

# 'EXTATIC' – Extreme-ultraviolet & X-ray Technology And Training for Interdisciplinary Cooperation

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<http://www.extatic.eu>

## EMJD Objective:

”to foster cooperation between higher education institutions and academic staff in Europe and Third Countries with a view to creating poles of excellence and providing highly trained human resources”

***Academic Partners include:***

- Dublin City University (Coordinator)
- University College Dublin
- King's College London
- The University of Southampton
- Czech Technical University-Prague
- The University of Padua
- The Military University of Warsaw
- RWTH-Aachen University

***Current associated academic partners include:***

- Colorado State University (USA)
- Purdue University (USA)
- Tongji University (China)

***Current associated industry/ private laboratory partners include:***

- Silson (UK)
- Prevac (Poland)
- *XENOCS (France)*
- EPPRA (France)
- Rigaku Innovative Tech. (Prague)
- Bruker (Germany)
- Fraunhofer-ILT (Germany)
- *XFEL GmbH (Germany)*

## EXTATIC structure

Foundation module (5 cr)

2 domain specific modules (2x5 cr)

2 generic/transferable skills modules (2x5 cr)

Special topics module (5 cr)

Research: doctoral study plan, at least 2 institutions  
(home+host), Ph.D. thesis

- Help students attain a thorough grounding in X-Ray Science and Technology
- Build a community of researchers and research students at the forefront of X-Ray S&T
- Welcome Week within first month of Ph.D.:
  - Establish face-to-face contact and build personal relationships
  - Cover fundamentals to enable students to communicate meaningfully/in-depth with each other about their projects

- Lectures delivered during Welcome Week at rotating partner site
- 2012: 4 lectures by David Attwood, plus 8 lectures by partner institutions, plus student presentations on plans for Year 1
- Made available on YouTube channel for students unable to attend, and as a permanent resource

Students choose 2 modules from:

EUV and X-Ray Sources

Radiobiology

EUV Optics

Ultrafast Lasers & X-Ray Generation

Nanostructures and Ablation

EUV and X-Ray Metrology

EUV and X-Ray Photoionisation

- Delivery asynchronous, on-line
- Examination “Continuous Assessment”, *i.e.*, no terminal exam
- Various modes of delivery:
  - Video lectures/screencasts/podcasts
  - Reading assignments
  - Chat forums
  - ...



- Varies from (home) university to university
- Example from DCU:
  - Intellectual Property & Commercialisation
  - Research Ethics
  - English for Academic Purposes (0 credit)
  - Advanced Qualitative Methods
  - Advanced Quantitative Research Methods
  - Principles of Research Methodology
  - Personal and Professional planning and development for full time scholars
  - Postgraduate Tutor/Demonstrator Course

- Varies from (home) university to university
- Sample activities:
  - Report on seminars/workshops relevant to EXTATIC
  - Documented in publicly accessible blog

- Living document
- First version agreed during Welcome Week:
  - By all supervisors & student
  - Covers at least first year plus timetable for exchange (at least 6 months in host institution)
- Expect the unexpected – nothing set in stone
- Changes proposed to Academic Committee
  - Default position: agreed if student and supervisors are unanimously in favour and no EMJD rules are breached

<b>Student:</b>	<b>Daniel Adjei (Ghana)</b>
Supervisor 1 (home):	Alan Michette (KCL)
Supervisor 2 (host):	Henryk Fiedorowicz (MUT)

- Laboratory scale X-ray sources used to investigate the effects of ionizing radiation on biological cells
  - Microfocus source up to 15 keV (KCL)
  - Gas puff target irradiated with ns laser pulses in water window (MUT)
  - K-alpha X-ray source based on a solid/cluster target irradiated with fs laser pulses (MUT)

<b>Student:</b>	<b>Inam Ul Ahad (Pakistan)</b>
Supervisor 1 (home):	Henryk Fiedorowicz (MUT)
Supervisor 2 (host):	Alan Michette (KCL)

- X-ray and EUV microscopy based on Fresnel optics using a compact laser plasma light source with a laser irradiated gas puff target
  - No debris
  - Nanoscale imaging in EUV and water windows
  - Applications: nanoimaging of biological objects, investigation of magnetism, actinic EUV mask inspection

<b>Student:</b>	<b>Mewael Sertsu (Ethiopia)</b>
Supervisor 1 (home):	Piergiorgio Nicolosi (UoP)
Supervisor 2 (host):	Gerry O'Sullivan (UCD)

- Characterisation and design of multilayer EUV optics
  - measurements of the optical constants of materials in the EUV when deposited in ultra thin layers
  - multilayer characterization through different techniques such as XRR, XRD, TEM, XPS, AFM, EUV reflectometry
  - Some measurements at LSFs

<b>Student:</b>	<b>Hyun-su Kim (South Korea)</b>
Supervisor 1 (home):	Larissa Juschkin (RWTH)
Supervisor 2 (host):	Bill Brocklesby (UoS)

- High density structures required for features less than 10 nm prepared using EUV-IL
  - Study of interference patterns with sub-30 nm resolution and sufficient contrast
  - Numerical and analytical calculation, design of required diffractive elements, quantum coherence effects, exposure experiments, resist studies, characterisation of resulting nanostructures

<b>Student:</b>	<b>Girum Beyene (Ethiopia)</b>
Supervisor 1 (home):	Gerry O'Sullivan (UCD)
Supervisor 2 (host):	Larissa Juschkin (RWTH)

- Very high temperature plasmas are generated by high power lasers focussed on lightening sparks across electrode vacuum gap
  - Intense incoherent soft x-ray and EUV radiation.
  - Used at the cutting edge of nano-patterning, nano-imaging and element-sensitive diagnostics on nm scale (nanoelectronics, nanobiotechnology)



<b>Student:</b>	<b>Fahad Nawaz (Pakistan)</b>
Supervisor 1 (home):	Jiří Limpouch (CTU)
Supervisor 2 (host):	Alan Michette (KCL)

- A study of XUV emission from a capillary discharge.
  - Temporal, spectral and imaging diagnostics will be used for capillary discharge characterization.
  - Experimental research will be supported by theoretical studies.

<b>Student:</b>	<b>Aaron Bogmis (Cameroon)</b>
Supervisor 1 (home):	Lampros Nikolopoulos (DCU)
Supervisor 2 (host):	Bill Brocklesby (UoS)

- Study of chaotic very intense (GW peak power) EUV and X-ray FEL pulses when resonant processes are present
  - A stochastic Monte-Carlo approach
  - Ab-initio theory can't handle all electrons at 1 time
  - Rigorous approximate method to be developed and deployed
  - Comparison with experimental data

- Over 5 years, the EXTATIC program will fund over 40 students
  - Large community of X-Ray scientists
  - Program also open to self-funded students
  
- 2013 call now open, until 14<sup>th</sup> December 2012

1. Samantha Fahy – NCPST, DCU
2. Anne-Louise Holloway – NCPST, DCU
3. John Costello – Dean of FSH, DCU
4. Anne Scott – Deputy President/Registrar, DCU
5. Gerry O’Sullivan – UCD
6. Alan Michette - KCL