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Australian Government
Department of Education, Employment
and Workplace Relations

New Welding Technologies and their Impact on the Australian Jewellery Manufacturing Industry

Gillian Rainer

International ISS Institute/DEEWR Trades Fellowship

Fellowship supported by the Department of Education, Employment and Workplace Relations, Australian Government

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Executive Summary

The Australian jewellery industry has undergone dramatic changes over the last 20 years. In addition to the unprecedented increase in precious metal prices, the local manufacturing sector has been impacted since the early 1980s by the systematic reduction of tariffs and the implementation of various free trade agreements. This has resulted in an influx of cheap mass-produced jewellery—predominantly from Asia—and the growing movement to offshore manufacturing.

The dominance of imported jewellery in the Australian market means that most of the work being done by local jewellers is in repairs, remakes, and re-sizes, resulting in the loss of manufacturing skills. In response to these developments the Australian training sector needs to do more to support more competitive jewellery design standards. The national training package for jewellery apprentices (Certificate III in Jewellery Manufacture (Apprenticeship) MEM 30605) focuses on traditional skills needed frequently to fill gaps in on-the-job training. There is often little or no exposure to handcrafting of bespoke design jewellery. Drawing and design disciplines comprise a minimal component in apprentice training.

Other countries facing similar challenges have developed innovative and effective responses. One example is the Jewellery Industry Innovation Centre in Birmingham, UK. Recent case studies in Birmingham have demonstrated the direct benefits to jewellery manufacturing companies through collaborative projects involving knowledge transfer partnerships with higher education institutions. These studies have emphasised the development of a design strategy involving innovation in design and technology, analysis of market trends and fashions impacting on the company's product and liaison with customers and suppliers.

The Fellow visited a number of jewellery manufacturing businesses in London and Birmingham, as well as educational institutions and research facilities. The Fellow was also able to attend four significant International Jewellery Fairs in London and meet contemporary leading jewellery designer/makers.

The Fellow used her time in London and Birmingham to evaluate the technologies used in high-end manufacturing of jewellery for possible introduction to Australia. The technologies evaluated included laser welding, PUK pulse arc welding for joining traditional and non-traditional metals, such as titanium and stainless steel.

The introduction of the best of these technologies into the Australian jewellery industry through new training modules will help improve opportunities for Australian designers to develop innovative jewellery solutions using traditional and non-traditional materials.

By using distinctive Australian materials, local designers can differentiate their products from mass-produced imports and by using innovative marketing strategies and improved retailer education, they can introduce Australian consumers to new experiences of contemporary Australian jewellery.

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Abbreviations and Acronyms

BA	Bachelor of Arts
BIAD	The Birmingham Institute of Art and Design
CIT	Central Institute of Technology (formerly Central TAFE, WA)
CAD	Computer-aided design
CAM	Computer-aided manufacturing
DEEWR	Department of Education, Employment and Workplace Relations
ERDF	European Regional Development Fund
EU	European Union
HND	Higher National Diploma
Hz	Hertz (the units used to measure pulse frequency)
ISS Instiute	International Specialised Skills Institute
JAA	Jewellers Association of Australia
JIIC	Jewellery Industry Innovation Centre, Birmingham
JMGA	Jewellers and Metalsmiths Group of Australia
JSIP	Jewellery Sector Investment Plan
KTP Scheme	Knowledge Transfer Partnerships Scheme
LSW	Laser spot welder
ms	Millisecond (a common unit of time, equal to 0.001 second, used to measure pulse duration)
Nd YAG crystal	Neodymium doped yttrium aluminium garnet crystal
nm	Nanometre – 1.0 x 10^{-9} metre (one billionth of a metre)
Ø	Beam diameter
OHS	Occupational health and safety
PUK	A trademarked brand of a pulse arc welding machine designed and manufactured in Germany specifically for the jewellery industry
RP	Rapid prototyping

Abbreviations and Acronyms

TAFE	Technical and Further Education
TIG	Tungsten inert gas
μm	Micrometre/micron – 1.0×10^{-6} metre (one millionth of a metre)
WA	Western Australia

Definitions

Ablation	Removal of surface material in the case of laser ablation by vaporisation.
Annealing	A heat treatment process that causes changes to the physical properties of the metal, such as strength and hardness.
Carbonisation	The conversion of an organic substance into carbon or carbon containing residue through heating at high temperatures.
Collet	A holding device that clamps the material to be held in a collar and then tightened by a tapered outer collar.
Design	Design is problem setting and problem solving. Design is a fundamental economic and business tool. It is embedded in every aspect of commerce and industry and adds high value to any service or product—in business, government, education and training, and the community in general. Reference: 'Sustainable Policies for a Dynamic Future', Carolynne Bourne AM, ISS Institute 2007.
Foaming	The partial degradation of the surface by creating gas bubbles within the material, which scatters the light and produces light marks.
Haptics	Technology that interfaces with the user through the sense of touch.
Hard soldering	Joining similar or dissimilar metals by solder, through the application of high temperatures to the objects.
Innovation	Creating and meeting new needs with new technical and design styles. (New realities of lifestyle). Reference: 'Sustainable Policies for a Dynamic Future', Carolynne Bourne AM, ISS Institute 2007.
Lab jack	An adjustable height platform for supporting work inside the weld chamber.
Lasing	The process by which lasers operate.
Optical pumping	The process of using light to raise or 'pump' electrons in an atom or molecule from a lower to a higher energy level.

Definitions

Pickling	The process of soaking objects in a dilute acid solution to remove oxides and glassy flux residue caused by heating and soldering.
Skill deficiency	A skill deficiency is where a demand for labour has not been recognised and training is unavailable in Australian education institutions. This arises where skills are acquired on-the-job, gleaned from published material or from working and/or studying overseas. Reference: 'Directory of Opportunities. Specialised Courses with Italy. Part 1: Veneto Region', ISS Institute, 1991. There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the intellectual property to themselves. Over time these individuals retire and pass away. Firms likewise come and go.
Sustainability	The ISS Institute follows the United Nations for Non-Governmental Organisations' definition on sustainability: *"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".* Reference: http://www.unngosustainability.org/CSD_Definitions%20SD.htm

Acknowledgements

Gillian Rainer would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide her throughout the Fellowship programme.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the Institute are our Fellows. Under the **Overseas Applied Research Fellowship Programme** the Fellows travel overseas. Upon their return, they pass on what they have learnt by:

1. Preparing detailed reports to government departments, industry and education institutions.
2. Recommending improvements to accredited educational courses.
3. Offering training activities including workshops, conferences and forums.

Over 180 Australians have received Fellowships, across many industry sectors.

Recognised experts from overseas also conduct training activities and events. To date, 22 leaders in their field have shared their expertise in Australia.

According to Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010':

> Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.
>
> International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.[1]

In this context, the Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows' overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the Institute's work.

For further information on our Fellows and our work see www.issinstitute.org.au.

[1] Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010', pp. 1-2 http://www.skillsaustralia.gov.au/PDFs_RTFs/WWF_strategy.pdf

Acknowledgements

Fellowship Supporter

This Fellowship has been supported by the Department of Education, Employment and Workplace Relations (DEEWR), Australian Government.

The Australian Government's Department of Education, Employment and Workplace Relations (DEEWR) implements government policies and programs to provide education and training opportunities for all Australians, to increase employment participation and to ensure fair and productive workplaces. Education, training and workforce participation are central to our goal of building a productive and socially inclusive nation, one which values diversity and provides opportunities for all Australians to build rewarding social and economic lives. Gillian Rainer would like to thank them for providing funding support for this Fellowship.

Supporters

- AR Dellow, Laser Specialist and Jeweller
  Tony Dellow, Director
- artsource
  Jenny Kerr, Manager, Client Services
- Change Act Share
  Maria Spanou, Jewellery Sector Project Assistant
- Jewellers Association of Australia
  Ian Hadassin, CEO
- Jewellery Industry Innovation Centre (JIIC)
  Dr Ann-Marie Carey, Research Fellow, and Frank Cooper, Technical Manager
- Linneys Pty Ltd
  Alan Linney, Principal
- Maunfacturing Skills Australia
  Bob Paton, CEO
- Rofin-Basel UK Ltd
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  Karin Paynter, Assistant Director Technology and Training

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Individuals and Organisations Impacted by the Fellowship

- Ian Hadassin
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- Jewellers and Metalsmiths Group of Australia
- Mal Gammon
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- Michael Dieckmann
  Chair WA Branch, Jewellers Association of Australia
- Peter Keep
  Jewellery Apprentice Lecturer
  Central Institute of Technology
- The Gold and Silversmiths Guild of Australia

About the Fellow

Name: Gillian Rainer

Employment

- Lecturer in Jewellery and Object Design, Central Institute of Technology, Western Australia

Qualifications

- Bachelor of Arts, Curtin University of Technology, 1980
- Certificate IV in Assessment and Workplace Training BSZ40198, 2003

Memberships

- Design Institute of Australia – Associate Member
- Artsource – Access Member
- Jewellers and Metalsmiths Group of Australia (JMGA)
- FORM[2]

Gillian Rainer's interest in jewellery making began at the age of 10 when her father, a Professor of Dentistry, taught her the ancient art of wax casting.

Her career in jewellery making started as a teenager when she enrolled in a summer school class at the Fremantle Arts Centre. After initially taking jewellery units at Perth TAFE during her first year Bachelor of Arts, the Fellow subsequently moved full time to jewellery design study at the Western Australian Institute of Technology (now Curtin University).

Her most significant contribution to the jewellery industry has been as a teacher in jewellery design and production in both Australia and New Zealand. For over 30 years she has successfully combined her teaching with work as a jewellery designer and maker.

The Fellow has contributed to group jewellery shows and has had solo exhibitions. One of her most significant exhibitions was *Impulse and Response* for which she was curator, and she co-exhibited at the Goethe-Institut in Wellington, New Zealand (NZ) with pre-eminent German goldsmith, Hermann Junger and a group of NZ jewellers.

More recently the Fellow has participated in of group exhibitions including *Precious Ore Precious Ties* at the Miners Hall of Fame in Kalgoorlie, Western Australia and *The Ring Project* at the Kingfisher Gallery in West Perth.

The genesis of the ideas that inform her current work is in the fundamental micro and macro forms and patterns that occur in the natural world. The Fellow is fascinated by the simple geometry found in plants and animals and the way that these patterns are repeated on various scales and in endless repetitions to create complexity and diversity.

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[2] FORM is an independent, not for profit organisation that promotes creativity across the state of Western Australia.

Aims of the Fellowship Programme

The Fellowship had four principal aims:

- First, acquire new skills in the use of laser welding and pulse arc welding for jewellery manufacture using a variety of materials including precious metals, non-precious metals and incorporating gem material, wood, plastics, glass, ceramic, stone and other materials.
- Second, establish new international networks of people using the latest technology who could be accessed for advice by Australian designers and manufacturers.
- Third, get a first-hand insight into how new technologies and contemporary design trends are being integrated into the UK jewellery manufacturing industry, and ascertain how these are used to advance their strategy to remain competitive and commercially viable in the face of low cost, mass-produced imports.
- Fourth, investigate how educational and training programmes in the United Kingdom are developed in consultation with industry to meet current and future industry requirements.

The Australian Context

The Australian jewellery industry has undergone dramatic changes over the last 20 years. In addition to the unprecedented increase in precious metal prices, the local manufacturing sector has been impacted upon since the early 1980s by the systematic reduction of tariffs and the implementation of various free trade agreements. This has resulted in an influx of cheap mass-produced jewellery—predominantly from Asia—and the growing movement to offshore manufacturing.

The pressure these changes have placed on profit margins for domestically designed and manufactured product has been a key contributor to the closure of at least 80 per cent of local jewellery manufacturing companies. The value of imported pearl and stone—both semiprecious and precious—jewellery, goldsmith and silver smith wares and other articles of precious or semiprecious materials, such as watches and clocks increased from $499 million in 1998–1999 to $2.2 billion in 2008–2009—an increase of 346 per cent. Finished jewellery imports over the same time increased by 405 per cent.[3]

The Jewellers Association of Australia (AJA) estimates that imports comprise approximately 90 per cent of jewellery sold in Australia today.[4] This is predominantly low cost, low added value product from Asia (particularly from China and India) with a low labour cost component.

A contributing factor for this is that Australian consumers are driven by price point, with little awareness or interest in where products are made and under what circumstances. Ethical issues regarding 'conflict-free diamonds' and the occupational health and safety (OHS) standards and working conditions, including the use of child/slave labour in jewellery 'sweatshops', overseas is of little concern to Australian consumers.

The dominance of imported jewellery in the Australian market means that most of the work being done by local jewellers is in repairs, remakes, and re-sizes, resulting in the loss of making skills. The low priority given to originality and excellence of Australian design and manufacture by domestic consumers is of great concern to the AJA:

> *"Unfortunately, apart from at the high end of the market, most jewellery in Australia is sold with a price focus. I believe that if we don't move away from the price-focused path then the jewellery industry is never going to exhibit strong and profitable growth."* [5]

Given increasingly competitive jewellery markets, Australian producers face the choice of either trying to survive in the face of declining profit margins or taking the initiative and differentiating themselves with innovative design driven products.

The AJA is of the view that the only viable response is for Australian designers and manufacturers to differentiate their product through innovation:

> *"All I can suggest is that retailers try to gain a competitive edge by positioning themselves as different from the rest of the market."* [6]

The training sector in Australia needs to do more to support more competitive design standards in jewellery.

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[3] Australian Bureau of Statistics 269, *897 Jewellery, goldsmiths' and silversmiths' wares, and other articles of precious or semiprecious materials*, nes; Original, A1828620K, Jan 1988 – June 2009

[4] Ian Hadassin, CEO JAA, Jewellery World Magazine, 22/01/2009

[5] ibid

[6] ibid

The Australian Context

The national training package for jewellery apprentices (Certificate III in Jewellery Manufacture Apprenticeship MEM 30605) focuses on traditional skills needed frequently to fill gaps in on-the-job training. There is often little or no exposure to handcrafting of bespoke design jewellery. Drawing and design disciplines comprise a minimal component in apprentice training.

The Jewellery Design and Production award courses offered in TAFE colleges and universities throughout Australia provide more rigorous design education. Graduates from these design-based studies may move into the trade as designers or into apprenticeships. Others may find work as designer/makers producing work for exhibition and galleries. There has been minimal collaboration or sharing of knowledge and skills between the trained designer/makers and trade jewellers, either within the educational institutions or in the marketplace.

Other countries that faced similar challenges have developed innovative and effective solutions. One example is the Jewellery Industry Innovation Centre in Birmingham, UK. Recent case studies in Birmingham have demonstrated the direct benefits to jewellery manufacturing companies through collaborative projects involving knowledge transfer partnerships with higher education institutions.[7] These studies have emphasised the development of a design strategy involving innovation in design and technology, analysis of market trends and fashions impacting on the company's product and liaison with customers and suppliers.

> *"The programme resulted in radical changes within the business including product diversification and the recognition of the value of design to overall commercial success. The programme also led the company to completely revise their product range and move into a new high value added niche market through a design strategy and reappraised operations, management, production, products and marketing."* [8]

The combination of innovative design and efficient use of new technology has resulted in development of new product, reduced product-to-market times and improved bespoke design service that has revitalised businesses competing against low priced imported product.

The Fellowship provided the opportunity to evaluate technologies used in high-end manufacturing of jewellery for possible introduction to Australia, including laser welding, pulse arc welding for joining traditional and non-traditional metals, such as titanium and stainless steel.

The introduction of the best of these technologies into the Australian industry through new training modules offered by organisations, such as the Industry Skills Council, will enhance opportunities for Australian designers to develop innovative jewellery solutions using traditional and non-traditional materials and develop niche markets using distinctively Australian gem materials such as Pink Argyle diamonds, Broome pearls, opal, stone, wood and glass.

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[7] A Gay Penfold, Diversification, Design, Strategic Planning and New Product Development: A Jewellery Industry Knowledge Transfer Partnership, University of Central England, Birmingham, The Design Journal, Volume 10 Issue 1, Ashgate Publishing Limited 2007

[8] ibid

The Australian Context

By using distinctive Australian materials, local designers can differentiate their products from mass-produced imports. By using innovative marketing strategies and improved retailer education, they can introduce Australian consumers to new experiences of contemporary Australian jewellery.

Current Australian Nationally Accredited Courses in Jewellery Design and Manufacture:

- 91047 NSW Diploma of Jewellery and Object Design
- 91046 NSW Advanced Diploma of Jewellery and Object Design
- MEM30803 Certificate III in Jewellery Manufacture
- MEM30605 Certificate III in Jewellery Manufacture
- 40050 SA Certificate III in Engineering (Jewellery)
- 21622 VIC Advanced Diploma of Engineering Technology

SWOT Analysis

Strengths

- New innovative jewellery using diverse materials
- Location/access to unique high quality raw material
- Growing global awareness of Australia as a brand concept
- Existing skills and knowledge
- Educational/training infrastructure (TAFEs & Universities)
- JAA new Code of Conduct
- High quality jewellery repair capabilities

Weaknesses

- Inadequate research and development
- No overarching marketing strategy to promote an Australian jewellery identity in domestic and overseas markets.
- Australia is geographically isolated from centres of technology, R&D and innovation in design.
- Retailers are poorly informed about issues affecting the industry.
- Consumers and manufacturers are resistant to change.
- There is currently inadequate statistical data on industry trends.
- A lack of relevant accredited training modules.
- Inadequate communication and collaboration between the education sector and the jewellery industry.

The Australian Context

Opportunities

- International research into new technologies.
- Utilisation of new technologies to produce innovative high value added jewellery.
- Growing design awareness in the local and global consumer markets.
- A design led revitalisation of the Australian Jewellery Manufacturing Industry.
- Niche market opportunities using unique Australian gem material.
- Faster turnaround on repair and remake of existing jewellery.

Threats

- Cheap imports flooding the domestic market.
- Falls in the value of the dollar.
- Consumer indifference about where jewellery is made.
- Industry complacency about the ongoing viability of the domestic jewellery design and manufacturing sector.
- Educational and training modules failing to respond to—and reflect—rapid changes in technologies relating to welding and associated required skill sets.

Identifying the Skills Deficiencies

The following specific skill deficiencies were identified by the Fellow prior to her departure to the United Kingdom:

Application of new and emerging technologies for joining and combining materials for innovative jewellery production.

Learn each step in the use of laser welding and PUK pulse arc welding for creative jewellery applications with specific questions relating to:

- types of material—metal/non-metallic
- thickness and profiles
- heat generated at weld point
- OHS requirements
- material inputs and outputs/by-products.

Objective: Become skilled in laser welding and PUK pulse arc welding techniques for innovative jewellery production for one-offs and niche manufacturing, with particular reference to quality assurance and sustainability.

New welding technologies for jewellery restoration and repair.

Analyse and evaluate the use of PUK pulse arc and laser welding applications in:

- The repair of casting porosities.
- Restoration of vintage jewellery, without ruining the integrity of the piece.
- Delicate repairs without risking further damage to fragile antique jewellery.
- Repair of damaged components that are in close proximity to precious and semiprecious stones, enamel and other fragile or ephemeral material.
- Re-use and recycling of component parts to create new pieces.

Objective: Gain skills and new insights in the use of PUK pulse arc and laser welding for restoration and repair purposes.

The commercial viability of these new technologies in Australia for jewellery production, restoration and repair, including small studio production, niche and large-scale manufacturing.

Obtain insights on:

- design styles, parameters and solutions
- material use
- speed and cost of manufacture
- training availability and cost of training
- infrastructure costs and changes
- strategic promotions and marketing
- industry culture.

Objective: Obtain new insights regarding the impact of new technologies on the design and manufacture of innovative jewellery.

Identifying the Skills Deficiencies

Address current inadequate professional networks between Australian and overseas jewellery designers and educators.

Through new international networks established by this Fellowship, new insights will be sought on the following:

- Development of new technologies in the UK and Europe
- Effective industry cultural attributes within the overseas jewellery industry.
- New product development
- Changing market trends due to new technologies.

Objective: Broaden and deepen professional networks between Australian and overseas jewellery designers and manufacturers in order to take advantage of technological advances occurring overseas in a timely manner.

The International Experience

The Fellow visited London and Birmingham to gain new insights on laser welding. Both cities have a recognised jewellery 'quarter' occupied by polishers, stone mounters, stone setters and other specialists who operate as separate and specialist businesses. Australian jewellers, by contrast, have tended to structure their businesses as a one-stop-shop.

AR Dellow

Laser Specialist and Jeweller, Hatton Garden, London

Contact: Tony Dellow, Director

Hatton Garden is known internationally as London's jewellery quarter and the United Kingdom's diamond centre.

AR Dellow operates two manual laser spot welders (LSWs). Tony Dellow and his team of three jewellers, a stone setter and business manager service the jewellery quarter seven days a week. Dellow also conducts weekend training courses in laser welding at Holts Academy.[9]

The laser spot welders at AR Dellow are in constant use. The workshop also uses flame soldering with oxy-propane and micro welding using electrolytic gas generation.

The Fellow was given the opportunity to get hands-on experience with the laser welder. A significant initial adjustment that had to be made by the Fellow was to become familiar with using a 15x magnification microscope. Using a microscope also requires a readjustment in hand–eye coordination. To get maximum benefit from a LSW, an operator must have a good understanding of the metallurgical properties of the alloys being welded. Because of its similar thermal properties to platinum, the Fellow used stainless steel for her initial sampling of the LSW.

Using the LSW so early in the Fellow's itinerary served as an excellent foundation for deeper learning on the more technical aspects of the range of lasers.

Set-up Procedures for Laser Welding

Correct adjustment of the 15x magnification microscope is vital in ensuring the correct weld position at the focal point of the laser beam. To get the clearest possible focus and cross hair alignment with the focal point of the laser beam, the operator must:

1. Move the eyepieces closer together or further apart to suit individual. One circular shape should be clearly visible for perfect stereo view. Place a stainless steel plate on the lab jack provided and adjust the height.
2. Have the stainless sheet sharply in focus.
3. Looking through the right ocular with left eye closed adjust the cross hair to maximum sharpness.
4. Looking through the left eyepiece only, adjust again so that the object is in focus.
5. Fire the laser once to check that the intersection of the cross hairs lines up exactly on the resulting weld spot. Adjust if necessary.
6. Loosen the bolt below the microscope, realign cross hair with spot, and tighten.

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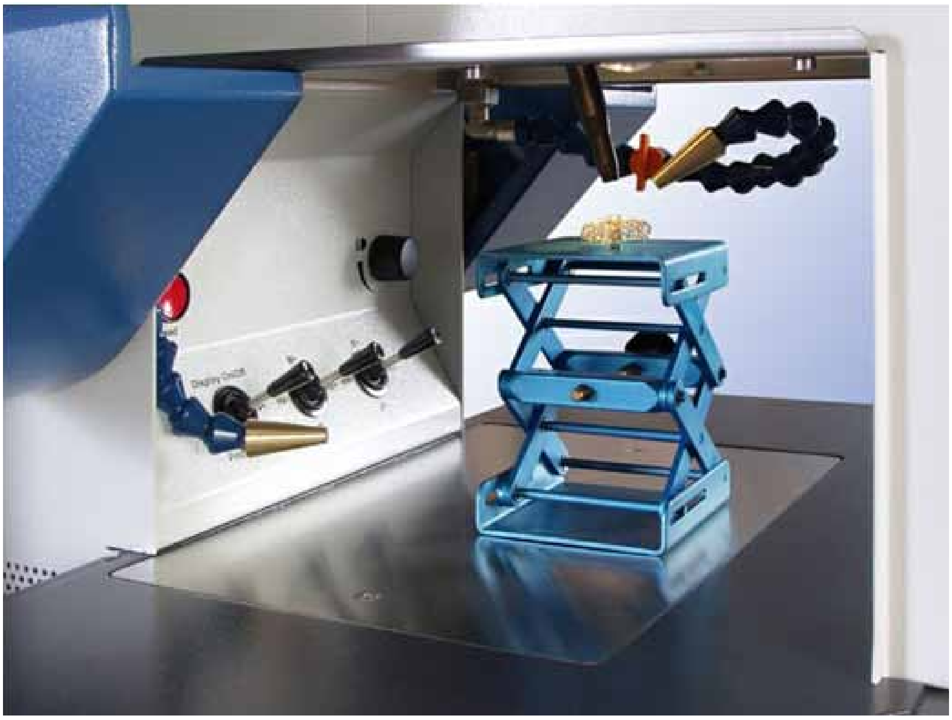
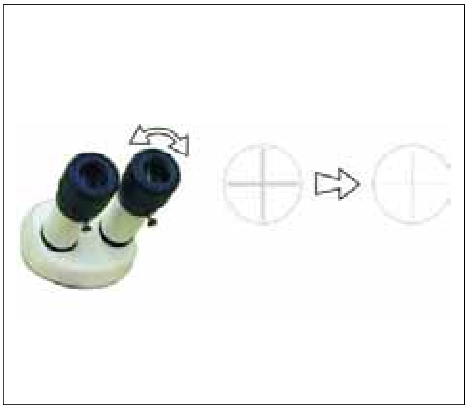
[9] A Located in Hatton Garden, Holts Academy is a not-for-profit organisation that provides training for all levels of the jewellery industry and runs a variety of projects aimed at assisting growth of the jewellery industry in the UK through supporting existing businesses, new start-ups and those wishing to enter the industry. www.holtsacademy.com

The International Experience



Lab jack (image courtesy of The Goldsmiths' Company)



Focusing the Microscope (image courtesy of Rofin Laser Micro)

Working Position (image courtesy of Goldsmiths' Company)

These procedures are critical for effective work and comfort. An operator using incorrect microscope adjustment will not work efficiently and accurately.

The Fellow was also given a demonstration of the *Rofin StarWeld* desktop manual laser welder.[10]

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10 Rofin-Baasel have specialised in producing laser machinery for a wide range of industries for 35 years. The Star Weld Manual Desktop laser welder is readily portable, fitting in the boot of a car, and highly suitable for a workshop where space is limited.

The International Experience

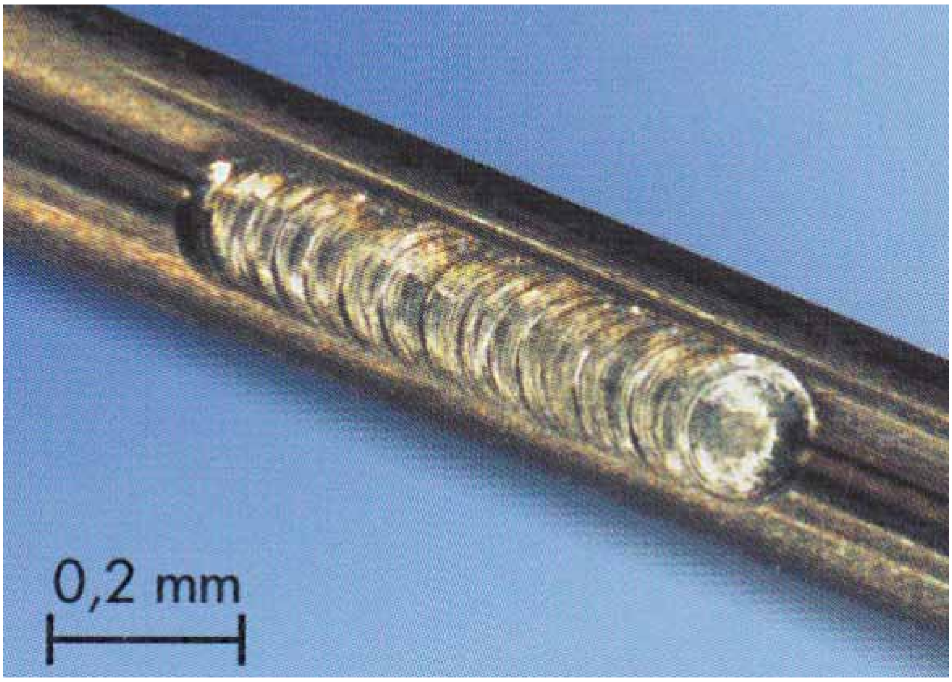
The manual laser welder is operated using a foot pedal. The pedal depresses in two stages: the first stage releases argon gas and the second stage fires the laser pulse. Pulse frequency settings can be one pulse per second or a series of pulses. Argon is used for welding titanium, aluminium and certain low carat alloys as the gas provides a protective shield that inhibits the formation of oxides.

The capacity of a laser to produce the results desired depends on the power of the beam (voltage), pulse frequency (Hz), pulse duration (ms) and laser beam diameter (Ø).

The Fellow tested different settings on an eight-millimetre thick stainless steel coaster. Practice was needed to find the focal point and accurately position the piece. Experimenting with different parameter settings gave the Fellow a basic understanding of different spot welds that can be achieved by changes to voltage, duration of pulse and beam diameter. Initially the frequency was set at one pulse per second.

When the pulse of laser energy is focused into a small spot (adjustable form approximately 0.3 to 2.0 millimetre Ø) onto the work piece, the energy density (energy/area) becomes quite large. The light is absorbed by the work piece causing a 'keyhole' as the focused beam drills into, vaporises and melts some of the metal. As the pulse ends, the liquefied metal around the 'keyhole' flows back in, solidifying and creating a small 'spot' weld. The entire process takes milliseconds. By increasing the voltage on a short duration narrow beam, deeper penetration of the material is possible. This approach is used for welding thicker material, such as heavy ring shanks.

By extending the pulse rate more heat is conducted. This results in a wider and deeper melt pool. This method is used for welding silver, which is an efficient conductor of heat and requires more energy to achieve strong weld results.



Seam weld

Increasing the beam width while keeping the voltage constant reduces energy density over a larger area of the work piece. The resulting shallow weld pool is suitable for smoothing out weld spots on seams and subsequent polishing. As the laser can fire many pulses per second, moving the work piece during the laser firing process enables the operator to achieve separate spot welds or overlapping spot welds to create a seam weld.

During her time at AR Dellow the Fellow observed practical applications of laser welding. Replacing a broken catch or repairing a damaged fine chain is difficult—if not impossible—using flame soldering. A bolt-ring catch contains a fine steel spring that, if heated, losses tension. Laser welding makes such a job routine. There is no need for clean up, post-weld pickling or polishing.

Another job observed was the repair of a gem set antique watch with a broken link. Using flame soldering for such a task is complex and time consuming. Stones would have had to be removed and reset after finishing. The watch mechanism and face would have to be protected from the heat and require post-weld pickling to remove flux and oxides.

Broken watch bracelet

Completed repair

The International Experience

Repair enamel jewellery (image courtesy of Tony Dellow)

In contrast, pulse laser welding allows for cooling between each spot weld, resulting in a very small heat affected zone. This makes it ideal for thin sections requiring welding, adjacent to heat sensitive materials. Repairs can be done safely as close as 0.2 millimetres from heat sensitive material. Because no solder is added, the integrity of the surrounding metal is preserved. If filling material is required, the same alloy as the parent metal can be used. Enamel jewellery is similarly unaffected by laser welding.

Further examples of repair work carried out by Tony Dellow included a tortoise shell and silver box. A section of the hinge had torn away from the lid. This repair using conventional technology would be virtually impossible and certainly not cost effective. Using the laser the repair was quick and clean.

Repair of tortoiseshell and silver box (image courtesy of Tony Dellow)

Repair of tortoiseshell and silver box (image courtesy of Tony Dellow)

The tiara with enamel, pearls and set stones was easily modified with the addition of two pre-set diamonds using the laser welder.

Modification of tiara (image courtesy of Tony Dellow)

Modification of tiara (image courtesy of Tony Dellow)

Platinum ring sizing and alterations make up a significant proportion of Dellow's work. Demand for seamless rings without solder lines makes the laser welder a perfect tool for the job. Ring sizing, re-tipping of claws and re-shanking can be done without having to protect or remove stones. Minimal post-welding processing is required and the integrity of the object is retained both visually and structurally.

Rofin-Baasel UK Ltd[11]

Contacts: Dave MacLellan, Sales Manager, Micro Division, and Paul Hughes BA (Hons), Sales, Laser Marking Products

Rofin-Baasel is the UK sales and service subsidiary for the Rofin group.[12]

Headquartered in Dusseldorf, Germany, Rofin designs and builds industrial lasers for metal and plastics welding, marking, etching and engraving, metal and non-metal cutting and surface modification and ablation.

The two days at Rofin-Baasel provided a unique opportunity for the Fellow to gain a deeper understanding of the theory and practice of laser welding and marking, including the history of laser welding, the lasing process, the physics of lasers used in micro-scale laser welding of specific metals and the application of laser welding systems in the jewellery industry.

There are countless applications for laser marking and engraving. Vector-based laser marking software delivers precise, rapid engraving. No tool bits make contact with the engraved surface. Unlike the wear and tear to tools used in mechanical engraving, laser engraving does not involve tools making contact with the target surface. Laser technology is also more environmentally friendly in that no solvents or caustic chemicals are used in the process.

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11 www.rofin-baasel.co.uk

12 www.Rofin.com

The International Experience

Lasers can mark nearly all metals, many plastics, ceramics, glass, quartz, wood, film, fabric, paper and rubber with high contrast and without adding any undesirable substance. The laser does not cause surface modification. Laser marking is used in a variety of applications and industries including medical, aerospace, automotive, pharmaceutical, and electronic.

There are a range of commercial jewellery applications for laser engraving and marking to create decorative surfaces, inscriptions, cells for inlay or enamel, identification marks in stones, and hallmarking.

The laser provides five different marking methods: annealing, laser engraving, surface removal, colour change, and hallmarking.

Annealing

Laser annealing creates an indelible mark induced by heat and oxygen without noticeable material ablation. Annealing is used on metals that change colour (such as stainless steel) when exposed to heat and oxygen. The laser heats small areas of the work piece until annealing colours appear. Annealing leaves the surface of the material unharmed while producing high-contrast, clear markings. As a burr-free process, annealing has significant advantages when used on finished surfaces. Process speed is lower compared to engraving. Because annealing is a thermal process, engraving speed is slower than other forms of laser engraving.

Annealing (image courtesy of Rofin Baasel)

Laser Engraving

The laser engraves the material surface, down to a depth of around 10 µm. Engraved marks are durable, forgery-proof, resistant to wear, tear and corrosion and can only be removed by heavy grinding.

Laser engraving (image courtesy of Rofin Baasel)

Laser engraving (image courtesy of Rofin Baasel)

Surface removal (image courtesy of Rofin Baasel)

Surface Removal

Selective ablation of lacquer coats or anodising layers of a material exposes a different colour underneath.

This laser process produces coloured markings. It is used for marking anodised aluminium and labels made of special multiple-layer foils.

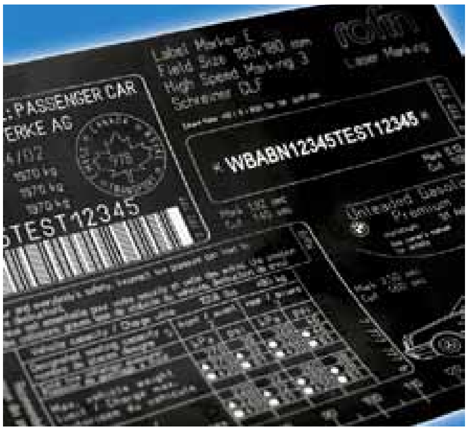
The perfume container to the left is anodised aluminium where the coloured anodising has been removed to reveal the 'white' aluminium below.

The International Experience

Colour Change

Laser marking of polymers relies on a carbonisation (or foaming) process caused by laser beam absorption. Carbonisation is a thermochemical reaction that produces dark marks. Foaming is a partial degradation process created by gas bubbles in the material that scatters the light and produces light marks.

Colour change



Colour change

Hallmarking

Hallmarks are distinctive marks applied to a precious metal. Precious metals are rarely used in their pure form for jewellery or other objects. Instead they are alloyed with other metals. In the UK it is required by law to hallmark any article containing precious metals if the alloy content is stated at point of sale.[13] No such legal requirement exists in Australia.

Handmarking is a traditional method of stamping three marks: the maker's or manufacturer's mark, metal and fineness and the assay office mark.[14]


Handmarking hallmarks

Laser hallmarking and engraving are increasingly popular. Mass produced jewellery is generally light weight and hollow and is very difficult to hallmark using conventional stamping methods. During laser hallmarking, a very fine laser beam of high power is used to melt and vaporise material, thus allowing creation of a detailed mark. Unlike the traditional method, laser hallmarking is similar to etching in that material is removed during the process. A laser hallmark requires minimal cleanup or post-processing, does not cause bruising or deformation and is consistent in depth and quality.

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[13] UK Hallmarking Act 1973

[14] The London Assay Office offers two additional optional marks: the date mark and the traditional fineness mark.

For high-end product a deeper hallmark, closely resembling a stamped mark, is also possible and can be achieved without the risk of deformation.

Goldsmiths' Fair 09[15]

Goldsmiths' Hall, London

Goldsmiths' Fair provided the Fellow with an opportunity to see contemporary British jewellers and silversmiths showcasing their wares. The Goldsmiths' Fair coincided with *Origin: The London Craft Fair.*[16] Events such as these provide established and emerging designers and makers with an important marketing and networking platform. The events are judged and highly competitive.

At both the Goldsmiths' Fair '09 and the London Craft Fair the Fellow met a number of makers who use laser cutting and welding and the PUK welder.

Tom Rucker

Tom Rucker was the first Master Goldsmith in the UK to introduce laser welding to the jewellery trade. Over the past 15 years he has developed a unique laser welding technique known as GEO.2. These exquisite platinum and 18 ct gold with pearl and gems pieces of jewellery show the exceptional design possibilities provided through laser welding.

Angela Fung

Angela makes highly interactive kinetic jewellery using laser cutting and other new technologies in combination with traditional bench skills.

Jewellery by Tom Rucker

'Silver Glide' by Angela Fung, a bangle with moving amethyst, pink topaz and garnet stones, 18 ct gold rivets.

[15] www.thegoldsmiths.co.uk

[16] www.craftscouncil.org.uk/origin09

The International Experience

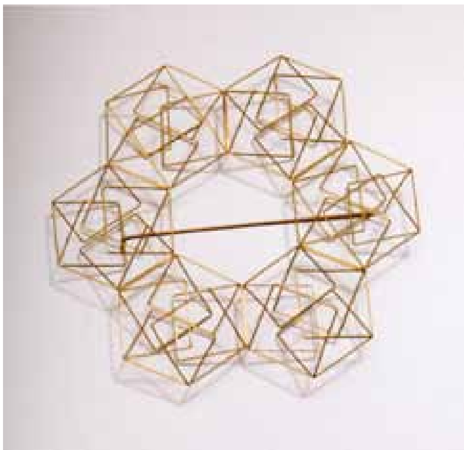
Sarah Herriot

Sarah Herriot generates her forms using computer-aided design and computer-aided manufacturing (CAD, CAM) in two halves that are then laser welded together.

Kamilla Ruberg

This delicate wire brooch below, reflecting Ruberg's fascination with geometry, is an excellent example of the superiority of laser welding over soldering in ensuring the wiring remains taut.

'Fine Twist' ring, in 18 ct gold by Sarah Herriot



'Anamorphic Brooch No 7' by Kamilla Ruberg

Andrew Lamb

Lamb first used a laser welder while at the Royal College of Art in London. He subsequently was introduced to the PUK 2. He now owns and uses a laser welder and a PUK 2.

This brooch by Andrew Lamb, inspired by woven textiles, comprise a combination of fine 18 ct gold and silver wires, layered, twisted and overlapping

David Poston

David Poston describes his work as restrained, uncluttered and functional. His hand-made jewellery is aimed at creating a tactile experience for the wearer rather than for ornamental ostentation. Poston uses hot-forged titanium and stainless steel often with 24 ct detail utilising laser welding to join his constructed hollow forms and to weld the forged titanium bangle forms.

750 Yellow Gold Laser welded Hollow Bangle by David Poston

Treacle and Syrup by David Poston

The Goldsmiths' Company

Contact: Karin Paynter, Assistant Director Technology and Training.

The Goldsmiths' Company is one of the 12 great livery companies in the City of London.[17] It received its first royal charter in 1327. The Goldsmiths' Company continues to play an important role in the industry through the provision of technical training and promoting excellence in the design and crafting of silverware, jewellery and art medals, supporting commissions, competitions and exhibitions. The annual Goldsmiths' Fair is open to the public and provides an excellent marketing opportunity for new and established makers.

The Fellow was provided with a set of technical papers, with particular emphasis on new technologies and a set of DVDs dealing with current research and development projects, as well as information about international trade fairs, the latest in equipment and design trends, and scholarly papers on metallurgy

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[17] Formally known as The Worshipful Company of Goldsmiths

The International Experience

Change Act Share[18]

Contact: Maria Spanou, Jewellery Sector Project Assistant[19]

Change Act Share began as the communications arm of the Jewellery Sector Investment Plan (JSIP).[20] The JSIP is an industry-led project created to address challenges facing the international and national market. The principal objective of the JSIP is to consolidate Hatton Garden as the international jewellery industry centre synonymous with quality design and innovation. The JSIP is funded by the European Regional Development Fund (ERDF), London Development Agency, The Goldsmiths' Company, the Borough of Camden and the private sector.

The JSIP identified jewellery as a global growth industry. JSIP market research confirmed that branding and fashion are the primary drivers in decisions to purchase jewellery. Research also pointed to increased spending per purchase along with an increase in the number of high disposable income women buying more jewellery. Emerging markets in developing countries were also identified.

On the downside, JSIP research showed that poor consumer knowledge about materials and processes hindered their capacity to discern between high and low quality product. The need to better educate consumers was seen as an important first step in boosting demand for high-quality, designer jewellery and allied products. Other hurdles identified included the high cost of involvement in international trade fairs, insufficient export market intelligence, lags in uptake of new technologies and poor business skills. Higher education graduates tend to work as independent designer/makers, thereby hindering the transfer of design knowledge to the wider industry.

The JSIP recommended the implementation of a series of industry-wide initiatives including capital equipment grants for small jewellery businesses to help with the cost of up-tooling, assistance through the London Jewellery Exports project to prepare designers for exhibiting at international trade fairs, a mentoring programme for up-and-coming designers and the establishment of a UK jewellery trade directory listing suppliers, designers, manufacturers, retailers and industry media contacts.[21]

The project continues to evolve in response to industry feedback.

The Birmingham Jewellery Quarter

The Birmingham jewellery quarter is a major British commercial centre for the jewellery trade and related metal working industries. Around 5,000 people work in the quarter, mainly in small to medium enterprises. A series of economic regeneration initiatives are focussing on retaining and revitalising the quarter as the City Region's Creative Village.

The Birmingham jewellery trade emerged from the 18th century buckle and button industry that had given Birmingham its reputation as the toy shop of Europe.

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18 www.changeactshare.org

19 maria.spanou@camden.gov.uk

20 Jewellery Sector Investment Plan, October 2005. See www.changeactshare.org

21 www.changeactshare.org

The International Experience

As the buckle trade declined from the end of the 18th century, Birmingham's engravers, die sinkers, solderers, platers, polishers, precious metal dealers, and tool makers adapted their skills to the manufacture of small gold and silver accessories including jewellery.

The establishment of the Assay Office in 1873 gave Birmingham jewellery its own hallmark. The 1881 census shows that, including watchmakers, nearly 20,000 people were employed in the industry, making it the second largest employer to the brass and copper sector.

In 1887 the Birmingham Jeweller's and Silversmith's Association was established to set trading standards, provide technical education, and find new markets.[22] In 1888 the Birmingham School of Jewellery was founded and since 1890 it has been located in Vittoria Street.

Jewellery Industry Innovation Centre (JIIC)[23]

Vittoria Street, Birmingham

Contacts: Dr Ann-Marie Carey, Research Fellow, and Frank Cooper, Technical Manager

The Jewellery Industry Innovation Centre (JIIC) provides mentoring and other services for the local jewellery industry, including training in CAD, CAM, rapid prototyping, surface finishing, laser welding and marking, anodising and colouring, and project management.

The JIIC was established in 1997 to enable small and medium enterprises to better access technology. Although there was an initial emphasis on technology transfer, it became apparent to the JIIC project managers that there was little investment in design and that new technology alone would not address industry problems. Design skills were identified as one of the strategic options for businesses to generate new markets or to enable firms to diversify away from a reliance on low value-added products. Local manufacturers could not compete with the influx of low value, predominantly Asian product by continuing to produce low value (9 ct gold) imitative jewellery ranges that lacked innovation in design. Design intervention that delivered high value-added product was recognised as crucial to improved competitiveness.

Funded by the EU and the British Government, the JIIC focused its activities initially on getting computer-aided design (CAD) and rapid prototyping (RP) technologies into industry. In its first five years of operation, funding from the European Regional Development Fund (ERDF) through its *Innovative Frameworks for Business* programme went to assist approximately 200 jewellery businesses in the West Midlands region.

The JIIC also assists companies with new product design and development, market research and trend analysis. It is currently delivering its New Product Development Project to over 150 businesses. Qualifying companies receive expert design assistance either through bespoke design services or training in specific CAD programs. Increased use of design strategies has enabled companies to diversify and move away from low value-added ranges towards innovative, high value-added product. The JIIC has been particularly active in, and successful at, fostering collaborations between universities, design graduates and the jewellery industry.

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22 Now known as the British Jewellers' Association

23 www.jewellery-innovation.co.uk

In addition to facilitating new technology evaluations, providing various kinds of technical support the JIIC also offers a range of education and training programmes and short courses where participants have access to laser welders and cutters, marking machines and anodising and polishing facilities.

Although focused mainly on the jewellery industry the JIIC also assists other industries including electronics, giftware, ceramic, white goods industries and engineering.

Training room – Dr Ann-Marie Carey, laser welding (image courtesy of The Fellow)

Monitor for training purposes. A camera is fitted to the microscope to enable the image, seen by the operator, to be viewed on the monitor by trainees (image courtesy of The Fellow)

Birmingham Institute of Art and Design (BIAD)

School of Jewellery, Birmingham City University[24]

Contact: Gaynor Andrews, Course Director

The Birmingham Institute of Art and Design (BIAD) is one of the largest and most prestigious institutes of art, architecture and design education in the United Kingdom. BIAD offers a comprehensive range of courses for almost 4,000 students at all levels, from further education to higher research.

Gaynor Andrews is the Course Director for the Higher National Diploma (HND) in Jewellery and Silversmithing. She has built strong links with manufacturing jewellery companies through competitions and collaborative projects. She also supervises Knowledge Transfer Partnerships and is a Teaching Fellow for CAD and Haptics technology. Andrews works closely with the JIIC to ensure new technologies are incorporated into the relevant curricula and she is committed to combining practical skills and new processes with good design.

24 www.bcu.ac.uk

There are several study pathways for students, including horology, gemmology and jewellery silversmithing. The qualifications available go up to PhD level.

During the course of this visit the Fellow recognised that similar issues to those experienced in Australia exist regarding graduates from concept driven art and design-based courses emerging without adequate skill sets required for work in the jewellery industry. This has been addressed recently by the School of Jewellery with the addition of the BA (Bachelor of Arts) Design for Industry as an add-on year for the HND graduates. This top-up degree provides skills in CAD, CAM and laser technology and students get the added benefit of being located in the jewellery quarter with all its allied industries. Graduates also have access to ongoing learning and skill development through year-round short courses.

Students and graduates get hands-on industry experience through the Knowledge Transfer Partnerships (KTP) scheme. The KTP scheme is a government funded program linking British companies with expertise available in universities. The KTP and its predecessor, the Teaching Company Scheme, have provided British companies with new opportunities to break into new technologies, new markets, new processes and production methodologies. Originally focused on engineering, the KTP has diversified to include not only the physical and social science disciplines, but also the arts, the media, and the social environment and now covers most UK business sectors.

Sutton Tools–Thomas Sutton (B'ham) Ltd[25] and Weston Beamor Ltd,[26] Birmingham

Contacts: Joshua Kindness, Sales Manager (Sutton Tools), and Glen Day DGA, Production Manager (Weston Beamor Ltd)

Sutton Tools is the UK agent for Lampert Werktechnik GmbH.[27] Lampert Werktechnik is a German company that developed micro-arc or micro-TIG welders for use in jewellery production and repair as a lower cost option to manual laser welders. TIG welding was first used in the 1940s for welding magnesium and aluminium. TIG has found wide acceptance for welding most types of metals including steel, nickel alloys, titanium and precious metals.

Weston Beamor was the first company in the UK to provide a commercial casting service to the jewellery industry. Its state-of-the-art casting facility makes casts in Platinum (950), Palladium (950), Gold (22 ct, 18 ct, 14 ct, 9 ct), and sterling silver (925). The company has 113 employees, making it the largest employer in the UK jewellery industry.

Visits to Sutton Tools and Weston Beamor provided the Fellow with the opportunity to get new insights into the technologies and applications of micro-TIG[28] welders (more commonly known as PUK welders) and laser welders in use throughout the jewellery industry. The visits were of particular benefit in enabling the Fellow to assess, through on-site observation and use, the respective advantages and disadvantages of these particular welding methodologies.

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25 www.suttontools.co.uk

26 www.westonbeamor.co.uk, www.domino-wb.co.uk

27 www.lampert.info

28 TIG welding stands for tungsten inert gas welding

Laser and PUK technologies bring to the jewellery industry a fundamentally new and different source of heat resulting in the possibility of new processes for manufacturing. These processes allow jewellers to join materials that cannot be joined by traditional flame and solder technology, to reduce the number of steps in assembling parts and to realise innovative design possibilities.

While both PUK and laser welding represent a significant departure from the traditional method of joining parts in jewellery, they are manual skills that complement existing bench skills.

The joining of metal parts in jewellery making, silversmithing and goldsmithing has traditionally been accomplished using solder. Soldering is the joining of similar or dissimilar metals by use of solder and the application of heat to the object. A 'hard' solder is so called because of its high melting temperature. Hard solders have a melting temperature ranging between 680 degrees Celsius for the lowest melting point silver solders to 1390 degrees Celsius for platinum hard solder. These solder alloys are generally of similar colour and composition to the parent metals being joined. There are several grades of solder that melt at decreasing temperatures, thereby enabling subsequent solder operations to be performed without re-melting a previous join. However, there is a limited number of re-soldering operations possible without risk of re-melting of solder and resultant degradation of the solder seams.

Jewellers have traditionally used flame as a heat source for soldering. Usually this is by way of a gas torch that generates a large amount of diffuse heat. The heat is conducted through the metal, resulting in annealing of the surrounding metal, oxide formation and potential damage to heat sensitive materials such as gems, enamel and organic materials. Careful planning is required when determining the order of assembly of complex objects. If any subsequent repair, alteration or re-sizing is required disassembly of the object can be time consuming and therefore costly.

Laser and PUK welding can frequently short-circuit this because of the precise nature of the heat they deliver.

Pulse Arc (PUK) Welding

Arc welding uses a power supply to create an electric arc between an electrode and the work piece to melt the metal at the weld point. TIG welding is a manual arc welding process in which an arc is formed between a pointed tungsten electrode and the work piece in an atmosphere of inert gas, known as a shielding gas, to shroud the area around the weld to prevent oxidation. The small, intense arc generated by the electrode is ideal for quality and precision welding. By controlling the heat input, welds can be made on a range of materials of varying thicknesses. The electrode is not consumed in the process and if filler material is required it is fed in manually into the front edge of the weld pool. Materials added to the welding spot are usually of the same type of metal as the welding object.

PUK welders are 'pulse arc' welders. When the welder is fired, capacitors inside the machine charge up and release energy in a single pulse. This produces small, short duration spot welds similar to those produced by laser spot welders.

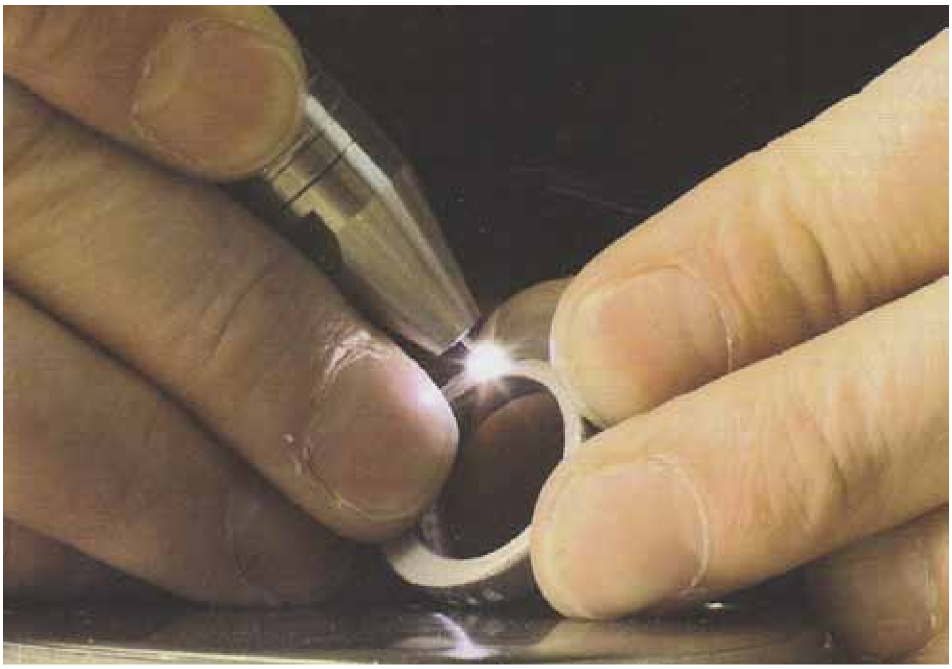
The International Experience

There are three models in the latest generation of PUK welders. The basic model is designed specifically for tacking prior to soldering without needing to use jigs or binding wire. The *Professional* and the *Professional Plus* models incorporate electronic controls for the adjustment of power and pulse parameters. With the *Professional Plus* model, over 30 per cent more power is generated to hard-weld metals like silver. Both professional models include a 10x magnification welding microscope. The microscope contains a liquid crystal shutter that closes during welding to protect eyes. There is also an optic unit for use on larger pieces or for use with the basic model that includes a magnifying lamp and glare protection. All viewing is done through a shaded shield that automatically darkens when the arc is made.

The cost of a top-of-the-range PUK welder, plus all accessories, is around AUD $10,000.

Each of the models includes a control unit, a welding hand piece with tungsten electrodes, clips and tweezers for holding the work piece. The hand piece can be clamped to free-up the hands for holding parts or adding filler material. The work piece must be positioned on the work table and clamped with either an alligator clip or cross locking tweezers to ensure optimal electrical contact.

All these devices can be connected to the control box and constitutes the positive lead. The hand piece is the negative lead. The collet holds the replaceable electrode, which protrudes several millimetres from the tip. To begin the welding process the retractable electrode tip in the hand piece is touched to the work piece completing the electrical circuit. Argon shielding gas (at 99 per cent purity) then flows from the tip. An audible signal is heard just before the electrode automatically retracts, starting the welding process by creating a momentary arc that makes one spot weld. Depending on the setting used, the process takes about 2 seconds.



PUK 3 welding

The degree of pressure exerted on the tip is the most critical factor in creating a good weld. It is crucial that the electrode tip remains sharp. To achieve this, the electrode must be reground regularly using diamond abrasive wheels or files. This requires removing the electrode from the collet by removing the end cap, loosening the collet, removing and replacing the blunt electrode, tightening the collet and then closing the end cap. The procedure can take as little as 30 seconds.

The setting of welding power and pulse time allows for regulation of the spot weld diameter (from 0.3 mm–3.0 mm) and penetration depths up to 0.8 mm with minimal heat development in the surrounding metal. Deep penetration is best achieved with metals that have low heat conductivity using a high power setting. Penetration depth also depends on the angle that the electrode is held at in relation to the work piece. Deepest penetration is at 90 degrees. The parameter settings vary for different metals according to their melting temperatures and thermal conductivity. Silver is the most problematic of the precious metals to weld when using either laser or a pulse arc welder. Because of its high thermal conductivity, it requires short pulse times and high power. It is possible to weld metal as thin as 0.1 millimetres using the microscope and the micro-mode function. Two different electrode diameters are available (0.5 and 0.6 millimetres). The larger electrode diameter means that a higher welding current can be used.

As with the laser welding systems, additional metal such as welding wires (0.25–0.4 millimetres in diameter) can be added by hand to fill porosity along fracture lines and in deep weld positions, such as thick ring shanks. In this situation a ‘v’ is filed at the join and then with successive passes the groove is backfilled with the parent metal. All precious metals and precious metal alloys made of gold, silver, platinum and palladium, high-grade steel and titanium, as well as many tin alloys and aluminium alloys can be welded using a PUK.

Solders are not recommended for use with a PUK welder due to the additives in the solder alloys burning and causing porosity. Repairs around soldered areas are therefore complicated and removal of existing solder is recommended. A PUK welder delivers many of the attributes of the manual laser welders at a much lower capital cost. There are, however, some differences and limitations that need to be considered.

With the PUK welder the electrode must touch the area to be welded to start the welding process. The length of the electrode therefore limits the area reach. There are also issues relating to the tungsten tips causing contamination of the weld. This is less likely to occur with an experienced user. Repair of casting porosity is possible with a PUK welder by opening and cleaning out the trapped investment by drilling and then welding a post into the pore. Welding without shielding gas is not possible with a PUK because of heavy oxidation and rust formation around the weld point. The required use of 90 per cent pure argon is an additional expense associated with pulse arc welding.

Laser Welding

A laser can emit an amplified light beam produced by a chain reaction initiated by a single photon interacting with excited atoms. This photon stimulates the emission of more photons, with a waterfall effect. Therefore, the laser effect requires a suitable external energy source to start the process. The mechanism of external power supply is known as optical pumping.

A laser system consists of three parts:

1. An energy source, in this case a flash lamp, usually referred to as the ‘pump’ or ‘pump source’, which initiates the lasing process.
2. An active medium ‘gain medium’ or ‘laser medium’.
3. A system of mirrors forming an optical resonator that multiplies the emission.

Nd: YAG crystal (purple rod), flash lamp (central cylinder), gold-plated laser cavity and mirrors (image courtesy of Crafford LaserStar Technologies)

Laser welding represents a complete departure from the traditional method of joining parts in jewellery making.

Laser technology enables jewellers to join materials that cannot be joined by traditional flame and solder technology. It reduces assembly steps and provides the means to realise innovative designs.

As already outlined, laser welding provides a very precise heat source that allows joins to be made very close to heat sensitive materials. This precision also makes multiple welds in close proximity possible without the risk of re-melting previous seams as with solder joins.

Laser welders are used for a variety of applications. It is an invaluable tool for restoring surface casting faults and porosity at any stage of the manufacturing process. Frequently a casting fault is identified in the final stages of polishing after the stones have been set. With a laser the porosity can be opened, foreign material removed and then refilled with a parent alloy without heating the surrounding material.

No oxide is formed during this process and re-polishing is only required in the localised area of the weld point. A laser can open the pore and vaporise any detritus and weld-close the pore without risk of tungsten contamination. Furthermore, the pulse beam can be widened to effectively polish the surface after completing a weld. This is not possible with the PUK welder.

While solders are generally not recommended for PUK welding, laser welders are able to utilise solders of various grades, as well as parent metal filler material without causing degradation of the weld or surrounding metal. Because it is pedal operated the laser also offers more positioning options as both hands are free to position and manipulate the work piece.

With a laser welder, positioning of the head of a ring on a shank prior to soldering, can be easily achieved by spot welding it in place. No binding wire or jigs are required to set-up the parts as they can be held in the hands of the operator. The correct orientation can be checked prior to soldering. This saves time not only in the milliseconds it takes to weld but in the pre-positioning and set-up. Rings can be rapidly re-sized without stone removal and minimal post-processing. Particularly significant with platinum, without the addition of solder the seam is invisible.

Depending on the make and model, current prices of laser welders range between AUD $20,000–$40,000.

Knowledge Transfer: Applying the Outcomes

The aim of the knowledge transfer activities is to raise the profile of new welding technologies available for use within the Australian jewellery manufacturing industry.

A deeper, perhaps less apparent, aim is to enhance the future of the industry by means of adopting a 'work smarter' approach with improved design and manufacturing skill sets to present our world-class natural resources in their best possible light.

Information needs to be delivered to appropriate industry representatives, educators, students, apprentices and hobbyists. Given that, ideally, local geography should not limit the dissemination of the knowledge, a number of methodologies are envisaged.

These include face-to-face information sessions, information made available on the internet and through articles in industry-based publications for maximum penetration into the jewellery manufacturing industry. Wherever possible, content should be designed in partnership with machinery manufacturers to ensure that, from its inception, the activity satisfies the needs of its target audience. Ideally face-to-face information sessions should be made available on a national basis.

In December 2009 the Fellow organised and co-facilitated a visit by a sales representative from Laser Resources, Victoria, to Linneys jewellers in Subiaco, Western Australia (WA). This experience showed that co-participation of delivery of information between technology manufacturers and jewellery manufacturers can provide beneficial results.

The incoming Chair of the WA Branch of the JAA has proposed the Fellow deliver an information session at one of their regular scheduled meetings to inform their members of the findings of the Fellowship. This session would comprise an audio visual presentation and question and answer session.

Similarly a request has been made to deliver the findings to the May meeting of the JMGA Perth branch. The Fellow proposes to seek the approval of the JMGA President to extend the invitation to a wider audience and to invite the Laser Resources Sales Manager to deliver a demonstration.

Website design could commence immediately and costs would depend on where the domain is housed. Website content can include high quality photographs of the process and a narrative of what's happening in each stage of the process.

Content of the website can be easily formatted and distributed for publication in industry-based publications and newsletters.

Recommendations

Government

Recommendations:

- In collaboration with the jewellery industry, Australian, State and Territory Governments assist in funding a comprehensive industry survey to obtain up-to-date information regarding the size of the industry, the value of imports and exports and international trends.
- Arising from such a survey, they then work with the industry to develop a strategic plan to address training requirements and professional development requirements for industry participants.
- Contribute to the funding of research and development hubs attached to higher learning institutions, where new technologies are available and can be made available to enhance existing education and training programs.

Industry

Recommendations:

- Undertake closer collaboration with educational institutions to develop curriculum that incorporates new technology and innovation in design.
- Develop clear pathways for design graduates to achieve smooth transitions into commercial operations.

Professional Associations

Recommendations:

- Jewellery industry professional associations currently have very low rates of membership. Consequently the industry does not have a sufficiently unified voice that can advance the commercial interests of the industry.
- The AJA undertake a comprehensive membership drive to provide sufficient financial resources for it to effectively represent the interests of the Australian jewellery industry to Federal, State and Territory Governments.

Education and Training

Recommendations:

- Currently there are no units being offered in either the Metals and Engineering training packages (apprentice training curriculum) or the design-driven Diploma or Advanced Diplomas of Jewellery and Object Design award courses, specifically relating to new welding technologies.
- New learning material will need to be written for inclusion in existing courses, and short courses will also need to be developed for up skilling current industry personnel. There is also scope for development of master classes for graduates and designer/makers. Post training, there is potential for the equipment to be available for hire in situ for an hourly rate.
- TAFE institutes offering courses in jewellery design and manufacture invest in new jewellery manufacturing technologies and associated staff training.

Recommendations

- TAFE institutes offering courses in jewellery manufacture and design examine the feasibility of creating jewellery manufacture and design research and development hubs in partnership with the jewellery industry and professional associations to provide a pool of expertise on domestic and international market trends that can be fed into training programs.
- A series of master classes in jewellery manufacture and design be established in nominated TAFE institutes.
- Relevant TAFE institutes take the initiative in engaging with the jewellery industry to identify current and future training requirements.
- CIT take a leadership role in the rejuvenation of the Australian jewellery industry by purchasing a laser welder and a PUK3 welder and setting up operating courses for practitioners and students.

ISS Institute

Recommendation:

- The ISS Institute can support the development of a sustainable regeneration of the jewellery manufacturing industry by continuing to develop overseas study and research opportunities and facilitating programmes that bring international industry and education leaders to Australia.

References

Bibliography

Australian Bureau of Statistics 269, *897 Jewellery, goldsmiths' and silversmiths' wares, and other articles of precious or semiprecious materials*; Original, A1828620K, Jan 1988–June 2009

Miller, Hector. & TWI Ltd., April 2005, *Technical Report Tungsten Inert Gas Welding for Silversmiths*, The Goldsmiths' Company Technology and Training, (CD)

Penfold, Gay., 2007, *Diversification, Design, Strategic Planning and New Product Development: A Jewellery Industry Knowledge Transfer Partnership,* University of Central England, Birmingham, The Design Journal, Volume 10, Issue 1, © Ashgate Publishing Limited

London Development Agency, London Borough of Camden, The Goldsmiths' Company, City Fringe Partnership, 2005, *Jewellery Sector Investment Plan*, October 2005.

MCA Regeneration Consultancy, April 2004, *London Borough of Camden Hatton Garden Economic Analysis and Action Plan for the Jewellery Sector and Area.*

Taylor, Peter. 2005, *New Technology Focus: New Joining Technologies for Jewellers*, The Goldsmiths' Company Technical Bulletin, Issue 2, p 5

Websites

Benchpeg, Issue 97, 12/05/2009, online newsletter, viewed Jan 4 2010, *The Future's Bright for London's Jewellery Sector*, www.benchpeg.com/news

Hadassin, Ian, 2009, CEOJAA, Jewellery World Magazine, viewed 11 June 2009, http://www.jewelleryworld.net.au/2009/01/22/article/Ian-Hadassin---JAA---CEO/ZFLKZARZSA.html