Institution: The University of Manchester

Unit of Assessment: UoA9

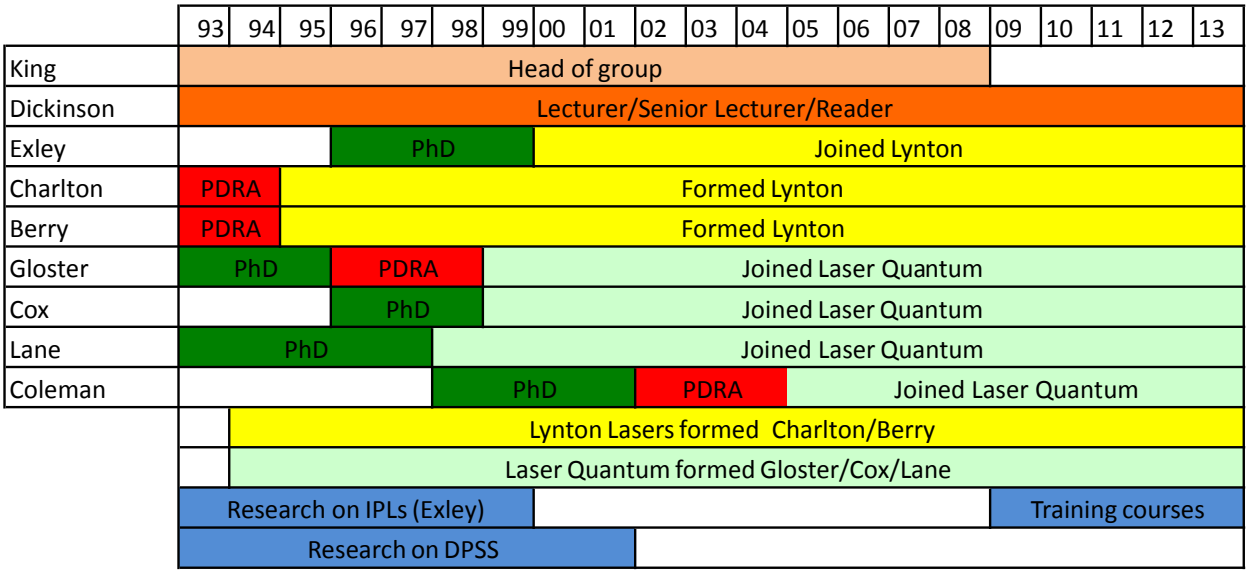
Title of case study: Transfer of laser research and development to spin-out companies, Lynton Lasers Ltd and Laser Quantum Ltd.

1. Summary of the impact (indicative maximum 100 words)

Research in the laser photonics area has led to the formation and continuing development of two spin-out companies, Lynton Lasers Ltd and Laser Quantum Ltd, with annual turnover of £5.3m and >£12m respectively, and direct economic impact of [text removed for publication] over the REF period. Laser Quantum Ltd manufacture and market OEM diode pumped solid state lasers and Ti:sapphire lasers, which are incorporated in the products of major international companies in the scientific and entertainment sectors. Lynton Lasers Ltd manufacture and market medical devices for the cosmetic and aesthetic surgery market. Their products and services have underpinned the business of [text removed for publication] over the REF period. With an average cost of between [text removed for publication] over the REF period.

2. Underpinning research (indicative maximum 500 words)

The impact is based directly on research that took place in Manchester from 1993 to the present day with publications throughout this period. The key researchers were: Professor Terry King, Dr Mark Dickinson, Dr Jon Exley, Dr Andrew Charlton, Dr Andrew Berry, Dr Lawrie Gloster, Dr Alan Cox, Dr Steve Lane and Dr Dan Coleman. A timeline showing their involvement with the research and subsequent spin-out companies is shown below.



There are two main areas of research involved with this case.

The first is in the field of Laser Photomedicine where the researchers were looking into ways of using light to treat vascular lesions and other skin conditions. The main research findings were:

1. That a filtered flashlamp (now known as an Intense Pulsed Lightsource (IPL)) was successful in treating a range of skin lesions [1];
2. That by varying the pulse length of the flashlamp, different types of lesions at varying depths within the tissue could be targeted [1];
3. That by pre-cooling the tissue with a cryogen spray, deep lesions could be treated without causing damage to the surface tissue [2].

Since this initial work, the group in Manchester has worked on a range of other sources, including fibre lasers [6], and has also used these for tissue interaction studies, which has informed the development of new laser devices by Lynton Lasers Ltd (used for hair and tattoo removal).

The second area is in the field of compact, efficient, diode-pumped laser sources. This resulted in techniques for spectrally matching sources with pump bands to improve efficiency and power output in Diode-Pumped Solid State (DPSS) lasers. The main research findings were:

4. That Yb doped S-FAP (strontium flourapatite, $Sr_5(PO_4)_3F$) could be efficiently pumped by diode lasers [3];

5. That Yb doped S-FAP was an efficient 1-µm source that could be Q-switched easily [4].
6. That high efficiency lasers can be made using Er and Pr doped glasses [5];
7. That a Tm laser can be efficiently pumped by an Yb silica laser [6].

3. References to the research (indicative maximum of six references)

The research was published in leading journals and presented at international conferences. The SPIE series of conferences is recognised as one the world leading conferences for topical research in Optical Engineering. Optics Communications has an impact factor of around 1.5, and papers [3], [4], [5] and [6] have 22, 17, 16 and 32 citations respectively (source: Web of Science). The starred (*) papers best illustrate the quality of the research.

Publications:

[1] J. Exley, M. R. Dickinson, T. A. King, A. J. Berry, and S. Jamieson, "The development of a broad band light source with variable pulse length and energy for the treatment of vascular lesions," *Lasers in Surgery: Advanced Characterization, Therapeutics, and Systems VII, Proceedings of the SPIE - The International Society for Optical Engineering,* vol. 2970, pp. 327-334, 1997.

[2] J. Exley, M. R. Dickinson, T. A. King, A. Charlton, S. Falder, and J. Kenealy, "Comparison of cooling criteria with a cryogen spray and water air spray," *Laser Tissue Interaction X: Photochemical, Photothermal, and Photomechanical, Proceedings of the SPIE - The International Society for Optical Engineering,* vol. 3601, pp. 130-140, 1999.

[3] *M. R. Dickinson, L. A. W. Gloster, N. W. Hopps, and T. A. King, "Continuous-wave diode-pumped Yb^{3+}:S-FAP laser," *Optics Communications,* vol. 132, pp. 275-278, 1996. **DOI:** 10.1016/0030-4018(96)00367-7.

[4] *L. A. W. Gloster, P. Cormont, A. M. Cox, T. A. King, and B. H. T. Chai, "Diode-pumped Q-switched Yb:S-FAP laser", *Optics Communications*, 146(1-6), pp. 177–180, 1998. **DOI:** 10.1016/S0030-4018(97)00543-9.

[5] D. J. Coleman, P. Golding, T. A. King, S. Jackson, "Spectroscopic and energy-transfer parameters for Er^{3+}-doped and Er^{3+}, Pr^{3+}-codoped GeGaS glasses", JOSA B, 19(9), pp. 1982-1989, 2002. **DOI:** 10.1364/JOSAB.19.001982.

[6] *Y. H. Tsang, D. J. Coleman, T. A. King, "High power 1.9 µm Tm^{3+}-silica fibre laser pumped at 1.09 µm by a Yb^{3+}-silica fibre laser", *Optics Communications*, 231, pp. 357-364, 2004. **DOI:** 10.1016:j.optcom.2003.11.072.

4. Details of the impact (indicative maximum 750 words)

Lynton Lasers Ltd and Laser Quantum Ltd are both spin-out companies from the University of Manchester and were formed in each case by former members of the School of Physics and Astronomy.

LYNTON LASERS

Lynton Lasers Ltd (formed in 1994) has a core business in aesthetic and cosmetic surgery using light, that builds directly on the research at Manchester. They currently manufacture and market sources for applications such as tattoo and hair removal, and for the treatment of vascular lesions. They operate a clinic in Manchester and also provide regular training courses for users of their treatment systems. Staff from the photon physics area at the University of Manchester teach on these courses, maintaining regular updates of current research into the market place (such as a better understanding of laser tissue interactions accrued from using new sources such as fibre lasers[5][6]). The core of the company business is underpinned by the study and application of light/tissue interactions and uses intense pulsed light (IPL) systems, one of their main product lines. Lynton Lasers Ltd now employs [text removed for publication]. The direct economic impact over the REF period is around [text removed for publication] but there is also a secondary impact in that their products and services have helped improve the quality of life of up to [text removed for publication] clients/patients since 2008 and over [text removed for publication] people have been trained in the use of the systems (with Dickinson and Binks contributing to the training courses since 2008). With around [text removed for publication] systems in the field, and 2 treatments per week, there would have been over [text removed for publication] treatments over the REF period, and at between [text removed for publication] per treatment that amounts to a monetary value of up

to [text removed for publication]. Lynton Lasers now has a market share of around [text removed for publication] for IPL sources. Without the background research in Manchester on IPLs, this product range would not exist [text removed for publication].
Lynton Lasers keeps records of testimonials from users of their products, but one example sums the service up with: *'Lynton Lasers provide the highest standards of customer care, backed by years of research, design technology and on-going clinical studies. ……. My Lynton system has enabled me to deliver 100% satisfaction and results to my patients for vascular lesions / red veins, sun damage and excess hair removal. The client word-of-mouth recommendation has increased my business turnover by another 55%.'*
There are many companies and organisations that can corroborate the impact that Lynton Laser's products and services have had for them – contacts details for three that have provided corroboration are listed in Section 5 below [text removed for publication].

LASER QUANTUM
Laser Quantum Ltd spun-out of Manchester University in 1994 and [text removed for publication]. Manufacturing DPSS lasers in the UK, Laser Quantum delivers over [text removed for publication] lasers a year to over 30 countries covering 13 product ranges from UV through to infrared. The monetary impact of the research is around [text removed for publication] over the REF period.
Laser Quantum now has a subsidiary in the US, Laser Quantum Inc, and a service centre in Japan as well as distributors and representatives worldwide. The research carried out in Manchester on optical coupling and spectral matching of pump emission to gain material absorption bands has been instrumental in the design and production of their current product range [text removed for publication].
Laser Quantum's clients range from academic institutes through to multi-national OEM companies and include major defence companies both in the UK and around the world, several measurement instrumentation manufacturers as well as medical diagnostics and instrumentation. They are also amongst the world's largest pump-source suppliers for Ti:sapphire and dye lasers.
[text removed for publication]

5. Sources to corroborate the impact (indicative maximum of 10 references)

Letters supporting the statements made have been supplied by:
[text removed for publication]