RESEARCH REPORT

1. Name: Ryan Alexander （ID No.: SP06101）

2. Current affiliation: University of Sheffield

3. Research fields and specialties:

Humanities Social Sciences Mathematical and Physical Sciences
Chemistry X Engineering Sciences Biological Sciences
Agricultural Sciences Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: Arakawa's Labs, University of Tokyo, Industrial Institute of Science

5. Host researcher: Prof. Y Arakawa

6. Description of your current research

Lasers emitting at 1.3um are required by the telecoms industry for signal propagation in fibre optics, as this is the wavelength at which there is very low light attenuation and the chromatic dispersion minima occurs. The current incumbent quantum well lasers suffer from a high threshold current and are very sensitive to temperature changes, requiring expensive circuitry to control their properties. A new generation of lower dimensional quantum dot type lasers has been theoretically predicted to be temperature insensitive, have a low threshold current and a high modulation bandwidth. Low threshold currents and temperature insensitivity have been proven in practice using p type modulation doping, however quantum dot lasers lag behind quantum well lasers with a much slower realized modulation bandwidth. A very high bandwidth is crucial for high speed data transfer and a faster internet. My current research is focused on the characteristic study of 1.3um quantum dot lasers and improving their performance.

7. Research implementation and results under the program

Title of your research plan:

Small signal modulation study of delta p-doped quantum dot lasers

Description of the research activities:

Before leaving for the JSPS summer programme, four quantum dot wafers were grown by MBE with: 0 (undoped), 6, 12 & 18acc/QD P-type Berylium modulation doping. The wafers were both grown and processed into laser arrays at the university of Sheffield.

In conjunction with Arakawa's labs at the university of Tokyo my first task was to set up collaboration with Fujitsu in order to test the small signal modulation characteristics of the laser arrays. A lot of preparation work was required to match the lasers cavity loss to the modulation bandwidth peak. Fujitsu very kindly highly reflectively coated my samples to achieve the optimum modulation bandwidth peak. After individually cleaving the lasers the devices were mounted and bonded at Fujisu ready for characterization testing.

In depth current/voltage, current/output power and spectrum characterization was performed on the coated devices allowing a thorough assessment of the laser properties that university of Sheffield currently grow and how these characteristics change with increasing doping levels. The threshold current, slope efficiency and the gain of the lasers were found to increase with higher doping levels while the voltage reduced. Bi-modal lasing was found to occur in my lasers indicating a non-uniform dot size across the layers. In comparison to other groups published data my lasers were found to have a small ground state to excited state energy separation causing the excited state to begin to lase at lower injected currents.

The final part of the testing was to test the small signal modulation bandwidth of each laser array and determine how the doping and coating reflectivity affects the characteristics. Testing was just completed at the time of writing therefore data analysis has not been preformed to conclude on the results. During the preparation and testing procedure I gained a huge insight to the characteristics of the lasers grown at the university of Sheffield and how ours compare to other groups in the same field.

8. Please add your comments (if any):

I would like to thank JSPS and the British Council for allowing the me the opportunity to take part in the summer programme, it has been an amazing experience and I have learned so much both culturally and academically. My great thanks to Prof. Arakawa for hosting me and helping out with the Fujitsu collaboration. Total thank you to Fujitsu, and especially Yamamoto-san for allowing me to use their resources and time, and their kind help in coating, bonding and testing my lasers. Finally my hugest thank you to Ishida-san for his organizational help, time, very insightful discussions and his eternal patience with helping me test.

My thanks to my supervisor Dr. Hogg for all his help in getting me sorted for the programme.

RESEARCH REPORT

1. Name: Sarah Hill （ID No.: SP06102）

2. Current affiliation: The University of Manchester

3. Research fields and specialties:

Humanities Social Sciences Mathematical and Physical Sciences
X Chemistry Engineering Sciences Biological Sciences
Agricultural Sciences Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: National Institute of Advanced Industrial Science and Technology (AIST)

5. Host researcher: Dr Shigeru Futamura

6. Description of your current research

The use of non-thermal plasma discharges for environmental clean-up methods is a growth area with considerable potential for establishing a novel environmental technology of proven efficiency. A plasma discharge is created when an electric field is applied to a gas causing a breakdown and the production of electrons and ions. These electrons and ions can react further with other gas molecules giving active species which help to destroy the target pollutant molecules. Plasma discharges have been shown to remove a large variety of gaseous compounds from sulphides and ammonia which cause odour control problems at sewage works, to carcinogens such as benzene, to ozone depleting substances like chlorofluorocarbons. They are also regarded as a promising route for hydrogen production via the processing of hydrocarbons such as methane. Conventional methods are already in place for the removal of many VOCs but these do have drawbacks, namely efficiency. Many gas processing plants work constantly at the highest power to ensure the most hazardous waste is dealt with correctly even if removal is only required sporadically, causing much waste of power. Plasma systems have a very fast response time and applied power could be increased as and when needed saving much energy. Many catalysts are currently used in gaseous clean-up which can cause further issues with respect to catalyst poisoning leading to deactivation and reduced efficiency. Plasma systems can operate without the need for a catalyst and have been shown to increase lifetimes when used in conjunction with a catalyst bed.

My specific research areas have been concerned with VOC removal, particularly short chain hydrocarbons such as propane and propene, using plasma reactors. I have undertaken work at hyper-atmospheric pressure to investigate the effect on efficiency and

have developed a model to assess the destruction pathways of the molecules within the discharge. The products of the propane/propene conversion in the plasma are also of interest. This is assessed by calculating the carbon balance to ascertain how much hydrocarbon is converted to CO_2 and CO and how much is converted to other carbon containing compounds.

7. Research implementation and results under the program

Title of your research plan:

The Effect of Catalyst Type on the Conversion of Propane and Propene in a Surface Discharge Reactor

Description of the research activities:

The experiments conducted were carried out using a surface discharge reactor (SDR). Flow rates of 1 $Lmin^{-1}$ were used along with a PerkinElmer Spectrum One FTIR detection system, calibrated accordingly. An AC voltage was applied to produce the discharge, the frequency was varied between 50Hz and 1kHz and the pK-pK voltage was varied from 14 kV to 32 kV. This gave specific input energies (SIE) in the range of 14 JL^{-1} to 930 JL^{-1}. A selection of catalysts were used to try and improve the hydrocarbon removal, titanium dioxide (TiO_2), gamma alumina (Al_2O_3) and zeolite NaA were used along with the dielectric barium titanate ($BaTiO_3$) which was employed to alter the electronic properties of the discharge. A one stage reactor configuration was used throughout these experiments

The following graphs (figures 1 and 2) show the results obtained during propane and propene destruction.

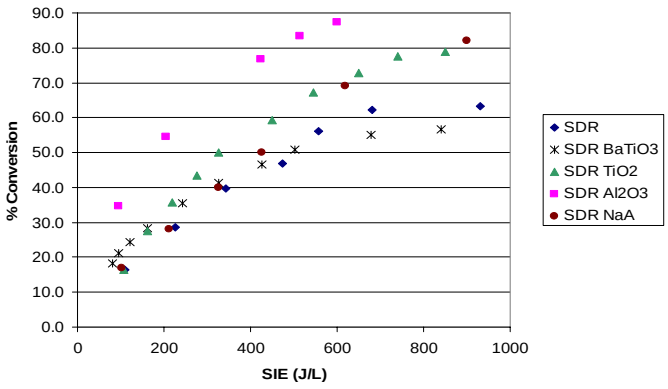


Figure 1: The effect of different catalysts on propane conversion in SDR

Figure 1 shows an increase in propane conversion when a SDR is used in conjunction with catalyst bed. The improvement is most pronounced at high SIE and Al_2O_3 is the catalyst which produces the best conversion of propane.

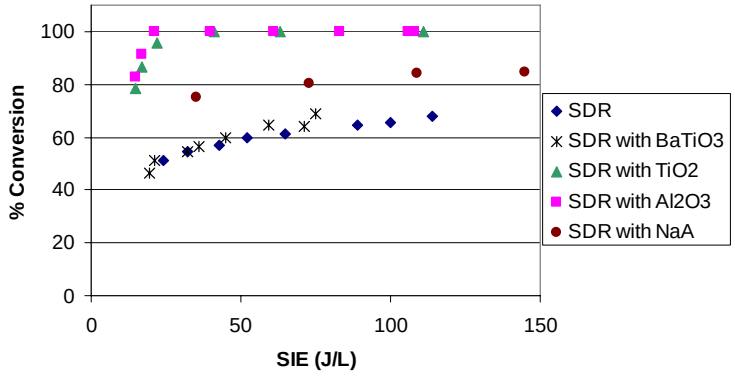


Figure 2: The effect of different catalysts on propene conversion in SDR

As with propane destruction this graph shows that the addition of a catalyst bed increases the conversion of propene. It should also be noted that the SIE required to convert propene, even without a catalyst, is far lower than that required for propane. This result is to be expected as propane is a more stable molecule than propene. Al_2O_3 and TiO_2 are the best catalysts for propene removal and exhibit almost identical results, reaching 100% conversion at only 25 JL^{-1} SIE.

It is interesting to note that under normal catalytic conditions Al_2O_3 is used as a catalytic support and must be doped with a metal in order to show catalytic activity. However, when used in conjunction with a plasma discharge Al_2O_3 shows favourable catalytic activity to improve the removal of propane and propene.

8. Please add your comments (if any):

I have thoroughly enjoyed my stay in the excited state chemistry group at AIST Tsukuba. My host researcher has been most welcoming and helpful throughout my stay. The facilities here in Tsukuba are excellent and I am in no doubt that my stay here has enhanced my research both in substance, actual data collected, and awareness of how the Japanese research sector is set up and the considerable differences to that in the UK.

9. Advisor's remarks (if any):

The JSPS fellow has observed interesting catalytic effects in the decomposition of propane and propene with a silent discharge plasma reactor. The information on the product distributions is important in discussing the catalytic effects. The plot of the major product(s) selectivity against substrate conversion should be helpful can show us different action mechanisms of the catalysts investigated.

RESEARCH REPORT

1. Name: Andrew M. Kelly （ID No.: SP06103）

2. Current affiliation: University of Bath

3. Research fields and specialties:

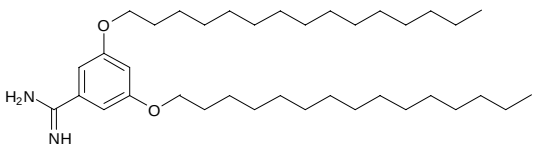
Humanities Social Sciences X Mathematical and Physical Sciences
Chemistry Engineering Sciences Biological Sciences
Agricultural Sciences Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: The University of Kitakyushu

5. Host researcher: Prof. Kazuo Sakurai

6. Description of your current research

Previous work within the Sakurai group has reported on the synthesis of a novel cationic lipid bearing an amidine headgroup and its application as a novel transfection reagent.



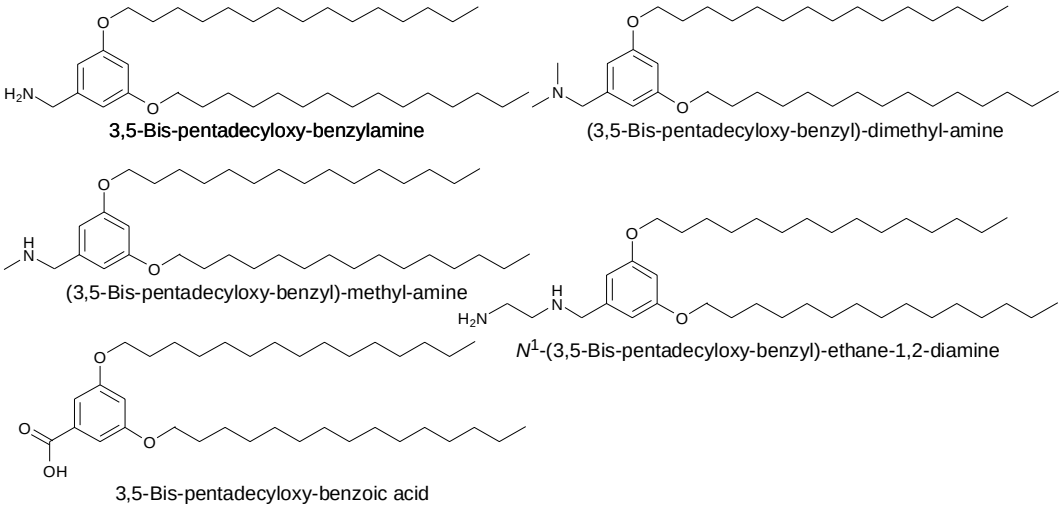
Cationic lipid TRX (3,5-bis-pentadecyloxy-benzamidine)

A lipoplex is an ionic complex, formed from the complexation of cationic surfactants (or lipids) and plasmid DNA (pDNA). Ionic intermolecular binding between the positively assist in the transfection (the introduction of DNA into eukaryotic cells such as animal cells) of bound pDNA. Indeed, since bacteria such as e-coli contain pDNA, almost 20% of current clinical trials of gene therapy involve transfection of such lipoplex macromolecules.

A lipoplex was observed on addition of pDNA to the TRX lipid. The lipoplex formed was engineered to have a slight overall positive charge by varying the cation-to-anion ratio since it has been shown that this assists in transfection of the pDNA.

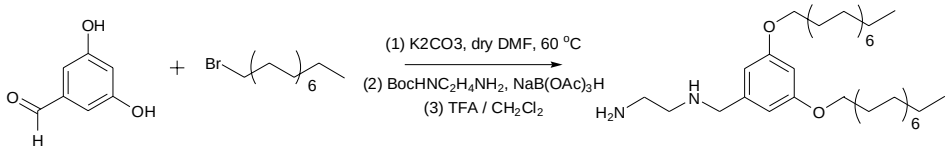
7. Research implementation and results under the program

A series of novel lipids were designed, synthesized and tested against the TRX and another commercially available lipid for transfection ability.



Short series of synthesized lipids for pDNA transfection studies

By varying the substituents at the nitrogen centre, the nucleophilicity of the lone pair, and thus the strength of binding with both pDNA and the cell wall was varied. An oxygen analogue of the amidine head-group, the benzoic acid based lipid was also synthesized for comparison. Bio-assay studies using standard Luciferase fluorescence techniques showed ethylene-di-amine based lipid N^1-(3,5-Bis-pentadecyloxy-benzyl)-ethane-1,2-diamine to have a significantly higher degree of transfection than the previously reported TRX lipid with a corresponding high cell count (number of living cells following transfection) indicating this lipid to be significantly stronger in the transfection of pDNA.



Synthesis of N^1-(3,5-Bis-pentadecyloxy-benzyl)-ethane-1,2-diamine

Standard alkylation protocol followed by reductive amination and facile cleavage of the Boc group using TFA methodology afforded the di-amine lipid in good yield.

It is thought that the success of the novel lipid is due to the combined nucleophilicity of the di-amine moieties forming stronger ionic interactions with the phosphoric acid groups along the DNA backbone. Since both primary and secondary amines have been tested individually in the study and observed to show considerably weaker transfection than the di-amino lipid, the combined binding to the pDNA strand is thought to condense the DNA into small micellular spheres the diameter of which better matches the desired dimensions

for cellular uptake.

This research will published in a scientific journaland a patent for the novel lipid.

Title of your research plan:

The synthesis and biological application of a series of novel lipids for pDNA transfection

Description of the research activities:

Retrosynthetic analysis

Design of synthesis towards target lipids

Organic synthesis of target lipids including Silica Gel Chromatography

Structural determination using ^{1}H NMR Spectroscopic Analysis

Triple helical lyposome formation with co-lipids (DOPE and DLPC)

Lypoplex synthesis with pDNA (pEGFP-C1)

Transfection to cells (Hep G2)

Bio-assay analysis using Luciferase Fluorescence analysis

Total cell count analysis

RESEARCH REPORT

1. Name: Sophia Ali Khan （ID No.: SP06104）

2. Current affiliation: Pontificia Universidad Catolica

3. Research fields and specialties:

Humanities Social Sciences X Mathematical and Physical Sciences

Chemistry Engineering Sciences Biological Sciences

Agricultural Sciences Medical, Dental and Pharmaceutical Sciences

Interdisciplinary and Frontier Sciences

4. Host institution: Institute of Space and Astronautical Science (ISAS)

5. Host researcher: Professor Murakami

6. Description of your current research

Amongst the first results of extragalactic mid-infrared astronomy was the discovery of a small number of galaxies that emit the bulk of their luminosity in the infrared. The InfraRed Astronomical Satellite, *IRAS*, detected large numbers of these ultraluminous infrared galaxies (ULIRGs) in the local universe. In 1997, a new population of galaxies was discovered at submillimetre wavelengths using the Submillimetre Common User Bolometer Array (SCUBA). These galaxies were regarded as the high redshift counterparts of local *IRAS* ULIRGs since they shared similar properties (fundamentally, that the bulk of the luminosity is emitted in the restframe far-infrared, powered by a combination of star formation and an active nucleus).

But SCUBA-selected ULIRGs tend to have higher luminosities, and those with comparable luminosities to *IRAS*-selected ULIRGs tend to have cooler temperatures. SCUBA-selected ULIRGs also have star formation rates *at least* one order of magnitude greater than their *IRAS* counterparts.

To investigate the nature of a possible evolutionary relationship between *IRAS* and SCUBA-selected ULIRGs, my collaborators and I began a blank deep survey in the short-submillimetre (the intermediate waveband between *IRAS* and SCUBA). The survey was designed to select ULIRGs through their far-infrared thermal dust emission (measured near the peak of their spectrum) at the epoch of peak cosmic star formation rate density.

Through this survey, we have discovered the first galaxies selected in the short-submillimetre. These sources are ULIRGs that occupy a region of parameter space

(luminosity, temperature, redshift) in-between local *IRAS* and high redshift SCUBA galaxies, and are predicted to lie below the SCUBA detection threshold. Our survey thus complements SCUBA in revealing ULIRGs that might be missed otherwise, allowing us to constrain the nature and evolution of the ULIRG population as a whole.

7. Research implementation and results under the program

Title of your research plan:

Monsters of the Universe: unveiling the brightest infrared galaxies in the *Akari* Deep Field

Description of the research activities:

This summer, I have developed a two year research programme to maximise the science return from the *Akari* Deep Field, and participated in the testing of the *Akari* data reduction pipeline.

Akari is an infrared survey mission from the Institute of Space and Astronautical Science of the Japan Aerospace eXploration Agency, launched in February 2006. Its primary mission, the All-Sky Survey, is the first of its kind since the survey undertaken by *IRAS* in 1984. It will also undertake deep extragalactic surveys of selected regions at 2-180 microns. One such survey, the *Akari* Deep Field (ADF), is an 8 sq. degree region which will be imaged with the Far Infrared Surveyor. It will be the deepest *ever* survey in the far-infrared.

I am the Principal Investigator for a follow-up survey to observe the ADF in the submillimetre. The scientific motivation of a submillimetre survey, combined with the ultra-deep far-infrared data, is to select extremely luminous infrared sources in the ADF, alongside colder, higher redshift submillimetre galaxies that are undetected in the far-infrared. These non-detected galaxies could be high redshift galaxies or hyperluminous (i.e., with an infrared luminosity at least tenfold that of a ULIRG). The hyperluminous galaxies will be the most luminous objects in the Hubble volume and are extremely rare. As a co-investigator on the ADF, I have proprietorial access to the ADF data, which will not become public until one year after the end of the *Akari* mission.

Another part of my summer research has been an analysis on the state of the *Akari* data reduction effort. Using an alternative method of reducing the data I did not find any problems in the reduction solution that are unknown or unaccounted for at the present time. This is a very encouraging result.

In order to meet the science objectives of the survey, I will return in ISAS in February 2007 to further assist in the data reduction and analysis phase of the ADF. I also anticipate hosting my ISAS colleagues at Pontificia Universidad Catolica, Santiago.

8. Please add your comments (if any):

Murakami-sensei, for being a wonderful host; Ukai-san and Kimura-san, for making my stay as easy as possible. Many thanks for patience and assistance at all times; Chris Pearson – I have learned so much from you, and I look forward to our continued collaborations – forever!; Yamamura-san – it has been a pleasure to get to work with you and I look forward to continued involvement on the data reduction pipeline.

Finally, many thanks to JSPS. The organisation of the 2006 summer programme, especially the travel arrangements, was very good, and the week in Sokendai was well-planned, with informative lectures, excellent language classes, a Japanese cultural evening and a wonderful homestay weekend. Thank you JSPS, for making our visit to Japan an easy, comfortable and, most importantly, unforgettable experience.

9. Advisor's remarks (if any):

Sophia has used her time spent in Japan to make new connections and collaborations with the infrared and sub-milllimetre community. In particular she has used her period at ISAS to sow the seeds for a potential future collaboration between the Japanese Akari team and her next position in Chile to follow up a deep infrared survey with Akari using the submillitre telescopes in Chile. We thus expect some future continuing collaboration with her.

Sophia also spent an albeit limited time working on the analysis for the All-Sky Survey data taken by the Akari satellite, allowing her to make contacts within the All-sky Survey team as well. Sophia mixed well with the graduate students at ISAS.

RESEARCH REPORT

1. Name: Alexander K. Kofinas （ID No.: SP06105）

2. Current affiliation: Graduate School of Business

Manchester Metropolitan University, Manchester

3. Research fields and specialties:

Humanities Social Sciences X X X Mathematical and Physical Sciences
Chemistry Engineering Sciences Biological Sciences
Agricultural Sciences Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: Tokyo Institute of Technology

5. Host researcher: Professor Kumiko Miyazaki

6. Description of your current research

The doctoral research in Manchester Metropolitan University Business School examines the knowledge management processes in the context of pharmaceutical R&D. Via in-depth case studies, I am investigating the development of knowledge-related routines and capabilities that augment and strengthen the drug discovery process. The main focus is on the bio-informatics function; an innovative technological revolution in the field of drug discovery. Though they started as an outcome of the human genome project and the biotech revolution of the 1980's and 1990's now they have become an important function of the pharmaceutical R&D and are viewed as a crucial means for reducing drug research and increasing the efficiency of drug discovery process. The knowledge management perspective is explicitly used to highlight the processes that are vital for the success of informatics projects. By utilizing a methodology portfolio of interviews, documentation, quantitative, and ethnographic data the research aims to outline the rich process of innovation when creating a new bio-informatics product. The final aim is to produce and develop a mid-range framework that highlights the factors that are important for the successful and useful knowledge production facilitated by a bio-informatics tool.

7. Research implementation and results under the program

Title of your research plan:

My research plan in Japan had three aims:
-To create a report on bioinformatics differences in Japan vis-à-vis UK and Sweden
-To produce a publication that explores the pharmaceutical industry in Japan, EU and US and differences in the national context for pharmaceutical companies.
-To explore and understand the academic environment in Japan and investigate potential for future activities.

Description of the research activities:

-Took active part in all the activities in Miyazaki sensei's lab including the various presentations, debates and the Summer Seminar

-Presented my own research during the Summer seminar and in an additional seminar in the Tamachi campus organized by Miyazaki sensei.

-Was kindly invited by Miyazaki sensei to various lectures and other activities that gave insights to the Japanese education and policy environment.

-Completed an article that will be presented in the third Art of Management Conference in Poland, Krakow.

8. Please add your comments (if any):

I felt that it was very difficult coming from social science to do a proper research in such a short period of time and especially during the Summer. My subject matter is human interactions and social circumstances. In two months, in a country as different as Japan, and during the holiday period it proved to be a formidable task. Even though Miyazaki-sensei was most helpful with contacts and ideas I found very difficult to do the first part of the project I had designed for myself.

I am planning to submit a publication in the Asian journal of innovation whereupon I will use some of the research I did this summer and the framework developed in my earlier research in Saitama university.

My contact with Miyazaki-sensei's lab made me quite hopeful of fruitful collaborations in the future. If I get the chance I would like to expand on what I started during this Summer.

RESEARCH REPORT

1. Name: CHAYANIN PRATOOMSOOT （ID No.: SP06106）

2. Current affiliation: Tissue Engineering Group, School of Pharmacy,
The University of Nottingham, NG7 2RD, UK

3. Research fields and specialties:

Humanities Social Sciences Mathematical and Physical Sciences
Chemistry Engineering Sciences Biological Sciences
Agricultural Sciences X Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: Department of Ophthalmology,
Kyoto Prefectural University of Medicine Kyoto

5. Host researcher: Prof Shigeru Kinoshita

6. Description of your current research

Ocular trauma and disorders that lead to corneal blindness account for over 2 million new cases of monocular blindness every year. A popular ocular surface reconstruction, the amniotic membrane transplantation (AMT), has been shown to aid corneal wound repair. In the past, the amniotic membrane has been employed as a biological bandage to aid wound healing, whilst reducing pain and discomfort. Over the last decade, the popularity of employing the amniotic membrane in ophthalmic applications has been witnessed; successful treatments for conditions such as chemical and thermal burns, Stevens-Johnson-Syndrome (SJS) were reported. Despite some success, failures of these treatments were documented where progressive corneal melts with persistent corneal defects and corneal calcification have been observed. Furthermore, the risks of transmissible infections from donors, which called for the need of stringent donor screening together with poor donor compliance have led to reduced availability of the membrane for clinical use. This project proposed to bioengineer a novel synthetic polymeric material that would serve as a biomimetic corneal bandage.

7. Research implementation and results under the program

Title of your research plan:

A Biocompatibility Study of a Thermosensitive Hydrogel

Description of the research activities:

It was of an interest to investigate the physiological response of the cornea to this hydrogel bandage. Biocompatibility of the biosynthetic bandage was evaluated. In this study the biocompatibility of the hydrogel was assessed *in vivo* using rabbits with corneal wounds.

Preparation of wounds

New Zealand white rabbits were subjected to one of two types of wounds: a pocket wound within the cornea, or a trephine wound in which the epithelium was excised using a scalpel blade.

Hydrogel formulations

The hydrogel was 35% (w/v) copolymer solutions were prepared with autoclaved distilled water. The solution was filter-sterilised, and kept cold on ice until further use.

Application of the hydrogel to the wound bed

For both types of the wounds, 35% (w/v) hydrogel solution was applied onto the wounds and was allowed to gel. Physiological examinations of the wounded eyes were made at designated time points of days 1, 3, 5, 7 and 14.

Physiological examinations

Slit lamp microscopy revealed that the hydrogel did not cause toxicity to the cornea. It was observed using fluorescein staining that the wound bed of the trephine wound healed by day 5, as there was no staining to the wound bed. Compare to the sham operations where no hydrogel bandage was applied, the wounds healed in a similar manner; no adverse defects were observed. Histological examinations for both

types of wound did not exhibit inflammation or cytotoxicity of the surrounding cells and that corneas followed the natural course of healing. It was concluded that the hydrogel did not cause any adverse toxicity and that it could serve as a bandage for cornea wound healing.

8. Please add your comments (if any):

I was very delighted to be given the opportunity to carry out research in Japan. My stay in Japan has been a fruitful one, where I had learnt immensely not only academically, but also about life. It has been an invaluable lesson and I am going to treasure every experience here. I hope that in the future I will have such an opportunity again to return to Japan and conduct more exciting research. I am very grateful to my host Prof Kinoshita and my colleagues, Sensei Tanioka, Dr Hori and Dr Kawasaki for their kindness and support, and of course JSPS for funding.

RESEARCH REPORT

1. Name: Robert Simpson （ID No.: SP06107）

2. Current affiliation: University of Southampton, England

3. Research fields and specialties:

Humanities Social Sciences X Mathematical and Physical Sciences
Chemistry X Engineering Sciences Biological Sciences
Agricultural Sciences Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: Advanced Industrial Science and Technology (AIST), Tsukuba

5. Host researcher: Prof Junji Tominaga,
Centre for Applied Near-Field Optical Research (CAN-FOR)

6. Description of your current research

My Ph.D research has concentrated on the investigation of novel materials for phase change optical and electrical data storage applications. Phase change data storage materials have the ability to exist in two different stable states; amorphous and crystalline. The two states have distinguishable properties including optical reflectivity, refractive index, structure and electrical conductivity. The materials can be switched between states by heating with a laser or electrical current. Recently, the work has led to collaboration with the University of Southampton's School of Chemistry. We are applying novel high throughput, combinatorial techniques to phase change data storage material discovery. The unimaginably huge range of compositions available and the large number of parameters to be optimised (switching time, archival stability, read/write endurance, reflectivity/conductivity) means fast efficient processes should be adopted to enable the most suitable material to be found in the shortest possible time. It is hoped that the combination of high throughput deposition and theoretical work will provide scientific insight into the phase change mechanism and contribute novel materials to the data storage industry.

7. Research implementation and results under the program

Title of your research plan:

An Investigation into the Sb:Te:Bi Ternary System for Phase Change Data Storage

Description of the research activities:

The aim of this work was to synthesise and screen novel phase change data storage compositions and then to evaluate specific compositions within an optical disc structure. Compositionally graded phase change films were prepared at the School of Chemistry, University of Southampton and their optical properties were investigated at the Centre for Applied Near-Field Optical Research, AIST, Tsukuba. However these films are not suitable for measurements that require a constant composition. Therefore films were also prepared, during the study period, to investigate the effect of Bi on the activation energy, switching times and density change in Ge2:Sb2:Te5, Sb2:Te8, Sb:Te and Sb2:Te3 phase change films. Activation energy for crystallisation, which can give insight into the crystallisation mechanism and is useful for estimating the archival lifetime of data written to the phase change film, was measured using Kissinger analysis. The optical properties of the films were also investigated.

Methodology: Bismuth doped Sb:Te films were deposited from elemental sources by Knudsen cell or e-beam evaporation in a UHV chamber. Each source was fitted with an independent shutter. By controlling of the source temperature and shutter position; a wedge of each element can me grown on the substrate. The composition gradient was achieved by simultaneously depositing all sources at once. The room temperature refractive index of the compositionally varied films was investigated using a HeNe (λ=632.8nm) ellipsometer. After measurement the films were protected against oxidisation by capping with Si3N4 by sputtering from a Si target in a reactive nitrogen atmosphere. The measurements of n and k were mapped onto the EDX composition data and this has been plotted on to the composition ternaries in Figures 1a and 1b.

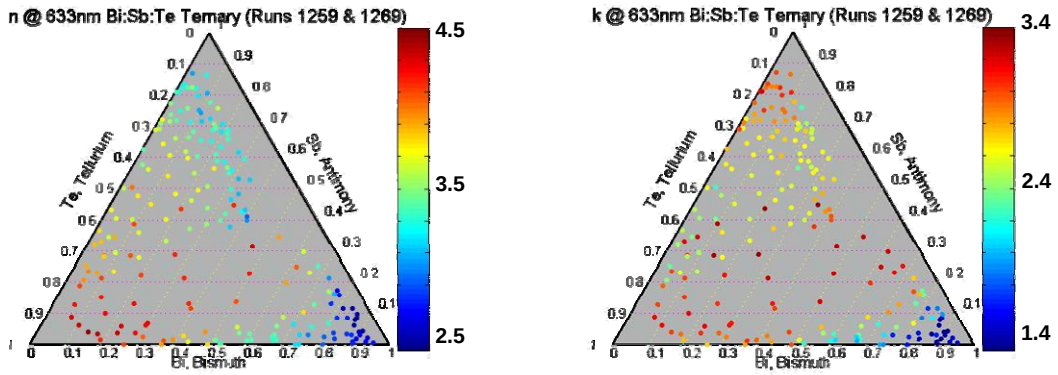


Figure 1: The refractive index and extinction coefficient of Sb:Te:Bi thin films

To investigate the phase change properties of Bi doped Sb_x:Te_y, Bi pieces were attached to Sb2:Te8, Sb:Te and Sb2:Te3 sputtering targets. The films were deposited at an RF power of 100W and a sputtering pressure of 0.5 Pa. The composition of resultant film was measured using X-Ray Fluorescence (XRF). Non-isothermal crystallisation of the 100nm thick films was carried out at heating rates of 5, 10, 15, 20 and 25 C/min The reflected optical-spectra of each film was measured as a function of temperature and heating rate. At the crystallisation temperature the film's refractive index undergoes a rapid change. Kissinger analysis was used to estimate the activation energy of the films for each measurement of peak crystallisation temperature. The Arrhenius plots are given in figure 2 and the activation energy dependence on bismuth concentration is given in table 1.

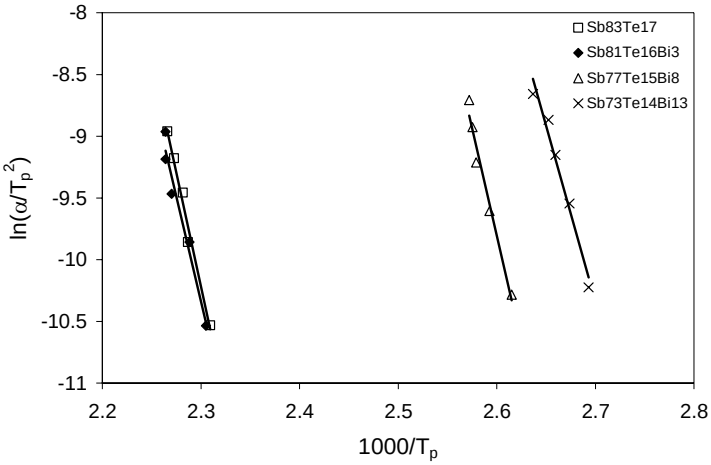


Figure 2: The Arrhenius plots for non-isothermal crystallisation of Bi doped Sb8:Te2 films

	Crystallisation		As-Deposited Refractive Index		Crystalline Refractive Index		
Composition	**Tx /K (20C/min)**	**E_a (eV)**	**n**	**k**	**n**	**k**	**Modulation (λ=690nm)**
$Sb_{83}Te_{17}$	165.3	3.19	3.532	2.938	2.8076	4.858	-14%
$Sb_{81}Te_{16}Bi_3$	167.7	2.91	4.055	3.070	3.011	4.751	34.2%
$Sb_{77}Te_{15}Bi_8$	114.75	3	3.731	3.354	2.600	4.874	9%
$Sb_{73}Te_{14}Bi_{13}$	103	2.47	3.839	3.261	3.054	4.434	30%
$Sb_{71}Te_{14}Bi_{15}$	N/A	N/A	2.320	5.159	2.320	5.159	0%

Table 1: Crystallisation and optical properties of Bi doped Sb8Te2 phase change film

Future Work: The volume change and crystallisation speed of phase change materials are important quantities which affect the number of write cycles and data writing rate respectively of the resultant memory device. The Sb:Te:Bi samples, described earlier, will be investigated using X-Ray Reflectance (XRR) to measure both the film thickness and the density change after crystallisation. The crystallisation speed will be gained by heating the films with a pulsed laser and monitoring the effect on the films reflectivity.

8. Please add your comments (if any):

Overall I regard the summer research experience a success. I have made a number of important measurements which complement my work in England. I hope that the collaboration can continue and a full formal characterisation of the Sb:Te:Bi system can be completed with the aim of fabricating an optical disc from some of the more interesting compositions. I have fully enjoyed my time at CAN-FOR; I have made some new friends who I know I will stay in touch with after this placement.

RESEARCH REPORT

1. Name: Margaret White （ID No.: SP06108）

2. Current affiliation: School of Civil Engineering and Geosciences,
University of Newcastle upon Tyne, Newcastle upon Tyne,
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3. Research fields and specialties:

Humanities Social Sciences X Mathematical and Physical Sciences
Chemistry Engineering Sciences Biological Sciences
Agricultural Sciences Medical, Dental and Pharmaceutical Sciences
Interdisciplinary and Frontier Sciences

4. Host institution: Osaka University, Osaka, Japan

5. Host researcher: Professor Satoru Nakashima

6. Description of your current research

My current research focuses on the identification and characterization of reactive organic and inorganic carbon (C) and nitrogen (N) pools in natural terrestrial sediments and soils, and within polluted environments (e.g. landfill sites). In these biogeochemical environments C and N exist in the most fundamental structures (e.g. aliphatic and aromatic C-H, C-OH, C=O and N-H functional groups) that comprise the basic units of organic and inorganic macromolecules.

Within natural and polluted environments, many C- and N-rich compounds exist as composite organo-mineral mixtures in addition to pure phases. The stability of organo-mineral composites in the environment depends on the complexation characteristics of the organics and inorganics involved, although the behavior of composites under varying environmental conditions is poorly understood and therefore difficult to predict. Recently and during my PhD, I have been investigating the interaction of organic compounds with inorganic (mineral) materials in terrestrial and aqueous environments under differing thermal and chemical conditions. This has allowed the determination of decomposition temperatures for the different labile and recalcitrant components of separate organic and inorganic phases, and as organo-mineral composites. Specific examples I have studied include terrestrial soils and organo-mineral solids from landfill sites. In terms of global C cycling, both soils and landfills have the capability to release large volumes of carbon dioxide and other pollutants to the environment under certain chemical and physical conditions hence understanding their degradation mechanisms is critical. To achieve this, I have helped to develop a novel thermal analysis

system (TG-QMS-IRMS) which allows (1) phase changes to be resolved as materials thermally decompose, (2) the direct measurement of coincident changes in sample mass incurred during the phase changes, (3) the simultaneous monitoring of volatile species evolved during thermal decomposition, e.g. water, carbon dioxide, methane, nitric oxide etc., and (4) the isotopic characterization of carbon dioxide gas generated during thermal decomposition reactions. TG-QMS elucidates thermal decomposition temperatures and chemical data for the different components within composite materials, thus indicating their stability up to and above 1000^{o}C. TG-IRMS allows different carbon reservoirs within composite materials to be determined and indicates the processes through which carbon has been sequestered in these materials.

7. Research implementation and results under the program

Title of your research plan:

Application of heated *in-situ* infra-red microspectroscopy to characterise the phyico-chemical effects of thermal degradation on plant and organo-mineral composite solids.

Description of the research activities:

In order to understand and characterise the physical and chemical behaviour of organo-mineral composites during their degradation, heated *in-situ* infra-red (IR) microspectroscopy experiments were carried out. This specialist analytical technique is particularly well suited to the study of complex materials as it allows changes in the physical chemistry of functional groups, e.g. aliphatic and aromatic hydrocarbons, carbonyls, hydroxyls and amides to be characterised *in-situ* during the thermal degradation of an entire organo-mineral composite sample.

Initially, reference data for organic materials (minerals absent) were obtained to characterise the changes incurred by organic functional groups during their thermal degradation. For this, samples of wheat straw, lignin, cellulose, and a cellulose and lignin 50:50 mix were investigated using stepped heating experiments between temperatures of 25^{o}C to 600^{o}C, with a heating rate of 10^{o}C/minute and transmission-reflection IR spectra were collected from the samples every 50^{o}C.

During the *in-situ* heating experiments for wheat straw, most of the IR absorption bands relating to functional groups such as H_2O (3450cm^{-1}), C-OH (3230cm^{-1}), aliphatic C-H (2965cm^{-1} and 2940cm^{-1}) and C=O (1725 cm^{-1}) showed significant decreases in intensity between temperatures of 250^{o}C to 350^{o}C. In comparison, the IR spectra obtained for cellulose during the same *in-situ* stepped heating experiments indicated that H_2O, C-OH and aliphatic C-H absorbance bands showed similar thermal behaviour to wheat straw. In contrast, the C=O absorbance bad band in wheat straw exhibited most similar thermal characteristics to lignin. The IR spectra

for wheat straw during heating were found to show the most similar thermal behaviour to the 50:50 mix of cellulose and lignin. Both these materials showed decreases in H_2O absorbance band intensity at around 25^{o}C-100^{o}C and 250^{o}C-350^{o}C. These dehydration events have been confirmed by TG-QMS during analysis of evolved volatiles from the same samples (obtained in Newcastle upon Tyne, UK). The decreases in the C=O absorbance band intensity between 300^{o}C-450^{o}C have also been confirmed by TG-QMS and evidenced by CO_2 evolution from the samples within the same temperature range. Results from this study indicate that *in-situ* heated infrared microspectroscopy can be successfully used to characterize the thermal behaviour of complex agricultural organics and is complimentary TG-QMS analysis (developed at Newcastle, UK).

IR spectra were also obtained for composite landfill solids. These data indicate the degradation of organics (predominantly aliphatics) in the presence of calcite (2530cm^{-1} and 2500cm^{-1}) during *in-situ* stepped heating experiments, although data analysis is not yet complete and N-bearing functional groups will also be characterised. Further work is necessary to understand the thermodynamics of these degradation reactions. Preliminary kinetic heating experiments have also carried out on organic reference materials (cellulose and lignin) in order to obtain reaction rate constants. The results are promising although further experimental work is to elucidate how the presence of minerals affects the degradation and overall reactivity of closely associated organics.

8. Please add your comments (if any):

My sincere thanks go to Professor Nakashima for his kindness and generosity during my stay in his laboratory. I was able to undertake a significant amount of experimental work that yielded new data sets within my research field. In collaboration with Professor Nakashima, I have already begun to prepare these data for journal publication. I hope that it will be possible to continue the collaboration between the Newcastle and Osaka research groups in the future. I would also like to thank all of Professor Nakashima's students and staff for their kindness and for making me feel so welcome in Japan. Thank you so much!

9. Advisor's remarks (if any):

This JSPS stay for Maggie was a fruit of my discussion with her supervisor Prof. David Manning of the University of Newcastle upon Tyne, last summer at an international conference in Canada. We are trying to develop a new methodology for characterizing complex natural organic-mineral composite materials by combining our *in-situ* heating IR microspectroscopy in Osaka and TG-QMS in Newcastle. Maggie's results during her 2 months stay appear to be extremely promising to establish this new combined method

from two international partner laboratories. Several papers can be envisaged from the obtained results. However, this 2 months stay was just an initiation of this collaboration and needs to be followed by the further exchange programs to produce more systematic data and good scientific publications.