, industrial applications and the development of transferable skills.

The broad aim of the Department in its postgraduate teaching is to focus on depth of study, critical awareness and evaluation, in selected areas of current research and advanced scholarship within the academic discipline of Chemistry, Physics and Engineering; while at the same time ensuring a more general all round ability. In addressing these aims, the postgraduate programme in Photovoltaics includes teaching and learning material on the theory, design and implementation of Photovoltaics while at the same time focusing on particular specialist areas of research to provide relevant background and depth of understanding.

Photovoltaic science and engineering is amenable to a wide range of teaching methodologies and this programme will make full use of these to stimulate the students to learn and take initiative with their own development. The teaching strategy will be guided by the need for the students to be effective professionals to include safe working in potentially hazardous situations, confident and competent in a laboratory and leading others.

Lectures are utilised as the main delivery mechanism, typically supplemented by supervised problem solving practical lab sessions and group discussion. Wherever possible modules will include group and small-scale project work, with student-led seminars and presentations of the outcomes. The web platform Moodle will be used to support teaching by providing supporting information in addition to the lecture notes. Guidance will be provided on where to seek additional information and self-test quizzes will be used so the students can test their depth of understanding. The resources of the CSER research labs will be available for practical demonstrations to support the teaching material. There will be some shared delivery of modules that may require students to attend the Wrexham campus from time to time. This will be timetabled so that module delivery will be blocked together so there will be a

requirement for students to attend a number of days at one or other campus. The campus for module delivery will simply be determined by the lead on each of the modules and is expected to break down as follows:

Trimester 1

- Fundamentals of Photovoltaics
  Lectures - Wrexham, Practicals - St Asaph
- Energy and the Environment: Economics and Policies
  Lectures and Practicals - Wrexham
- Research Methods
  Lectures – Wrexham

Trimester 2

- Advanced Photovoltaics
  Lectures and Practicals – St Asaph
- Advanced Materials Science
  Lectures – St Asaph (or via video link), Practicals – St Asaph
- Processes at Interfaces
  Lectures and Practicals – St Asaph

Trimester 3

- Research Project – St Asaph

Students will be expected to travel between sites by their own means (public transport is available between St Asaph and Wrexham campuses). Once the course is validated and enough students start, this should provide a suitable business case to extend the existing free University bus service between the Wrexham and Northop campuses to St Asaph. Whether the students are working on the Wrexham or St Asaph campuses they will have access to a quiet study area, with internet access and refreshments will be available throughout the day.

Lectures: This is usually a formal discourse for the purpose of dissemination of information, the demonstration of techniques and the discussion of supporting ideas and consequences. The lecture is supported by a full range of equipment including, whiteboard, video and computer projection facilities where appropriate. Although this type of presentation is suitable for a one-sided discourse, ample opportunity exists for questions, interaction and discussion.

Seminar and Tutorials: These activities encompass a wide range of activities, each suited to the particular module. Some tutorials will consist of the staff supporting students engaged in problem solving. Alternatively a tutorial may involve group exercises where each group is encouraged to allocate responsibilities, tasks etc. Generally this type of teaching is used to support the lecture, clarify the material and experiment with the techniques and skills required.

Laboratory: The nature of the chemistry and physics elements of the programme requires students to gain practical skills in the use and safe handling of materials and analytical techniques/equipment. There are two specialist laboratories, and a project laboratory at St Asaph. Activities including demonstrations, practical sessions and problem solving activities take place in the laboratories and are supported by a staff member, practising skills in the use of sophisticated analytical techniques and essential safe laboratory practice. Students will begin practical session with a series of demonstrations (video demonstrations will be utilised

for PT delivery where practical sessions occur before lectures), followed by directed study as a series of self-taught laboratory challenges within the three specialisms with an element of contact time with staff during the laboratory sessions. Students are expected to develop a plan, conduct experimental and write individual laboratory reports.

Group Work: For some modules, students are encouraged to work in groups to achieve set objectives. Assessment of these activities includes both group and individual elements. In this way, students learn to work as a team to achieve a common goal whilst at the same time individual contribution is recognised.

Dissertation: The dissertation serves the primary purpose of integrating technological and research strands, and does so in a context of a piece of substantial research. Assessment of the dissertation will be crucial in determining whether Masters level learning outcomes have been achieved.

The dissertation typically involves the student applying their knowledge of science and engineering to the solution of an unfamiliar problem. The problem is original to the student and its solution therefore requires the innovative application of knowledge and techniques either studied in the previous taught stage or acquired through independent research of recent and relevant literature.

The dissertation provides a means for integrating specialist scientific and engineering knowledge with analytical, problem solving, managerial and communication skills. All of these are exercised and evidenced through the execution and outcomes of the research project, which includes: a project proposal, dissertation and literature survey, which forms part of the dissertation.

Accreditation of the programme by chemical, energy and solar professional institutions/bodies is a major aspect of the programme and will be applied for in due course. In anticipation of submitting for accreditation, the programme has been designed to meet the requirements for accreditation and this has involved the integration of the skills required into modules across the programme. The learning and teaching strategy adopts various methods as detailed above, and utilises problem-based learning and group project work which also supports this. Professionals from industry will provide guest lectures at various points throughout the programme to meet the requirements of chemical and solar professional institutions/bodies as defined in the QAA Chemistry Benchmark statement and also to ensure the relevance of the course content to the photovoltaic and scientific communities, thereby enhancing the student's future employability within these sectors.

Students will be encouraged wherever possible to undertake their research project in an industrial setting, but is not a formal requirement of the programme, rather an opportunity to enhance the student experience.

Examinations: Examinations will take place on the Wrexham campus and be conducted in line with University Regulations.

Welsh Medium Provision: In line with the University's Welsh Language Scheme, students will be offered the opportunity to receive assessments of all modules through the medium of Welsh if requested. The development of some online material and lecture notes in the Welsh language will be made available as part of the Welsh Energy Sector Training (WEST) project at CSER (St Asaph). The student handbook and an introduction to using Moodle 2.0 will be available in Welsh. In addition to the above a number of Staff within CSER are Welsh learners.

Assessment strategy used to enable outcomes to be achieved and demonstrated

The Assessment strategy for this programme provides a framework for the assessment of students' competence, knowledge and understanding, and a grading of students for progression and the conferring of awards. It allows staff to give feedback to students and to evaluate the effectiveness of their own teaching. This strategy will be closely adhered to in the delivery of the programme and is guided by the QAA Chemistry benchmark statement (2007) section 6 Teaching, learning and assessment, Credit and Qualification Framework for Wales (CQFW) and Glyndŵr University Regulations.

Students will receive formative assessment, particularly during the practical and self-study elements of the programme to ensure they can keep track of their progress and development. This will also be a key factor in ensuring student engagement and retention on the programme of study. In the case of practical assessment, this may be a final summative assessment, so more frequent formative assessment provides academic rigour and increases student awareness and confidence in the subject.

There will be emphasis placed on students to undertake independent study and research activities, in particular when completing the Dissertation/Photovoltaic Project element of the programme. The Dissertation will be facilitated by a traditional summative assessment approach at the culmination of the work; however, there will be extensive use of formative feedback, milestones, and guidance from staff during this and other independent study and research-based assessment undertaken by students. This is common practice for such modes of study and is in line with the approach taken by postgraduate programmes in other HE institutions.

Guiding Principles of Assessment

All assessments will be approved by the programme lead, Academic Head of Department and the external examiners in line with university regulations, to ensure that each assessment:

- Is reliable and unambiguous in what they require of students;
- Is valid, up to date and relevant;
- Meets the learning outcomes and enable markers to distinguish the level of performance achieved.

Grade related criteria will be used to assess the students' work, with feedback provided to facilitate individual and group development. All assessment will be internally and externally moderated in line with university regulations, to ensure that assessment is fair and consistent.

Module leaders will collate work and are responsible for presenting this at assessment boards, to enable ratification of results in line with the university's assessment regulations. External examiners will attend assessment boards and contribute to the process, to ensure external validity of assessment. Students will be informed of provisional results prior to an assessment board, and in writing following ratification of the results, with re-submission dates if needed.

Assessment will be made clear, and module leaders will provide assignment briefs in written (paper and electronic format) and/or audio format (which has proved extremely popular in recent years), with clear links to module learning outcomes. Assessment criteria/briefs will be discussed face to face and/or in electronic format through Moodle™ (virtual learning environment), to enable the student to clarify the nature of the assessment and raise any concerns/areas for clarification. Students will be given at least three weeks' notice of the date

of an in class test and scheduled during the normal teaching period for the module to comply with University Regulations.

As discussed in the Welsh Medium Provision section above any candidate following this programme may choose to submit examination scripts or assessed work in either Welsh or English providing notification is provided to the Superintendent of Examinations within two weeks of their commencement to study. Further details can be found in the University Regulations.

Assignment Feedback to Students

As a general principle, unconfirmed results will be given to students as soon as possible and normally within a maximum of 3 weeks from the date of submission, in line with the University Regulations. Feedback will be provided via a standardised pro-forma in line with Glyndŵr University Regulations.

External Examiners

External examiners play a key role in the University's quality assurance processes. The primary responsibilities are to confirm that the University's academic standards are comparable with the standards obtaining in UK higher education, to provide advice on areas for improvement, and to confirm that the processes for calculating awards have been carried out rigorously and that awards are conferred in accordance with regulations. Examiners' main interactions include the following regular responsibilities:

- Review of examination papers and marking criteria, and coursework assignments and project titles; also the assessment schemes for modules and programmes;
- Moderation of samples of students' work and reporting on the marking standards;
- Completion of an annual report which asks examiners to say whether the University's academic standards are comparable with those in other UK HE institutions, and whether the standards of student performance are comparable with the standards of students on similar programmes in other institutions.

In association with their prime role in confirming academic standards, external examiners may be asked to perform the following functions from time to time:

- Consult on changes to course assessment schemes through the course modifications process
- Consult on a module, programme or departmental development

Assessment Boards

The end-of-year assessment process for programmes within the University Modular System must be uniform across and co-ordinated between Departments. The University has therefore adopted a two-tier system of Module Boards followed by Award Boards for the assessment of all its programmes.

Pre Module Boards

These provide opportunity to consider any issues that may need to be raised for discussion with the external examiners at the module board and prepare any supporting arguments.

Module Boards

These meetings provide a confirmation of students' marks and provide an opportunity for discussion of issues arising in the Department and immediate actions to be taken at module level which the programme leaders/Academic Head of Department consider to be relevant to the issues of academic standards.

Pre Award/Progression Boards

These provide opportunity to consider any issues that may need to be raised for discussion with the external examiners at the award/progression board and prepare any supporting arguments.

Award/Progression Boards

Has the responsibility for conferring the University's Awards, as well as a development agenda. The purpose of the award board is to make decisions on progression and awards for all students registered for the MSc programme for which the Board is responsible. In reaching a decision on progression or an award, the Board must consider the overall performance of the student, which is made up of module marks which have been confirmed by the Module Board.

Extenuating Circumstances Panel

The panel is to ensure consistency of treatment of extenuating circumstances across programmes and departments. Assessment Boards do not discuss student claims to extenuating circumstances for non-attendance at examinations or non-submission of coursework. Decisions on these claims are taken and notified to students outside the Board meetings by the University Extenuating Circumstances Committee. The Awards Board receives reports on the decisions and ensures they are reflected in the marks confirmed. Further details of extenuating circumstances and appeals can be found in the University Regulations.

List of Assessments

Below is a summary of the assessments required for this programme and an assessment schedule is also included.

Fundamentals in Photovoltaics

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent
1	3,4	Course Work	50%	Throughout Module	Equivalent to 2000
2	1,2	Examination	50%	2 hours	

Energy and the Environment: Economics and Policies

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent if appropriate
1	1, 2, 3, 4	Detailed Group report and Group visual/verbal presentation	60%	20 min presentation	2.500 equivalent
2	1, 2, 3, 4	Individual reflective journal and design diary or logbook	40%		1,500 equivalent

Both assessments are due at the same time, refer to assessment schedule below.

Research Methods

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent if appropriate
1	1,3	Individual submission	40%	N/A	1700
2	All	Oral or poster Presentation	60%	20 minutes	2500

Advanced Photovoltaics

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent if appropriate
1	1,2,3	Course Work: Lab practicals and case studies	50%	Throughout Module	Equivalent to 2000
2	1,2,3	Examination	50%	2 hours	

Processes at Interfaces

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent if appropriate
1	1,5	Practical	50%	Throughout module	Equivalent 2000
2	1-4	Examination	50%	2 hours	

Advanced Material Science

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent if appropriate
1	1,2	Research essay	50%	N/A	Equivalent to 2000
2	2,3	Individual submission report	50%	N/A	Equivalent to 2000

Research Project

Assessment number	Learning Outcomes to be met	Assessment Type	Weighting	Duration (if exam)	Word count or equivalent if appropriate
1	1, 5	1000 word project proposal	20%	N/A	1000 words
2	2,3,4,6	Dissertation	80%	N/A	20,000 words for dissertation

Taught Modules Assessment Schedule – Chemistry: MSc in Photovoltaics

Full Time Delivery

		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Code	**Modules (2013)**	**Cr**																														
	Fundamentals of Photovoltaics	20	**i**										**a**			**e**																
ENG705	Energy & Environment: Economics and Policies	20	**i** **i**												**a** **a**																	
	Research Methods	20	**i** **i**					**a**							**a**																	
	Advanced Photovoltaics	20																**i**									**a**				**e**	
	Processes at Interfaces	20																**i**								**a**					**e**	
	Advanced Material Science	20																**i** **i**							**a**					**a**		

i - Assignment brief issued **a** - Assignment submitted/assessment point e - Formal examination

Taught Modules Assessment Schedule – Chemistry: MSc in Photovoltaics

Part Time Delivery Yr. 1

		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Code	**Modules (2013)**	**Cr**																														
	Fundamentals of Photovoltaics	20	**i**																	**a**											**e**	
ENG705	Energy & Environment: Economics and Policies	20	**i** **i**																											**a** **a**		
	Research Methods	20	**i** **i**												**a**														**a**			

i - Assignment brief issued **a** - Assignment submitted/assessment point e - Formal examination

Part Time Delivery Yr. 2

		Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Code	**Modules (2013)**	**Cr**																														
	Advanced Photovoltaics	20	**i**																								**a**				**e**	
	Processes at Interfaces	20	**i**																							**a**					**e**	
	Advanced Materials Science	20	**i** **i**												**a**															**a**		

i - Assignment brief issued **a** - Assignment submitted/assessment point e - Formal examination

Assessment regulations that apply to the programme

The Taught Masters Degrees regulations apply to this programme. No module is eligible for trailing into Part Two.

Programme Management

Programme Team

Academic Staff:

Prof Peter Williams	Head of Chemistry/ **Academic Programme Leader**
Prof Stuart Irvine	Research Professor In Opto-electronics Materials for Solar Energy/**Programme Leader**
Dr Vincent Barrioz	Senior Research Lecturer
David Sprake	Lecturer in Engineering
Dr Andrew Clayton	Research Associate
Dr Dan Lamb	Research Fellow
Dr Louise Jones	Research Fellow/ Centre Manager
Dr Ian Ratcliffe	Lecturer in Science
Dr Jixin Yang	Senior Lecturer in Chemistry/Analytical Chemistry
Dr Rachael Rowlands-Jones	Research Assistant

Support Staff:

Emma Dawson	Centre Administrator
Steve Jones	Senior Research Technician
Peter Siderfin	Research Technician

The Programme will be managed under the auspices of the Department of Chemistry and the programme will develop and operate within the terms of the overall management of curriculum with the Graduate School. The programme will be taught by a number of Chemists, Physicists, Engineers and Materials Scientists.

However, there will be a designated Programme Leader, for the MSc programme contained in this proposal, who will be responsible for the day-to-day running of the programme. Responsibilities and duties include the following:

- The management and development of curriculum and the course portfolio;
- Student tracking and student records;
- Collation of results and presentation of data at assessment boards;
- Management/co-ordination of overall assessment activities across the programme;
- Liaison with external bodies and agencies;
- Quality assurance and annual monitoring, including compilation of the Annual Monitoring Report;
- Co-ordination of admissions activities and other recruitment activities, including relevant publicity activities.

At module level there is devolved responsibility for the following:

- The maintenance and development of teaching and learning materials for all students enrolled on the module,
- The publishing and updating of module timetables, which shall include a weekly

schedule of module sessions and required reading, to be distributed to students at the start of all modules,
- The setting, marking and collation of marks for all module assessments and examination papers, including resit assessments, and submission of student results to the Programme Leader,
- Tutorial support for students taking the module which they are responsible for
- Quality monitoring, including processing of annual student feedback questionnaires and, where appropriate, student feedback for individual modules,
- Liaison with part-time members of staff involved in module teaching.

Research and Scholarship underpinning the curriculum:

The strategy of the University is to encourage all staff to engage with research and use it to underpin the taught curriculum. The team members undertake research and scholarship related to their teaching and module delivery. Glyndŵr University uses the term scholarship to refer to, encourage and value a wide range of activities and outcomes that include subject-based and pedagogic research, consultancy, community engagement and knowledge transfer. The links between research and scholarship and teaching have identified that actively engaging with research and scholarship will provide opportunities for staff and students, help developing links with industry, and help to keep courses 'fresh' and up to date. The program team feels that linkages between research and scholarship and teaching are essential in existing and new curriculum areas. The programme's curriculum is underpinned by Research and Scholarship activities within Chemistry and CSER.

Briefly, in the programme team all members are actively involved in research and scholarly activities in various disciplines.

The Programme Leader (S. Irvine)
- PV SUPERGEN – PV Materials and Devices for the 21st Century – this is a UK research consortium project funded by EPSRC on advanced materials for thin film PV devices
- SPARC (Solar Photovoltaic Academic Research Consortium) – this is a consortium project funded by the Low Carbon Research Institute (LCRI) for industrial research on materials novel PV modules and power electronics.
- Knowledge Transfer Centre (KTC) for thin film PV supply chain – this is funded by A4B and carries out a series of applied research projects working with industry.
- Collaborative Industrial Research Project (CIRP) on Sensors for PV manufacture – this is funded by A4B and is a consortium project working with 6 PV supply chain companies investigating innovations in the PV supply chain that can enhance the value of manufacturing.
- SPECIFIC – this is an EPSRC funded Integrated Knowledge Centre led by Swansea University to research functionalization of the building envelope with energy generation and storage.
- Sinter free inkjet printing of metal interconnects – this is an EPSRC funded project in collaboration with Liverpool University to investigate the use of CVD precursors in ink jet printing for low temperature writing of metal interconnects in PV module manufacture.
- Smart Operation of Low Carbon Regions (SOLCER) – LCRI funded project on looking at integration of renewable energy generation with energy demand and storage.

This is enhanced by extensive research into thin film PV materials and devices (A. Clayton and D. Lamb) and scale-up and manufacturing of thin film PV materials by (V. Barrioz). The

programme is also supported by staff with industrial experience in the scale up of dye-sensitised solar cells to industrial manufacturing and outdoor and accelerated testing of PV devices (R. Rowlands-Jones) and scholarly activity related to this course which reflects investigations into current developments and trends in reducing PV materials costs and challenges to large scale manufacture and Integration of PV technologies.

All programme team members are committed to maintaining and developing links with industry, which help keep courses 'fresh' and up to date. The programme team feels that linkages between research and scholarship and teaching are essential in existing and new curriculum areas.

A selection of recent research outputs, is listed below:

Refereed Journal articles

- S. D. Hodgson, W. S. M. Brooks, A. J. Clayton, G. Kartopu, D. A. Lamb, V. Barrioz, S. J. C. Irvine, "Increased conversion efficiency in CdTe photovoltaics by luminescent down shifting with quantum dot/ PMMA films" Progress in Photovoltaics (submitted)
- G. Kartopu, A. J. Clayton, W. S.M. Brooks, S. D. Hodgson, V. Barrioz, A. Maertens, D. A. Lamb, and S. J.C. Irvine, "Effect of window layer composition in Cd1-xZnxS/CdTe solar cells", Progress in Photovoltaics (accepted for publication)
- P. R. Chalker, P. A. Marshall, S. Romani, J. W. Roberts, S. J. C. Irvine, D. A. Lamb, A. J. Clayton, P. A. Williams, "Atomic layer deposition of Ga-doped ZnO transparent conducting oxide substrates for CdTe- based photovoltaics" J. Vac. Sci. Technol. A 31 (2013) 01A120
- S. D. Hodgson, W. S. M. Brooks, A. J. Clayton, G. Kartopu, V. Barrioz, S. J. C. Irvine, "Enhancing Blue Photoresponse in CdTe Photovoltaics by Luminescent Down-Shifting using Semiconductor Quantum Dots", Nano Energy 2 (2013), pp. 21-27
- R. E. Treharne, K. Hutchings, D. A. Lamb, S. J. C. Irvine, D. Lane, K. Durose, "Combinatorial optimisation of Al doped ZnO films for thin-film photovoltaics" J. Phys. D: Appl. Phys. 45 (2012) Article number 335102
- A. J. Clayton, S. J. C. Irvine, E. W. Jones, G. Kartopu, V. Barrioz, W. S. M. Brooks, "MOCVD of Cd(1-x)Zn(x)S/CdTe PV cells using an ultra-thin absorber layer", Sol. Energy Mater. Sol. Cells 101 (2012) 68-72
- D. A. Lamb, S. J. C. Irvine, "A temperature dependent crystal orientation transition of cadmium oxide films deposited by metal organic chemical vapour deposition", J. Crystal Growth 332 (2011) 17-20
- W. S. M. Brooks, S. J. C. Irvine, V. Barrioz, A. J. Clayton, "Laser Beam Induced Current Measurements of Cd1-XZnXS/ CdTe Solar Cells", Solar Energy Materials and Solar Cells 101 (2012) 184-189
- V. Barrioz, G. Kartopu, S.J.C. Irvine, S. Monir, X. Yang , "Material utilisation when depositing CdTe layers by inline AP-MOCVD", J. Crystal Growth 354 (2012) 81-85
- L. Danos, T. Parel, T. Markvart, V. Barrioz, W. S. M. Brooks, S. J. C. Irvine, "Increased efficiencies on CdTe solar cells via luminescence down-shifting with excitation energy transfer between dyes" Solar Energy Materials & Solar Cells 98 (2012) 486-490
- W. S. M. Brooks, S. J. C. Irvine, V. Barrioz, "High resolution laser beam induced current measurements on CdZnS/CdTe solar cells" Energy Procedia 10 (2011) 232-237
- S. J. C. Irvine, D. A. Lamb, V. Barrioz, A. J. Clayton, W. S. M. Brooks, S. Rugen-Hankey, G. Kartopu, "The role of transparent conducting oxides in metal organic chemical vapour deposition of CdTe/CdS photo voltaic solar cells", Thin solid films

520 (2011) 1167-1173

- A. J. Clayton, S. J. C. Irvine, “Interpretation of absolute laser reflectance during optical monitoring of polycrystalline GaAs deposition on quartz using MOCVD”, Journal of Electronic Materials 40 (2011) 1437
- A. J. Clayton, S. J. C. Irvine, V. Barrioz, W. S. M. Brooks, G. Zoppi, I. Forbes, K. D. Rogers, D. W. Lane, K. Hutchings, S. Roncallo, “Metal-organic chemical vapour deposition of ultra-thin photovoltaic devices using a pyrite based p-i-n structure”, Thin Solid Films 519 (2011) 7360-7363
- D. Lamb, S. J. C. Irvine, “Near infrared transparent conducting cadmium oxide deposited by MOCVD”, Thin Solid Films 518 (2009) 1222-1224
- Y. Y. Proskuryakov, K. Durose, M. K. Al Turkestani, I. Mora-Sero, Garcia- G . Belmonte, F. Fabregat-Santiago, J. Bisquert, V . Barrioz, D . Lamb, S. J. C. Irvine, E. W. Jones, Impedance spectroscopy of thin-film CdTe/CdS solar cells under varied illumination, Journal of Applied Physics, Volume: 106 Issue: 4 Article Number: 044507 (2009)
- Y.Y. Proskuryakov, K. Durose, J. D. Major, M. K. Al Turkestani, V. Barrioz, S. J. C. Irvine and E. W. Jones, “Doping levels, trap density of states and the performance of co-doped CdTe (As, Cl) photovoltaic devices”, Solar Energy Materials and Solar Cells (2009) Volume: 93 Issue: 9 Pages: 1572-1581 Sep 2009
- E. W. Jones, V. Barrioz, S. J. C. Irvine, D. Lamb, “Towards ultra-thin CdTe solar cells using MOCVD”, Thin Solid Films 517 (2009) 2226-2230
- J. E. Hails, S. J. C. Irvine, D. J. Cole-Hamilton, J. Giess, M. R. Houlton and A. Graham, “As doping in (Hg,Cd)Te: an alternative point of view”, J of Electronic Materials, 37 (2008) 1291-1302
- S. J. C. Irvine, V. Barrioz, D. Lamb, E. W. Jones and R. L. Rowlands-Jones, “MOCVD of thin film photovoltaic solar cells – Next generation production technology?”, J. Crystal Growth 310 (2008) 5198-5203
- R. L. Rowlands, S. J. C. Irvine, V. Barrioz, E. W. Jones and D. A. Lamb, “SIMS analysis of intentional in situ arsenic doping in CdS/CdTe solar cells”, J Semiconductor Science and Technology 23 (2008) 015017
- R. L. Rowlands, V. Barrioz, E. W. Jones, S. J. C. Irvine and D. A. Lamb, “The Application of a Statistical Methodology to Investigate Deposition Parameters in CdTe/CdS Solar Cells Grown by MOCVD”, J Materials Science: Materials in Electronics, 19 (2008) 639-645
- V. Barrioz, S. J. C. Irvine, E. W. Jones, R. L. Rowlands and D. A. Lamb, “In situ deposition of cadmium chloride films using MOCVD for CdTe solar cells”, Thin Solid Films, 515 (2007) 5808-5813
- A.J. Clayton and S. J. C. Irvine, “The kinetics of parasitic growth of GaAs MOVPE” J. Crystal Growth, 300(2007) 277
- Mora-Sero, J. Bisquert, F. Fabregat-Santiago, G. Garcia-Belmonte, G. Zoppi , K. Durose, Y. Proskuryakov, I. Oja, A. Belaidi, T. Dittrich, R. Tena-Zaera, A. Katty, C. Levy-Clement, V. Barrioz, S. J. C. Irvine, Implications of the negative capacitance observed at forward bias in nanocomposite and polycrystalline solar cells, NANO LETTERS 6 (4): 640-650 Apr (2006)
- G. Zoppi, K Durose, S. J. C. Irvine and V. Barrioz, “Grain and crystal texture properties of absorber layers in MOCVD-grown CdTe/CdS solar cells”, Semiconductor Science and Technology 21 (2006) 763
- D. A. Lamb and S. J. C. Irvine, “A study of the growth kinetics and properties of the pseudo-binary ZnO-SnO2 for use as a TCO in thin film photovoltaics” 20th European Photovoltaic Solar Energy Conference, Barcelona, Spain, (2005) 1804-1806
- S. J. C. Irvine, V. Barrioz, A. Stafford and K. Durose, “Materials Issues in very thin

film CdTe for photovoltaics" Thin Solid Films, 480-481 (2005) 76-81

- D. Lamb and S. J. C. Irvine, "Growth properties of thin film ZnO deposited by MOCVD with n-butyl alcohol as the oxygen precursor" Journal of Crystal Growth 273 (2004) 111-117
- D. M. Ellis and S. J. C. Irvine, "MOCVD of highly conductive CdO thin films" Journal of Materials Science: Materials in Electronics 15 (2004) 369-372

Particular support for learning

Students on the programme will receive the following forms of student support and guidance:

Admissions: All students on the programme will have the opportunity to discuss their application with staff, and receive appropriate advice and guidance prior to admission. This will include review of expectations of the programme and clarification of workload and requirements.

Student Handbook: All students on the programme will receive a Student Handbook which will contain details and guidance on all aspects of the programme and forms of student support and guidance, programme-based, Department-based and institutional.

Induction**:** New students on the programme will undergo an induction process which will provide them with a full introduction to the programme, and will include elements of work on study skills and professional development (St Asaph Campus).

The team sets out to ensure that the students are informed and understand the programme requirements and the processes in place, such as student handbooks and personal tutor roles. They will also be introduced to their personal tutors and module leaders, so that expectations can be discussed from both tutor and student perspectives. This includes information on the requirements for academic and practical work, for example, module timetables, teaching methods and assessment strategies/types and documents that need to be completed, risk assessments and COSHH. This will be held at the St Asaph campus. A separate induction to the University and the facilities at the main campus will be held at the Wrexham campus.

Progress Review and Attendance Monitoring: It is recognised that each student has different needs and will learn at a different pace. Self-directed time is built into the programme to facilitate individual learning needs, to allow students to work at the pace that suits them. Regular monitoring of coursework, particularly in the early stages, enables the team to identify and address any problems. The Programme Leader is typically the first person to be approached by a student experiencing difficulties If the problem cannot be resolved by the team, they may then be referred to the Academic Head of Department or to Student Services, as necessary.

Student attendance will be subject to regular monitoring through registers and in line with UKBA requirements, this will also be a means of addressing issues of student support. There will also be regular reviews for each student with personal tutors.

Students are expected to attend 3 days (FT) and 1 day (PT) per week during delivery of the programme, meaning that existing classrooms and office space will be utilised. Some content however, will be delivered through e-learning housed within the Virtual Learning Environment (Moodle™). A range of equipment is currently available to support the delivery of the current programme.

Virtual Learning Environment (VLE): Moodle™ enables the programme team to provide on-line support for teaching and learning by:

- Providing on-line teaching resources (e.g. lecture notes).
- Structuring on-line class activities (e.g. using discussion groups).
- Conducting on-line assessments (e.g. creating multiple choice tests).

Students enrolled on the programme will be from a wide geographical area and therefore need an effective communication system. Whilst emails are utilised within the programme, the 'Moodle' site will provide an additional efficient communication method and a valuable learning resource for the programme students in all cohorts. Providing a variety of learning resources facilitates maximum student potential by catering for individual learning styles. Moodle provides the following:

- Announcement facilities to ensure information such as revised calendars or adaptation to sessions are communicated throughout the programme or to specific cohorts.

- All module hand-out materials are available prior to/ following each session. This enables students who learn more effectively by prior reading to access relevant materials wherever possible.

- Student's group work is placed onto the site to enable shared learning.

- Discussion sites are used to explore particular topics, contributing towards collaborative learning.

Monitoring and Feedback: The University has procedures in place for the regular review of its educational provision, including the annual review of both modules and programmes which draw on feedback from such sources as external examiners' reports, student evaluation, student achievement and progression data. In addition, programmes are reviewed every five years through a programme periodic review that includes external and student input.

Feedback from students plays a critical part in informing the Department's strategic thinking. It also allows the Department to evaluate how its service provision is viewed by its most important group of stakeholders, its students. Students can provide formal feedback on their individual programme of study in a number of ways:

- Staff-Student Consultative Committee: Student representatives, who are elected by the students, meet lecturing staff on the programme once a semester to exchange ideas about the programme. This allows students to communicate their shared concerns in an informal manner, and for the staff to react and respond speedily to address their concerns. SSCCs, chaired by a member of academic staff from outside the programme, will be held at least once per semester. The Chair will minute student feedback for action/response by the Programme Leader. Minutes of the SSCCs and the response from the Programme Leader will be posted on the programme pages of Moodle.

- SEMs (Student Evaluation of Module): Module Leaders will distribute SEMs at the end of each module. A summary of the analysis of the SEMs, along with any other feedback, will be passed to the Programme Leader for action/response.

Additional support for International Students:

The Photovoltaics MSc scheme is expected to attract students from the UK and internationally from Europe and Worldwide. The team understands that these students are a

long way from home – often for the first time – and are encountering a quite different culture. The team is well experienced in supporting students and visiting academics from around the globe and has found little difficulty in this respect. The personal tutors will be vital to ensuring that students' individual needs are met.

There is a network of support available at many different levels within the University and these combine to provide a supportive framework for the international students. Specifically, this includes three main activities:

- Language provision designed to ensure that the international students have achieved a minimum level of language skills before they embark on their chosen degree programme. This is a six-week pre-sessional intensive English Language for Academic Study course that aims to bring students to an IELTS (International English Language Testing System) level of 6.5 – the standard demanded for entry into the Masters Degree programmes.
- Glyndŵr University offers English language classes alongside studies that improve not only spoken and written English but also academic English. Classes take place weekly and are delivered by the University's English language tutors to also help students to integrate into the life of the local community as well as helping them develop transferable skills such as practical, research and report-writing skills.
- An induction/orientation course that precedes the start of formal teaching and that allows the international students to become familiar with the University and studying at the University whilst at the same time outlining some of the cultural differences that exist between their country of origin and the UK (Wrexham Campus).

Support within the programme team**:**

Personal Tutorial Support: The personal tutor is vitally important in providing support, and the programme team work hard to support students. Each student is allocated a personal tutor at the beginning of the programme, has timetabled sessions to engage in this process, and will be supported in academic context

The personal tutor is someone students can contact to discuss any problems. These may relate to special needs or personal problems that may affect the student's academic performance.

Programme-specific learning resources:

The Solar wall at the St Asaph campus and CSER will be utilised to support student learning and provide opportunity for hands-on experience of a large scale building integrated PV system and the data from the wall will be utilised for case studies and practical sessions.

The Student room at Glyndŵr University (St Asaph) has a small subject specific library, hot-desks and break out area to enhance the student experience and provide an effective environment for small group and individual working. This room has network points, Wi-Fi, desks and printer and also has computer resources available to allow students to access the Virtual Learning Environment (VLE).

Students also have access to the purpose built library and computer resource within Glyndŵr University (Wrexham), and are informed of the services available to them. The library and computing facilities provide the books, journals, electronic resources and up-to-date computing facilities that will support students' study and research. Students have access to a high speed computer network supplying a wide range of information resources and applications software, and students are increasingly being encouraged to access these

resources.

The University provides a wide range of software including word processing; spread sheet, database and presentation packages. Students are also able to attend workshops and seminars enabling them to make effective use of the resources available. Students are given a username and password to use the networked computers in the University. This allows for easy access to the internet and electronic mail as well as electronic information resources.

Equality and Diversity

Education should be part of a process to bring self-fulfilment to the individual, and teaching staff strive to uphold this by treating their students with respect, valuing their life experience and contributions in the classroom. This is further reinforced by the programme team making efforts to create a learning environment where students feel safe to ask questions and take part without fear of being embarrassed and where relationships with staff are collegial and friendly. Tutors believe that their role is that of facilitator of learning rather than just a transmitter of knowledge which the student receives passively.

Equality and Diversity are considered to be extremely important by the programme team and a number of measures have been put in place in many aspects of the programme to reflect this. The Admissions Policy at Department level clearly indicates how equality and diversity are integrated into the recruitment, selection and admission of students to the programme.

Programme information will be readily available through recruitment events and on the Glyndŵr University website and prospective students are given the opportunity to discuss individual needs during the interview phase of selection, as well as with the personal tutor once commenced on the programme. Reasonable adjustments will be made as far as possible, and advice will be provided in line with individual requests and needs. Modules have also been designed to create a variety of learning materials to enable all students to engage with the programme requirements, with the aim of enhancing inclusion and accessibility.

Individual needs will also be catered for in relation to completing the programme, with the support of the non-academic Student Support Services (Wrexham campus) sought as necessary. Resources and supportive mechanisms will be put in place as far as reasonably possible to allow the individual to engage with and complete the programme requirements on an equal footing with their peers.

APPENDIX A

MSc/PGD/PGC in Photovoltaics
Glyndŵr University Certificates of Continuing Education

- Fundamentals of Photovoltaics
- Advanced Photovoltaics
- Processes at Interfaces
- Advanced Materials Science
- Energy and the Environment: Economics and Policies
- Research Methods