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Preface

If the official opening of the Centre for Micro-Photonics (CMP) in October 2000 was the first milestone in the development of the Centre, I am pleased to report that we have successfully achieved the second milestone by the end of 2001, namely, all CMP laboratories have been equipped with the state-of-the-art lasers and photonic devices. This has created a solid and innovative foundation for the Centre to conduct cutting edge research projects in two challenging areas, nano-photonics and bio-photonics.

A number of new external research grants were awarded to the CMP in 2001. The Federal Government awarded a Systematic Infrastructure Initiative Grant (A$1.94 m) to Swinburne for establishing an Integrated Micro-Fabrication Facility as part of Backing Australia’s Ability: an Innovation Action Plan for the Future. In addition, the CMP won an Australia-USA Exchange Program from the Australian Academy of Science to carry out an international collaborative project on biomedical optics with Massachusetts Institute of Technology. Another Australian Research Council (ARC) grant, an ARC Discovery Project Grant, was awarded to the Centre in 2001. Including the other six ARC grants, the CMP has attracted a total ARC fund of A$1.6 m for 2000-2004.

As a key step in the photonics development at Swinburne, an undergraduate photonics course, in which the CMP is one of the core organisers, was approved by the University in 2001. The course is supported by the Federal Government as part of Backing Australia’s Ability: an Innovation Action Plan for the Future. In 2001, Mr. Daniel Day completed his PhD thesis. With excellent reviewers’ reports, he was awarded the PhD degree in June 2001 and became the first PhD graduate from the Centre. Mr. Mujahid Ashraf joined the CMP as an MSc student in 2001. Two undergraduate students, Mr. Ben Smith and Mr. Tom Rodgers, completed their R&D projects in the area of optical data storage and micro-fabrication. Mr. Sven Woldberg, an undergraduate student from Twente University, The Netherlands, completed a three-month training project in laser trapping. Mr. Wataru Inami, a PhD student from Shizuoka University, Japan, spent three months in the Centre for a collaborative project in particle-trapped near-field microscopy.

The main research achievements of the Centre in 2001 can be summarised as follows:

- Establishment of a new Monte Carlo simulation model for complex tissue structures.
- Development of a compact two-photon fluorescence microscope for endoscopic applications.
- Development of a new mechanism for generating micro-cavities in polymers.
- Development of a new recording and reading mechanism based on the polarisation sensitivity in polymer dispersed liquid crystal materials.
- Discovery of the polarisation dependence of morphology-dependent resonance in a micro-cavity under two-photon excitation.
- Establishment of a new theory for near-field Mie scattering.
- Development of an innovative liquid crystal cell for generating a doughnut beam.
- Development of scanning total internal reflection fluorescence microscopy.

The research output of the Centre in 2001 was impressive and comprehensive.
The first spin-off company of the Centre, 3DCD Technology Pty. Ltd., was established and funded by the Federal Government COMET grant for commercialisation of the 3-D optical data storage technology.

Two new provisional patent applications regarding optical storage and early cancer detection were lodged.

A contract was signed with the prestigious scientific book publisher, Springer Verlag, in Germany, to publish our new book entitled “Microscopic Imaging through Tissue-like Turbid Media: Monte-Carlo Modelling and Applications” in Springer’s book series of Biophysical Sciences.

The total number of publications from the CMP in 2001 was 34 (one book chapter; five internationally refereed journal papers, 3 proceedings papers; 22 conference abstracts, and three articles). Five public seminar presentations and six invited presentations at international conferences were given by the CMP staff members.

In 2001, the CMP was actively involved in a number of international exchange and collaboration activities:

- Our collaboration with Professor Satoshi Kawata at Osaka University was fruitful. A formal exchange and collaboration agreement between Swinburne University and Osaka University was signed in August. Two joint workshops between the two universities were held in Melbourne. The first one was the first Joint ARC and JSPS Workshop on Micro-photonics in March and the second one was the Joint Workshop on Nano-photonics in November.
- Professor PC Cheng from the State University New York at Buffalo, USA, successfully completed his sabbatical research within the Centre. As a result, a contract for a new joint book entitled “Biological Optical Microscopy” was signed with Springer Verlag.
- Supported by the Vice-Chancellor’s Scholarship, Mr. Djenan Ganic, a PhD student from the Centre, conducted a collaborative project in Professor Theo Tschudi’s Institute at the Technische Universität Darmstadt, Germany. A provisional patent application based on Mr. Ganic's work was lodged in Germany.
- Mr. Sven Woldberg, an undergraduate student from Twente University, The Netherlands, completed a three-month training project in laser trapping.
- Mr. Wataru Inami, a PhD student from Shizuoka University, Japan, spent three months in the Centre for a collaborative project in particle-trapped microscopy.

Thanks to the excellent performance of the CMP staff and students, I could continue to spend some time on international activities in 2001:

- I was involved in the HE Division’s China exchange and collaboration strategic program including Huazhong University of Science and Technology, Shanghai Jiaotong University and Tsinghua University.
- I was appointed to a Guest Professorship by Shanghai Jiaotong University and Huazhong University of Science and Technology in June and December, respectively. I was invited to give a series of lectures in Tsinghua University in May.
- I served on the organising/advisory committees of six international conferences.
- I continued to serve on the Regional Council of the International Society of Optics within Life Science and the Editorial Advisory Board of Optics Communications and Journal of Scanning.
I gave five public seminar presentations and three invited presentations on the international conferences.

It is evident that the CMP has grown successfully towards its mission and goal. I would like to thank all the CMP members for their valuable and important contributions to the Centre as well as to the successful organisation of the MDM2001 Conference. Finally, I would like to thank Professor Iain Wallace (VC), Professor Dale Murphy (DVC), Professor Kerry Pratt (PVC), the Chancellery Office and many other offices at Swinburne, for their continuing support.

Professor Min Gu
Chair of Optoelectronics
Melbourne
Feb 2002
Mission Statement

- To become an internationally leading centre in the area of micro-photonics.
- To create a world-class laboratory for training research students.

Goal

- To develop novel optoelectronic imaging methods for biological studies and industrial applications.
- To understand working principles of optoelectronic instruments in biological and industrial applications.
- To understand mechanisms for light interaction with biological materials.

Structure of the Centre

In 2001, the Centre for Micro-Photonics (CMP) included two academic staff members, four postdoctoral research fellows, one project officer, one administrative officer/PA, one senior technical officer, four PhD students, one MAppSc student, two undergraduate students, two visiting students and one visiting Professor. The CMP is divided into three research groups: biophotonics, photonic optical data storage and devices, and nano-photonics.
Staff Members and Students

Director: Professor Min Gu (Chair of Optoelectronics)
Administrative Officer/PA: Ms. Anna Buzescu
Senior Technical Officer: Mr. Mark Kivinen.

Biophotonics Group

- Professor Min Gu (Leader)
- Dr. Xiaosong Gan (Co-leader, ARC Fellow)
- Dr. Xiaoyuan Deng (Postdoctoral fellow)
- Dr. Ross Ashman (Postdoctoral fellow)
- Mr. Damian Bird (3rd year PhD student: Fibre optic two-photon fluorescence microscopy)
- Professor P. C. Cheng (visiting Professor from State University of New York, till March 2001).

Photonic Data Storage and Devices Group

- Professor Min Gu (Leader)
- Dr. Martin Straub (Postdoctoral fellow)
- Mr. Daniel Day (3rd year PhD student till March 2001 and Project Officer from March 2001)
- Mr. Dennis McPhail (2nd year PhD student: Optical Storage and micro-fabrication in polymer dispersed liquid crystal materials)
- Mr. M. Ashraf (MAppSc student: Fabrication of a liquid crystal lens with a tunable focal length)
- Mr. Ben Smith (R & D undergraduate student)
- Mr. Tom Rodgers (R & D undergraduate student)

Nano-Photonics Group

- Dr. Xiaosong Gan (Leader, ARC Fellow)
- Professor Min Gu (Co-leader)
- Mr. Djenan Ganic (2nd year PhD student: Near field Mie scattering for nanometry)
- Mr. Dru Morrish (2nd year PhD student: Morphology-dependent resonance in a micro-cavity under two photon excitation)
- Mr. Sven Woldberg (visiting student from Twente University, The Netherlands, August-November, 2001)
- Mr. Wataru Inami (visiting PhD student from Shizuoka University, Japan, September – December, 2001)

External collaborators with joint projects:

- Professor Ping Chin Cheng (State University of New York at Buffalo, USA)
- Professor Satoshi Kawata (Osaka University, Japan)
- Professor G. Kino (Stanford University, USA)
- Professor Yuri Kivshar (Australian National University, Australia)
- Associate Professor Paul Mulvaney (University of Melbourne, Australia)
- Dr. Sarah Russell (Peter MacCallum Cancer Institute, Australia)
Grants

1. ARC Large Grant (Min Gu): 1999 – 2001
   *Image reconstruction through tissue like turbid media*

2. ARC Large Grant (Min Gu): 2000 – 2001
   *Development of a compact super-resolving imaging system for 3D high density data storage*

3. ARC Large Grant (Min Gu): 2001-2003
   *Near field microscopy with an active lasing particle*

4. ARC IREX (Japan, Min Gu): 2000 – 2002
   *Near field optical microscopy with laser trapping*

5. ARC Fellowship (Xiaosong Gan): 1999–2003
   *Imaging through tissue*

   *Ultrafast microspectroscopy and imaging facility*

   *Three-dimensional image restoration in biological tissue*

Collaborations

*International*

- Darmstadt Technical University, Germany
- Hokkaido University, Japan
- Huazhong University of Science and Technology, China
- Max-Planck Institute for Biophysical Chemistry, Germany
- National Sun Yat-Sen University, Taiwan
- National Taiwan University, Taiwan
- Osaka University, Japan
- Oxford University, UK
- Shanghai Institute of Optics and Fine Mechanics, China
- Shanghai Jiao Tong University, China
- Shizuoka University, Japan
- Spectra-Physics Inc., USA
- State University of New York at Buffalo, USA
- Stanford University, USA
- Tsinghua University, China
• University “Politehnica” of Bucharest, Romania

**Domestic**

• Australian National University, Australia
• LasTek Pty Ltd, Australia
• Olympus Pty Ltd, Australia
• Peter MacCallum Cancer Institute, Australia
• St. Vincent’s Institute of Medical Research, Australia
• University of Melbourne, Australia
• University of Sydney, Australia
• Victoria University, Australia
• 3-D CD Technology Pty. Ltd., Australia

**International Visitors**

• 21 Feb. 2001: Dr. Peter Török, University of Oxford, UK
• 5 March 2001: Dr. Kazuya Goto, Osaka University, Japan
• 5 March 2001: Mr. Taro Ichimura, Osaka University, Japan
• 5 March-30 Nov. 2001: Prof. Satoshi Kawata, Osaka University, Japan
• 5 March 2001: Mr. Nick Smith, Osaka University, Japan
• 5 March 2001: Dr. Tadao Sugiura, Osaka University, Japan
• 5 March-16 June 2001: Mr. Sven Woldberg, Twente University, The Netherlands
• 2 May 2001: Dr. Yoko Miyamoto, University of Electro-Communications, Japan
• 1 March-26 Nov. 2001: Prof. P. C. Cheng, State University of NY at Buffalo, USA
• 25 Sept.-21 Dec. 2001: Mr. Wataru Inami, Shizuoka University, Japan
• 26 Nov. 2001: Prof. Chien Chou, National Yang Ming University, Taiwan
• 26 Nov. 2001: Ms. Bianxiang Fu, National Natural Science Foundation of China, China
• 26 Nov. 2001: Mr. Yuan-Hsing Fu, National Taiwan University, Taiwan
• 26 Nov. 2001: Fu-Han Ho, National Taiwan University, Taiwan
• 26 Nov. 2001: A/Prof. Fu-Jen Kao, National Sun Yet Sen University, Korea
• 26 Nov. 2001: A/Prof. Yoshimasa Kawata, Shizuoka University, Japan
• 26 Nov. 2001: Dr. Eugenio Mendez, CICESE University, Mexico
• 26 Nov. 2001: Prof. Herbert Schneckenburger, University of Ulm, Germany
• 26 Nov. 2001: Dr. Matsuo Shigeki, University of Tokushima, Japan
• 26 Nov. 2001: Prof. Chi-Kuang Sun: National Taiwan University, Taiwan
• 26 Nov. 2001: Prof. Din Pin Tsai, Taiwan National University, Taiwan
• 26 Nov. 2001: Prof. Guiying Wang, Shanghai Institute of Optics and Fine Mechanics, China
• 26 Nov. 2001: Prof. Jia Wang, Tsinghua University, China
• 26 Nov. 2001: Prof. Lihong Wang, Texas University, USA
• 26 Nov. 2001: Prof. Tony Wilson, University of Oxford, UK
• 26 Nov. 2001: Prof. Hanry Yu, National University of Singapore, Singapore
• 28 Nov. 2001: Prof. Wonho Jhe, Seoul National University, South Korea
• 28 Nov. 2001: Prof. Ernst Stelzer, EMBL-Heidelberg, Germany
• 28 Nov. 2001: Prof. Norihiro Umeda, Tokyo University of Agriculture and Technology, Japan
• 30 Nov. 2001: Dr. Yasushi Inoue, Osaka University, Japan
• 30 Nov. 2001: Prof. Manuel Nieto-Vesperinas, Instituto de Ciencia de Materiales de Madrid, Spain
• 30 Nov. 2001: Prof. Motoichi Ohtsu, Tokyo Institute of Technology, Japan
• 26-30 Nov. 2001: Prof. George Stanciu, University "Politehnica" of Bucharest, Romania
• 30 Nov. 2001: Prof. J. Tominaga, National Institute of Advanced Industrial Science and Technology, AIST, Japan
• 30 Nov. 2001: Prof. Xing Zhu, Beijing University, China

National Visitors

• April 2001: A/Prof. Vassilios Sarafis, University of Queensland
• May 2001: Prof. David Jans, Australian National University, Canberra
• May 2001: Dr. Mark Lam, Monash University, Melbourne
• May 2001: Associate Prof. Paul Mulvaney, Melbourne University
• 24 August 2001: Prof. Yuri Kivshar, Australian National University, Canberra
• 26 Nov. 2001: Dr. Sharma Manjula, University of Sydney

Conference Organisation

Min Gu:

2001: Organising Committee, International Workshop on Photonics and Imaging in Biology and Medicine, Wuhan, P. R. China.

X Gan:


D. Day:

Completed Thesis/Reports

- Mr. Daniel Day completed a PhD thesis in the area of nano-photonics (Thesis title: "Three-dimensional bit optical data storage in photorefractive polymers").
- Mr. Ben Smith, an R & D undergraduate student, completed a report in the area of optical data storage (Report title: "Fabrication of three-dimensional microstructures using 2-photon photopolymerisation")
- Mr. Tom Rodgers, a R & D undergraduate student, completed a report in the area of optical data storage (Report title: "Fabrication of microstructures in a photorefractive polymer")
- Mr. Sven Woldberg a visiting student from Twente University, The Netherlands, completed a report in the area of nano-photonics (Report title: "Laser trapping - Experimenting with dielectric particles")

Patent Applications

[1] M. Gu, X. Gan, E. Williams, E. Thompson
Provisional patent application, Diagnosis method, PR2656/01, (2001).
Provisional patent application, Method and device, PR4965/01, (2001).

CMP Seminar Presentations

- James Chon (CMP, Swinburne University of Technology, Melbourne), "Resonance behaviour studies of atomic force microscope cantilevers and its application as a local sensor", 15 Feb. 2001
- Martin Straub (CMP, Swinburne University of Technology, Melbourne), "Multi focal multiphoton microscopy: fast 3-d live cell imaging and lifetime applications", 15 Feb. 2001
- Dr. Peter Török (Department of Engineering Science, Oxford University, UK), "Vectorial diffraction theory for modern optical microscopy", 21 Feb. 2001
- Mr. Daniel Day (CMP, Swinburne University of Technology, Melbourne), "3-D cavity formation in photorefractive polymers", 5 March 2001
- Dr. Xiaoyuan Deng (CMP, Swinburne University of Technology, Melbourne), "SHG in prostate tissue", 5 March 2001
- Dr. Xiaosong Gan (CMP, Swinburne University of Technology, Melbourne), "Image reconstruction in tissue media", 5 March 2001
- Mr. Djenan Ganic (CMP, Swinburne University of Technology, Melbourne), "Near-field MIE scattering", 5 March 2001
- Dr. Kazuya Goto (Osaka University, Japan), "Transcutaneous energy and information transmission with NIR light", 5 March 2001
- Prof. Min Gu (CMP, Swinburne University of Technology, Melbourne), "Overview of research activities in CMP and cancer detection", 5 March 2001
- Mr. Taro Ichimura (Osaka University, Japan), "IR spectroscopy on tissue", 5 March 2001
- Prof. Satoshi Kawata (Osaka University, Japan), "Overview of research activities in LaSIE and 3-D fabrication", 5 March 2001
- Mr. Dennis McPhail (CMP, Swinburne University of Technology, Melbourne), "3-D data storage in polymer-dispersed liquid crystals", 5 March 2001
- Mr. Dru Morrish (CMP, Swinburne University of Technology, Melbourne), "Generation of doughnut beams using a LCD", 5 March 2001
Mr. Nick Smith (Osaka University, Japan), "Multi-photon laser surgery", 5 March 2001
Dr. Tadao Sugiura (Osaka University, Japan), "Laser trapping for near-field optics and force measurement", 5 March 2001
Dr. Yoko Miyamoto (Department of Information and Communication Engineering, The University of Electro-Communications, Tokyo, Japan), "Laser beams with phase singularity", 2 May 2001
Mr. Sven Woldberg (visiting student from Twente University, The Netherlands), "Laser-trapping: experimenting with dielectric particles", 14 June 2001
Dr. Xiaosong Gan (CMP, Swinburne University of Technology, Melbourne), "Multi photon fluorescence imaging through tissue", 15 June 2001
Prof. Yuri Kivshar (Non-Linear Physics Group, Australian National University, Canberra), "Self - trapped optical beams: spatial optical solutions", 24 August 2001
Mr. Wataru Inami (visiting student from Shizuoka University, Japan), "Analysis of scattered light distribution and radiation force for a strongly illuminated particle near a surface", 16 Nov. 2001
Publications

1. Books/Book Chapters

1.1 Three-dimensional localisation of fluorescence resonance energy transfer in living cells under two-photon excitation

2. Journal Papers

2.1 Multi-photon fluorescence microscopy - specimen response to high intensity illumination

2.2 Three-dimensional localization of fluorescence resonance energy transfer in living cells under two-photon excitation

2.3 Three-dimensional coherent transfer function for reflection confocal microscopy in the presence of refractive-index mismatch

2.4 Rewritable three-dimensional bit optical data storage in a PMMA-based photorefractive polymer with continuous wave illumination

2.5 Effect of saturable response to two-photon absorption on readout signal level of three-dimensional bit optical data storage in photochromic polymer

3. Published Proceedings

3.1 Near-field Mie scattering in optical trap nanometry
(Presentation at the *European Conference on Biomedical Optics*, at Munich, Germany, June 17-21, 2001)

3.2 Multi-photon fluorescence imaging through biological tissue and image reconstruction
(Presentation at the *European Conference on Biomedical Optics*, at Munich, Germany, June 17-21, 2001).

3.3 The stem vasculature of *na1/na1* and *na2/na2* in *Zea mays*

3.4 Dependence of second-harmonic signals generated in malignant human prostate tissue on excitation wavelength
3.5. Multi-layered optical data storage in a polymer-dispersed liquid crystal material under two-photon excitation

4. Conference Abstracts

4.1 Fluorescence resonance energy transfer microscopy under two-photon excitation
Min Gu
(Invited talk at the 2001 International Biomedical Optics Symposium, at San Jose, USA, Jan. 20-26, 2001).

4.2 Two-photon fluorescence microscopy using a single-mode fibre
D. K. Bird, Min Gu, Book of Abstracts, p. 4.

4.3 Second-harmonic generation microscopy in human malignant prostate
Xiaoyuan Deng, Min Gu, Elizabeth D. Williams, Erik W. Thompson, Programme and Abstract Book, p. 19.
(Presentation at the 2001 International Conference on Confocal and Near-Field Microscopy, at Amsterdam, The Netherlands, April 1-4, 2001).

4.6 Microscopic imaging through turbid media: a comparison of penetration depth between single-photon, two-photon and three-photon excitation
Min Gu, Programme and Abstract Book, p. 34.
(Invited talk at the 2001 International Conference on Confocal and Near-Field Microscopy, at Amsterdam, The Netherlands, April 1-4, 2001).

4.7 Polarisation property in morphology dependant resonance of a micro-cavity excited by two-photon absorption
Dru Morrish, Xiaosong Gan, Min Gu, Proceedings of ACOLS, p. 59.

4.8 Rewritable three-dimensional bit optical data storage in polymer dispersed liquid crystals
D. K. McPhail, Min Gu, A. Smallridge, Program and Book of Abstracts, p. 46.

4.9 Fabrication of three-dimensional voids in a photorefractive polymer

4.10 Construction and characterisation of a two-photon fluorescence microscope based on an optical fibre coupler
Damian Bird, Min Gu, Program and Book of Abstracts, p. 3.

4.11 Monte-carlo simulation of multi-photon fluorescence microscopic imaging through complex turbid media
Xiaoyuan Deng, Xiaosong Gan, Min Gu, Program and Book of Abstracts, p. 15.
4.12 Three-dimensional microstructures efficiently generated by laser-scanning two-photon photopolymerization  
M. Straub, B. Smith, Min Gu, Program and Book of Abstracts, p. 74.  

4.13 Quadrant-photodiode detection for three-dimensional optical data readout  
M. Ashraf, D. Day, Min Gu, Program and Book of Abstracts, p. 2.  

4.14 Two photon spectra and lifetimes of fluorescent proteins and other fluorescent labels  

4.15 Spatially resolved polarisation dependence of morphology dependant resonance under two-photon fluorescence excitation  
Dru Morrish, Xiaosong Gan, Min Gu, Program and Book of Abstracts, p. 51.  

4.16 Three-dimensional near-field Mie scattering by dielectric particles  
Djenan Ganic, Xiaosong Gan, Min Gu, Program and Book of Abstracts, p. 20.  

4.17 Scanning total internal reflection microscopy using an objective of NA=1.65  
James W. M. Chon, Xiaosong Gan, Min Gu, Program and Book of Abstracts, p. 10.  

4.18 Microscopic imaging through turbid tissue media  
Xiaosong Gan, Min Gu, Program and Book of Abstracts, p. 19.  

4.19 Detecting protein-protein interactions in cells using fluorescence energy transfer  
Blessing Crimeen, Ross Ashman, Ming Gun Xu, Mandy J Ludford-Menting, Min Gu, Sarah M Russell, Program and Book of Abstracts, p. 13.  

4.20 Study of biological specimen with multi-dimensional and multi-modality imaging technologies  

4.21 Scanning TIR microscopy: near-field Mie scattering and localized morphology-dependent resonance  
Min Gu, X. Gan, J. Chon, D. Ganic, D. Morrish  
(Invited talk at the 3rd Asia-Pacific Workshop on Near-Field Optics, at Melbourne, Australia, Nov. 28-30, 2001).

5. Others
5.1 Fabrication of three-dimensional photonic crystal structures using two-photon photopolymerization

5.2 Complex-shaped 3-D microstructures fabricated by two-photon photopolymerization


5.4 Second harmonic generation and its applications in biomedicine
Xiaoyuan Deng, Min Gu, *Opto News and Letters*, 93 (2001) 18