Ti-2007 Science and Technology, edited by M. Ninomi, S. Akiyama, M. Ikeda, M. Hagiwara, K. Maruyama
The Japan Institute of Metals (2007)

The Art of Refraction and Reflection-A history of the early evolution of the use of titanium in jewellery dedicated to the memory of Professor Harvey Flower

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This paper documents the early use of titanium in jewellery, tracing the early contacts between industry and the art college where the first experimental designs were realised. Most of the pioneers in this field are still working jewellers but little has been written about it and there is a danger that the knowledge of the early period of experimentation will be lost. This study is by no means a comprehensive survey of all the users of titanium but explores, with selective examples, how the creativity of key jewellers was stimulated by a novel and unusual metal. The paper concentrates on the UK because this is where titanium was first used in designed jewellery. The evolution of jewellery practices are presented in a series of case studies, which are milestones or defining moments in the exploration of the colouring and forming of titanium.

Keyword: *titanium (Ti), jewellery*

1. Introduction

This paper is dedicated to the memory of two men who were influential in the world of titanium. Joseph Cotton whose vision of the decorative potential of titanium, particularly when coloured, led to its introduction as a jewellery metal and to its continued use in this field for the last forty years and Professor Harvey Flower whose help and encouragement were invaluable in the early stages of my research. It was the SEM investigations by Harvey Flower that revealed the unusual phenomena, which are referred to as 'Flower Oxides', and have yet to be fully characterised[1)], **Figure 1.**

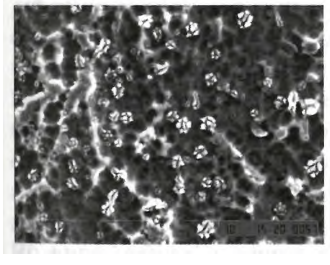

Figure 1. SEM of anodised scrap CP titanium (87volts)

Anecdotal evidence suggests that simple pins and earrings had been fabricated by workers in titanium plants from the early days of its manufacture. An example, perhaps in a more sophisticated setting, is the silver pendant by Malcolm Green, hallmarked 1963, set with titanium sponge, which is now in the collection of the Worshipful Company of Goldsmiths'. Industry values titanium for its unique combination of high strength and low weight, and although this has been exploited by a few designer/makers, it is titanium's colour potential that most attracted jewellers to the material and led to its expanding usage through the 1970s and 1980s.
The colours produced on titanium are a classic manifestation of interference and the sequence of colours exhibited by a thin detergent film on polished metal ranging from ochre through purple, blue, silver, yellow, pink and purple to green are the same as those shown by titanium when anodised.

2. The beginning

The promotion of the use of titanium for decorative purposes was initiated by Joe Cotton while he was a senior researcher at Imperial Metal Industries (IMI), the metals division of ICI. In 1964 when based at the IMI laboratories in Witton, Cotton approached one of the tutors at the nearby School of Jewellery in Birmingham, Gerald Whiles, with the idea that titanium would be a worthwhile new material for the students to explore.
For thousands of years jewellers used a range of metals with limited colours of yellow, red and white[2)]. Whether the yellow was high purity gold or a copper alloy, or the white was silver, platinum or a base metal alloy, the visual impact was essentially the same. Other materials and methods, namely vitreous enamels and gemstones, were needed to expand the palette to colours such as blue, purple and green. Titanium offered the possibility of a coloured metal surface without painting or enamelling.
The arrival of a new metal in a traditional craft area came at a period of radical change in jewellery design and making in the UK. Throughout the 1950s the extremely high purchase tax on luxury goods and the difficulty in obtaining precious metals had a stifling effect on jewellery design and manufacture. Designs were often copied from the nineteenth and early twentieth centuries. The training of the jeweller at the bench continued to follow a traditional apprenticeship system with emphasis on special skills and technical excellence and expertise.
In 1961 Graham Hughes organised the International Exhibition of Modern Jewellery at Goldsmiths' Hall[3)]. Students, influenced by the innovative work displayed at this exhibition, were embarking on new graduate programmes in jewellery created by major changes in education in art and design. Tutors from other creative disciplines were employed to encourage a cross-fertilisation of ideas. The school at Birmingham was part of the expansion across the UK of courses where students were encouraged to think about and experiment with materials other than precious metals and gemstones[4)].
In 1965 titanium, was introduced into this highly energised and creative environment.
The Birmingham silversmithing students visited IMI and were given samples of different forms of titanium to

experiment with. The technical staff at IMI, including Peter Hayfield, advised on methods for anodising, suggesting an ammonium sulphate solution as a suitable electrolyte. All the metal forming techniques were tried including some, such as forging, that the technicians at IMI thought would be difficult or dangerous. Images and, in some cases, actual pieces of work survive from this time but the makers have yet to be identified.

The exciting results being achieved in the Silversmithing School encouraged the jewellers to ask to be included in the project and this is when titanium was first used for designed jewellery.

One of the pioneer jewellers who first used titanium at Birmingham (1965-1968) was Ann Marie Shillito. The first identifiable piece of designed titanium jewellery is a belt buckle. The buckle was machined from thick sheet and coloured by anodising. Ann Marie became fascinated by the metal and continued working in titanium during her time at the Royal College of Art (RCA) from 1968-71. Throughout her career she has continued to experiment with the possibilities of titanium and uses it in her work today.

Another artist of note in the early decorative use of titanium was Pietro Pedeferri. Although a University researcher in the field of electrochemistry in Milan, he was inspired by the colour possibilities of the metal to produce wonderful compositions on titanium. The pieces range in size from 6x4 cm to 20x30 cm. His artistic experiments started in 1968 and he has published several books on the subject of titanium art as well as many scientific papers[5]. He is continuing to work on installation pieces constructed from intricately decorated panels.

In its drive to develop new markets for titanium, IMI produced decorative finishes with faceted effects, which on subsequent anodising produced multicoloured surfaces. Various students at Birmingham experimented with the use of this material including Margaret Fleming but the majority of the students found the highly patterned, grain-enhanced materials unusable in their work. Some mass-market jewellery manufacturers, such as Stratton, used this material for cufflinks etc. but quality control was a problem as it proved difficult to produce repeat sheets of patterned metal. I am indebted to Peter Hayfield for samples of this material.

At the same time salesmen from IMI were looking for other decorative applications. They approached a company in the Birmingham area, active in metal etching, Lewis and Clayton. The company used titanium to create `pictures' which were 'painted' by using a brush anodising technique. Ann Marie Shillito also used Lewis and Clayton to anodise titanium to her design for much of her work in the early 1970s.

3. Experimental phase

Word of mouth spread of the use of titanium through the 'close-knit' jewellery school network in the late 1960s as tutors and students saw pieces incorporating the new metal in degree shows. Eric Spiller recalls using it at Central in 1968 but he had been aware of the material in its industrial context. A chance discussion during a student visit to the London Metal Exchange rekindled his interest and enabled him to obtain supplies of the metal. Alan Wright notes that samples of titanium from IMI were brought into class at Central in 1969 and a necklace that he produced was one of the first pieces of titanium jewellery to be featured in a mainstream magazine. It was illustrated in Vogue in 1970 but ironically only in black and white. David Poston first used titanium at Hornsey in 1969 but did not work with it seriously until much later.

Students introduced to titanium tended to react in different ways. Some saw it as the potential solution to a problem of introducing colour into a design, e.g. Eric Spiller wanted coloured watch faces, some were just curious about the new material and some regarded it as an opportunity to differentiate their work in the market.

For the jeweller used to working with gold and silver, titanium presented a challenge. It is much harder to saw, file and form and when it becomes work-hardened it cannot be annealed under normal workshop conditions. It cannot be joined by soldering, except in an inert atmosphere and therefore requires some form of mechanical fixing to link elements together. All the forming, construction and finishing of a piece has to be completed before it can be coloured. Heating with a torch or in a kiln produces an overall rather patchy colour, as titanium is not a particularly good conductor of heat. More control is possible when anodising but large surfaces can be unpredictable. Some jewellers found titanium an interesting challenge and worth the effort for the creative possibilities given by the colouring of the surface. However many just set pieces of coloured titanium within a silver frame as traditionally used for gemstones or enamelled plaques.

Because of the high melting point of titanium it could be used as an insert with silver or gold cast around it. Pieces of titanium sheet and wire were inlaid in the wax model prior to casting. Ann Marie Shillito experimented with this technique but found only a limited range of titanium colour was possible. Kevin Coates developed his own method for casting gold with titanium. Problems arose in relation to Hallmarking when titanium was used with precious metals. The issue was resolved in 1974 when mixed metals involving gold and silver could be sold but not marked and the precious components had to be called white or yellow metal.

4. Workshop production and exhibitions

By the early 1970s titanium had become a regular product used in Jewellery courses. Several of the jewellers who had experimented with titanium on undergraduate courses continued their studies at the RCA and developed their work there. Others were first introduced to titanium at the RCA but did not develop work incorporating it until setting up their own workshops.

Many museum collections, one of which is Kyoto, include the exquisite cloudscape brooches by Ed de Large. He developed his own painstaking heat and anodising techniques, using precise masking and brush

anodising with the finest of brushes. His first use of titanium however was in 1974 for the base of a commissioned gold bowl while at the RCA. The block of titanium was machined to shape and anodised to a purplish/red colour.

His contemporaries at the RCA were Kevin Coates and James Brent Ward who both used titanium but in very different ways. The latter made scenic pieces with a freer approach and was interested in the technical aspects of the metal and its processing. With sponsorship from the Goldsmiths' Company, James Brent Ward published a report in 1978 that became the standard guide for jewellers on working with refractory metals[6]. The colour chart published in the report showed the typical sequence of interference colours. However the anodising voltages shown are only applicable for titanium that has been freshly etched with a hydrofluoric acid mixture.

Kevin Coates had yet a different response to the metal and titanium was just one of many materials, chosen for their visual impact, that he used when creating his mysterious, magical pieces. The three had a joint exhibition at the Electrum Gallery in October 1976, one of the first to be devoted to the new metal.

The previous year the first LOOT exhibition organised at Goldsmiths' Hall included titanium pieces by Donovan Baxendale, Karen Lawrence, Ann Marie Shillito, Mike Pinder and Roger Stone. Perhaps because they are the easiest colours to produce, many jewellers coloured titanium various shades of blue, making it a natural sky backdrop to scenic pieces, mostly brooches or pendants.

In the second year of the LOOT exhibitions in 1976, eleven of the three hundred and thirty exhibitors showed work incorporating titanium. In the catalogue[7], Graham Hughes, the Art Director at Goldsmiths' Hall, noted the use of 'a new metal and new colour' in the pieces exhibited. Among the exhibitors were Graham Crimmins and Scilla Speet who had started working with titanium as students at Birmingham in 1968. Scilla went on to the RCA (1970-73) and produced pieces that involved setting titanium rod into silver. In some pieces the titanium was then coloured using the brush anodising technique.

5. Unusual techniques

5.1 Chain mail

While a second year student at the RCA in 1974, Lexi Dick used titanium in combination with stainless steel to produce a chain-mail neckpiece but this was to be her only use of the metal. It was Mike Pinder, as a tutor at Manchester with the encouragement of Ann Marie Shillito, who explored and developed the use of titanium wire for chain mail.

5.2 Forging

Although generally hard to work, titanium can be cold-forged to a limited extent as shown by a hair comb and experimental candleholders by Ann Marie Shillito.

Brian Podschies another Birmingham student from 1973-77 became interested in the challenging metal and, after using the standard colouring techniques to produce corrugated titanium brooches and earrings, became `bored with just colour'. After graduation he started to use hot-forging as a way to achieve more visually `organic' surfaces. The forged pieces developed a thick white oxide encrustation parts of which were anodised after cleaning with hydrofluoric acid. This forging technique produced quite different results from those developed by David Poston in 1983 when he began hot forging the metal to produce a range of elegant and sensuous grey/black pieces.

5.3 Laser cutting

In the late 1970s Ann Marie Shillito became aware of the use of Ti for surgical implants and devised integral earwires, hand cut, for titanium earrings. Experiments in the late 1980s with laser cutting, in collaboration with Heriot-Watt University, produced brooches with integral pins.

6. Industrial production

For the first decade of its use, up to the mid 1970s, titanium was regarded as a special material used principally by designer/makers to produce one-off or limited edition pieces. The second half of the 1970s and the early 1980s saw production move to a more industrial scale. A substantial volume of simple, inexpensive pieces began to appear in the windows of the High Street Jewellers. Companies such as Simbol, Prism and Dust concentrated on producing multi-coloured jewellery in volume for the mass-market and the public perception of titanium changed.

Barry and Sally Milburn, who both studied at Central in the late 1970s, were inspired by the work of Ed de Large but saw titanium jewellery as a way to achieve their ambitions for a volume jewellery manufacturing business. Their company, Prism is still in business today and using titanium but uncoloured.

7. Niobium and Tantalum

Those jewellers who found the problems of using titanium too frustrating, both technically and commercially, but liked the colour possibilities moved on to niobium and tantalum, other refractory metals (so-called because of their high melting temperatures). Both were introduced to jewellers in the UK by Peter Gainsbury, Technical Director with the Goldsmiths' Company.

Niobium has the advantage of being more workable than titanium and a specific gravity at 8.57 closer to the 10.5 of silver. It can however only be coloured by anodising and not by heat. Many jewellers, including Peter's wife, Pauline, took to niobium with enthusiasm and produced necklaces and earrings with more sculptural forms. Some combined titanium and niobium to get multi-coloured patterns of greater complexity as different colours are produced on the two metals when anodised at the same voltage.

In a parallel development Ingeborg Bratman, via contacts in UK industry, also started working with tantalum. She produced pieces specifically for one of a

series of themed UK touring exhibitions on metal jewellery organised by Sarah Hosking of East Midland Arts in 1977. Tantalum has a specific gravity of 16.6, close to that of gold (19.3) and a very attractive blue/grey colour. A bangle and earrings made of anodised tantalum are on display in the Science Museum in London.
Titanium, niobium and tantalum were used by the Designers in Refractory Metals, a group formed by Pauline Gainsbury, who exhibited together in 1981. Other group members were Ann Marie Shillito, Jane Townsend, Jeanne Werge-Hartley and Susan Clarke.

8. USA

The LOOT exhibition in Minneapolis in 1978 featured a significant number of titanium pieces and subsequent workshops given in the USA by UK jewellers carried the use of titanium across the Atlantic. By the early 1980s metal artists such as Arline Fisch had started to experiment with the metal. One American jeweller who used titanium extensively and wrote his MA thesis about its use was Joseph Hall. The workshops also inspired Bill Seeley who produced hot-spun vessels and founded a company to supply titanium to the workshop jeweller.

9. 1980s

Students in the early 1980s were often inspired by the intricate images created by Ed de Large. One of these was Debbie Moxon who went on to develop her own particular method of heat-colouring titanium. Using precise geometric scoring and a fine flame she created a deceptively simple style whose complexity only becomes apparent with knowledge of the behaviour of the metal. She is still experimenting and developing her techniques for the heat-colouring of titanium and recent work features engraved areas.
Inevitably during the late 1980s the use of titanium in standard high-street pieces reduced its special appeal for the more design-led jewellers and only the most committed makers continued to use it. A notable example is Brian Eburah who studied at Central 1973-6 and still features titanium in his work today.

10. Maces

The light weight of titanium, so important in industry, has been seen as a disadvantage in a jewellery market where, for historic reasons, related to the use of precious metals, value has been connected with weight. Writing in the Financial Times in 2002, Vivienne Becker disparages `tinny titanium'. The possibilities offered for larger scale wearable pieces, which have to some extent been realised with aluminium have not been exploited for titanium.
The benefit of the lightness of titanium has been successfully used in maces, notably that for the Open University, which was designed by Eric Clements and made at Birmingham by Hamish Bowie, and, appropriately, for the Birmingham Polytechnic mace designed and made by Terry Hunt in 1988.

11. 11. 1990s

Apart from a few enthusiastic designer/makers, who continued to explore the potential of titanium, and curious students, who wanted to try working with an unusual metal, very little exciting and innovative work was produced after the early 1990s. Ann Marie Shillito has experimented with the combination of precious metal clay and titanium wire, which can be seen as a development of her earlier work with cast silver and titanium.
Continuing her student experiments with titanium in a silversmithing context, Susan Beale uses turned titanium stems for silver champagne flutes.

12. 2000s

Bringing the story up-to-date, the public have become more familiar in recent years with the pale grey of uncoloured titanium and have appreciated the strength and lightness of the material, particularly in sports equipment and spectacles. A very visible usage in the early 21st century has been the iconic Apple-Mac Titanium Power Book.
The popularity of body piercing and the biocompatibility of titanium have been combined to produce a wide range of titanium body jewellery both natural and anodised. This is mass-produced, as are the increasingly popular titanium rings. A wide range of titanium rings, often inlaid or combined with precious metals and diamonds, are now offered and the 'industrial' image of the metal is being successfully marketed to men.
There are however signs of a renewed interest in the colouring of titanium. Recently, Joel Degen, who in his early pieces in the 1980s appreciated uncoloured titanium as it was 'in tune with the machine aesthetic' of his work, has started to reintroduce colour. The production ranges of titanium jewellery are starting to feature engraved areas that are subsequently anodised.
At least two jewellers are currently exploring the decorative potential of the use of lasers to create coloured pattern on titanium. Sarah O'Hana is a jeweller working within the school of Mechanical Aerospace and Civil Engineering at the University of Manchester and Ann-Marie Carey, who produced laser-patterned niobium bowls as part of an MPhil project at the RCA is developing her work on laser marking of titanium at the Innovation Centre, part of the School of Jewellery in Birmingham where it all began forty years ago.

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