IMPROVEMENTS IN PLATINUM ELECTROFORMING

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INTRODUCTION

Despite Electroforming has long been a popular method for gold production in the jewellery industry, but its application in platinum has posed significant technical challenges. Much of platinum electroforming's advancements came from studies in electroplating, which came into discovery as early as the 1830s when electrochemistry was first studied; when electroplating of platinum and palladium was first presented by Alfred Smee in 1840, and when W. R. Grove devised the first fuel cell with platinum foil as electrodes in 1939.[1] In more recent years, throughout the 1980s and 1990s, various publications by Johnson Matthey discussed improvements of electroplating baths and the developments of their P & Q salts available for platinum plating. However, electroplating solutions from Johnson Matthey have limitations where platinum deposits are restricted to thickness of up to only 15 micrometers and not applicable for the electroforming process that requires a much thicker layer of metal deposits.[2] Despite the current advancements and common use of platinum in electroplating, achieving a stable quality of products with a wall thickness of at least 200+ micrometers through electroforming is a persistent challenge. Factors such as bath life, cost of recovery and refining, stability of surface quality are relatively difficult for platinum when compared to gold, and have hindered the jewellery trade in the implementation in production. There is much to resolve if platinum electroforming is to be adopted for mainstream jewellery manufacturing and there is little discussion on this topic in literature.

In light of the current platinum metal pricing trends, there is a renewed interest in the research of various platinum technologies, including alloy development, 3D printing, and electroforming. Recent advancements have resulted in improved performance across multiple parameters, thus overcoming some of the known limitations. This includes the use of non-harmful chemicals and development of a sustainable production process that eliminates negative impact from toxic substance in dated methods.

Finally, with the potential of maturing production capabilities, it is important to analyze the application of platinum electroforming to maximize value for the trade in terms of products and market positioning. By properly harnessing the unique capabilities of platinum electroforming, new markets can be created, new consumer segments can be untapped, and the jewellery trade can benefit from the enhanced performance and unique characteristics of platinum in innovative ways.

Part 1: Brief Background of Platinum Electroforming

Platinum as a premium white metal of choice:

Platinum possesses various attributes that make it an excellent material for jewellery:

1) Durability and strength: Platinum is a dense and strong precious metal, and has a relatively high density of 21.45 grams per cubic centimeter (g/cm3) at room temperature. It makes platinum a durable and sturdy metal for various industrial and scientific purposes where density is a critical factor, such as in laboratory equipment or catalytic converters.[3] For jewellery, it is highly resistant to wear, corrosion, and tarnish, making it ideal for every day wearing. However, platinum is commonly soft in its natural pure state, with a hardness of only 40 Hv on the Vicker Scale. Most platinum used for jewelry is alloyed at 950 purity level to reach a hardness of 100+Hv.[4]

2) Chemical Stability and Oxidation Resistance: Platinum is highly resistant to chemical reactions and corrosion. It is not easily affected by exposure to air, moisture, or common chemicals. It has high resistance to oxidation. This stability ensures that platinum jewellery retain their original appearance and structural integrity over time.

3) Longevity and Resilience: Due to its durability and resistance to wear, platinum jewellery can be passed down through generations as heirlooms. It retains its beauty and natural white color over time.

4) Lustrous Appearance: Platinum is a naturally white metal that does not require plating to maintain its color. Its naturally

white luster enhances the brilliance of gemstones. Its superior reflective properties enhance the brilliance of diamonds and precious stones.

5) Purity and Hypoallergenic: Platinum is also hypoallergenic, making it suitable for individuals with sensitive skin or metal allergies.

The inherent characteristic of platinum ensures its products retain their quality, beauty and functionality over time, under repeated use, and under extreme conditions like high heat and in corrosive environment. Its stability makes platinum a reliable metal for various applications, including jewellery, aerospace, medical implants, waste and pollution management, and alternative energy and storage.[5]

Development of platinum electroforming

Electroforming is an electrodeposition process, similar to electroplating and electrorefining. It involves two electrodes, an anode (positive terminal) and a cathode (negative terminal), submerged in a conductive electrolyte containing metallic salts and a source of DC power. When a current passes between the electrodes, metallic ions in the solution, and transferred into atoms on the cathode's surface.[6] These atoms accumulate layer by layer, creating a continuous deposit at a microscopic scale. For platinum, the cathode, typically a mandrel of the desired shape, is usually a low melting alloy. (Wax is not recommended due to high bath temperature.) The anode is commonly made of platinum. When an electric current is passed through the system, platinum ions from the bath are reduced and deposited onto the cathode.[7] When the required deposit thickness has been obtained, the piece is removed from the bath and the mandrel within is extracted, by drilling small holes in the platinum surface then melting and emptying the alloy inside. Acids are also used in this process to separate alloy from the platinum.[8]

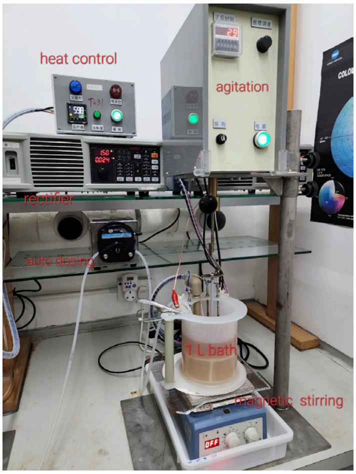

Figure 1: Electroforming setup

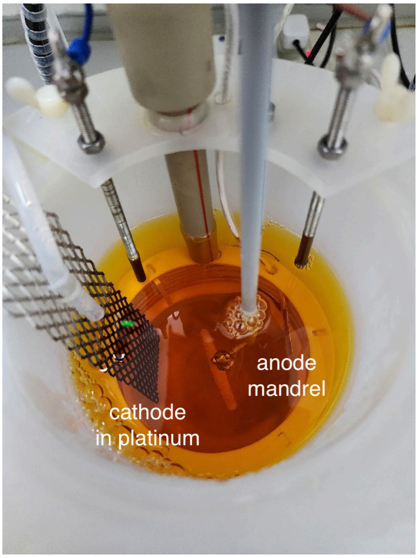

Figure 2: the electroforming bath

Figure 3: mandrel casted in low melting alloy

The development of platinum electroforming has primarily been driven by advancements in electroplating technology and the need for high-quality, complex parts. For platinum electroplating, the two most common electrolytes used are P salt solution, comprised of dinitrodiammine platinum $Pt(NH_3)_2(NO_2)_2$ and the Q salt solution, comprised of sodium hexahydroxyplatinate ($Na_2Pt(OH)_6$).[9] Electroforming borrows the basis of these solutions and modifies them to create a long running bath, capable of deposition of platinum over longer periods of time to achieve a thickness that far surpasses plating. Electroplating Engineers of Japan Ltd prepared platinum in a bath comprising chloroplatinic acid, alkali metal chloroplatinates and soluble carboxylate.[10] They also developed a solution quite similar to Q salt with sodium hexahudroxyplatinate and sodium hydroxide to dissolve the platinum, with the addition of other salts.[11] These modified solutions developed from plating are fundamentally the basis of current platinum electroforming technology. Over time, researchers and engineers have made refinements to the electroforming process to improve the quality and efficiency of platinum deposition. Factors such as bath composition, temperature, current density, and plating time have been optimized to achieve uniform and defect-free coatings. The development of advanced power supplies and control systems have also contributed to better process control and repeated production. Since, platinum electroforming has been in use for many years in various industries, including electronics, medical and aerospace. However, it is still not widely commercialized for jewellery production.

It is important to address that unlike gold, platinum electroforming implements cyanide-free electrolytes due to the difference in its electrochemical properties. These alternative electrolytes utilize different chemical compositions that do not rely on cyanide compounds. The absence of cyanide in the platinum electroforming process puts the mind at ease on critical environmental and health risks, that are often associated with the general electroforming process. Of the solutions, only P salts for electroplating raise environmental concerns as it uses ammonia and ammonium nitrate which are less environmentally friendly. Though there are some companies that still uses ammonia, majority has switch to an acid base solution. For electroforming, the few companies that currently run salt solutions are sodium hexahydroxyplatinate based, comprised of sodium platinate, sodium hydroxide, sodium oxalate and sodium sulfate. The solution is not hazardous. Through the entire process required to electroform a platinum product, the only material that requires careful handling and disposing is nitric acid that is used mainly before and after electroforming, to clean, empty and remove the low melting alloy used for the mandrel. By utilizing environmentally friendly electrolytes, manufacturers can minimize the potential negative impacts on workers, communities, and ecosystems, aligning with the jewellery industry's resolve on responsible and sustainable practices.

Key challenges of platinum electroforming

The adoption of plating technology is lacking for platinum electroforming process and there are still many technical challenges that hinder the process for mass production, especially for jewellery. (On the other hand, gold electroforming is very mature and vastly used.) Some of the limitations are attributed to platinum's unique metal characteristics. Major challenges include:

1) Internal stress: Solutions for platinum plating deposits layers with thickness less than 5 micrometers. For electroforming of jewellery, a much higher wall thickness must be achieved to 150+ micrometers; complexes borrowed from plating builds up too much internal stress during electro-deposition of the platinum layer and cannot efficiently produce at stable quality. A frequent and common issue as a result of internal stress is brittleness, often as a result of hydrogen ions trapped in the platinum layers.[12] At a higher concentration, temperature, and current density, the higher chance for hydrogen and other elements to interfere during the deposition process. Recently, researchers are working with new platinum complexes to reduce internal stress and to better maintain bath conditions for repeated use. The new formulation is based on P and Q salts on the market, with modifications as a proprietary technology, used in a system with much lower operating parameters to reduce internal stress in the solution, that will be looked at

later in part 2 of this material (as System B).

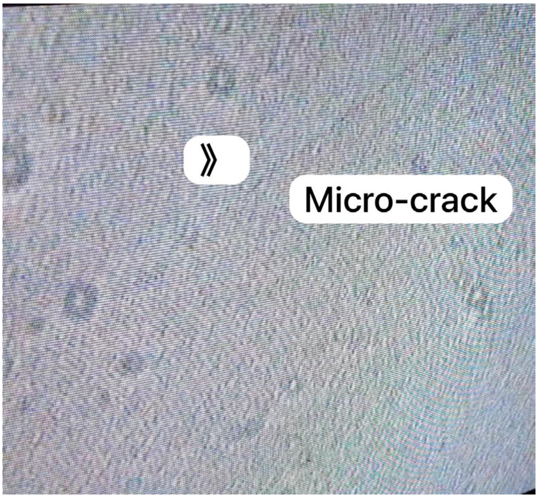

Figure 4: Microcrack as a result of hydrogen trapped in deposited platinum layers

2) High conversion cost for platinum complex: Converting gold salts is relatively common and easy, and there are many suppliers of gold salts in the market. To convert platinum metal to a suitable complex for electroforming however, is a far more difficult task. Due to platinum's high cost as a precious metal, few studies and publications have been made since the 1990s and very few companies have done further work. Amongst them, Electroplating Engineering of Japan Ltd. (EEJA) and Pino Aliprandini are the most active in making advancements in the platinum electroforming solutions. The recent lowered spot price for platinum, especially relative to gold, welcomed a wave of new research and companies working on both plating and electroforming. Mass markets like China and India are both interested and invested in solution development. Still, the cost of working with precious metal significantly affects the overall production cost of electroformed parts, and finding ways to optimize the chemical conversion process is an ongoing challenge.

3) Limited supply of suitable platinum complex in the market: Most suppliers can offer common platinum complexes such as Dinitrodiamminplatinate, Hexachloroplatinate, Dihydrogen dinitrosulphatoplatinum, Hexahydroxyplatinate, etc. However, these complexes are not ideal for direct application for platinum electroforming. Modifications are required for use. Only few proprietary chemicals suppliers can provide the turnkey solution, for example

EEJA or Pino Aliprandini, etc. The current solutions trialed and employed in market are alkaline baths and can electroform platinum thickness more than 200 micrometers with hardness more than 300 Hv. In China, retailers like Chow Tai Fook launched electroforming products into the market in 2022 via mass production that satisfied quality standards. Though technically possible, there are much to be done to decrease wastage and cost from an efficiency standpoint.

Figure 5: Electroformed charms with black enamel work launched by Chow Tai Fook in 2022

4)   High recovery and refining cost of platinum: Despite the discovery of new platinum complex and methods to significantly extend the bath's repeated use, there is still the day when the bath will exhaust and needs to be recovered. Due to platinum's high value, relatively low volume and cost in refining small batches, the recovery and refining of platinum from the solutions is a costly process. To lower the cost of metal recovery, current research is testing methods to regenerate the bath instead. By regeneration, excess complexes and residue are removed from the bath, and new platinum salts are added. It is not an easy task to maintain a perfect condition for electroforming but it is the best alternative from

a cost standpoint, as well as an environmental one. The attempt to repeat production instead of recovering and refining the platinum bath still lacks consistency, and will require more research and trials.

5) Short bath life: The above points extensively outlined the cost of creating the bath, the recovering and refining of platinum; so the relatively short bath life in the current solutions is in fact the greatest cause for its expensive operation and obstacle for mass production. A fair comparison, to the widely employed gold baths that are consistently used to produce jewellery, shows that a gold bath can run for at least 10 times before the need for maintenance, while platinum can only do 3-5 runs before deterioration begins to show on the electroformed surfaces. Reasons of the difference is attributed to internal stress mentioned above, and where impurities and the operating parameters such as pH levels, temperature, and current density are significantly more sensitive in the platinum solutions.

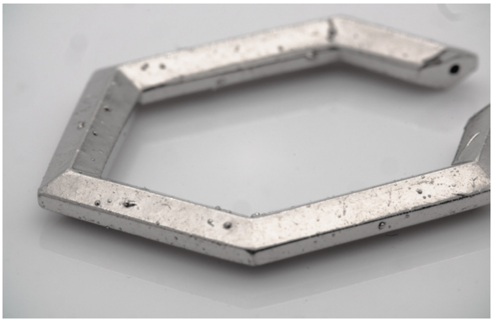

Figure 6: comparison of platinum surfaces after 1 run (on the left) and 3 runs (on the right).

Furthermore, gold baths after 10 uses can be replenished and regenerated without the need to recover and refine. New salts can be added to the solution after excess anions are removed, and the baths can continue to produce for multiple runs before having to repeat the regeneration process. Technically, gold electroforming solutions seldom require replacement if the baths are operated with care. On the other hand, the platinum complex is not a simple salt, and the anion complex left behind after electro-reduction are not easily removed; excess anion left in the bath is disruptive to the electroforming process and is one of the main reasons for short bath life.

From the cost point of view, an expired bath would then run into the high cost of recovering and refining the platinum electrolytes. It also means every run needs to maximize output as the bath deteriorates with every repeated use. Current setups require 3kg of platinum salt and each bath is only estimated to produce 600g, after which the remaining platinum has to be recovered, refined, converted to salt and redeposited for new use. The cost of running a platinum bath, aside from metal cost is currently more than a double of gold electroforming. One of jewellery's latest efforts in the research and development of platinum electroforming has been focused on extending bath life in attempt to lower production cost and to make the process sustainable.

Part 2: Recent Developments in platinum electroforming

Since 2020, the jewellery trade has witnessed a resurgence of development in electroforming for platinum. The price hike of rhodium from USD3500/oz to a high of USD25000+/oz led companies to look for rhodium plating alternatives, and platinum was a prime candidate with its spot price consistently below USD1000/oz. The commercial benefits renewed the interest in platinum plating and convinced various companies to take it one step further into the research and development of electroforming. Of the various challenges described in the previous section, bath life and stability of quality are the key technical limitations that lead to high wastage and high production cost of metal recovery. There is still significant amount of work required in these two areas in order to enhance efficiency, and recent efforts do show promising potential for improvement.

Currently, the largest output of platinum electroforming being used for jewellery is in China, if not the only market that is employing it for mass production. Products were tested in small batches and distributed to market by some of the major Hong Kong retailers. The first collection explored product types like earrings, charms, bangles and pendants. Labour fees were 4-6 times higher than casting, partially because of the higher cost of production (including reasons mentioned above) and the novelty that allows retailers to price by piece instead of being priced by weight. Aside from the shift in consumption behavior in post-covid dynamics that resulted in a slowdown of non-gold sales, platinum electroforming slowed in distribution due to difficulty in fulfillment, with wastage running higher than initial expectations. Feedbacks from manufacturers and retailers attribute the main cause to short bath life and the breakdown of quality after the first run of a bath. Compared to gold electroforming, which is by now a very mature production method in China, with developed baths that can be continuously regenerated for reuse (so that the bath does not technically expire); platinum in its current state sees bath life that starts to deteriorate and expire after 5 runs, some shows inconsistency in surface quality as early as after 3 runs.

Figure 7: Deterioration in electroforming surfaces include porosity, pits and pox like bubbles. Most often shows up on flat surfaces where deposition occurs at a slower rate compared to corners. Ring electroformed from the 1st run of a bath (top), compared to a ring formed from the 3rd run of the same bath. (bottom)

Problems from limited reusability of the platinum baths hinder both production time and cost. The trade grew conservative for quantity and cautious for distribution, until improvements for the platinum solutions can resolve issues of consistency in quality. At the time this material is presented, two distinct electroforming systems are still actively researching, developing and testing to solve quality issues for jewellery platinum production, and each with its own advantages and disadvantages.

Table 1: Working parameters of electroforming baths

Parameter	System A	System B
1. Platinum concentration	17 – 26 g/L	10 – 13 g/L
2. pH	13.6 - 14	11 – 13
3. Specific gravity	10 – 14 Baume	>13 Baume
4. Temperature	88 -95 degree Celsius	45- 60 degree Celsius
5. Current Density	2.0 -3.0 A/dm2	0.5 -0.7 A/dm2
6. Current concentration	0.1 -0.3 A/L	0.03 A/L
7. Deposition efficiency	28 -30 mg/Amin	28 -30 mg/Amin

System A has its origin from Japan and is currently used in Asia, particularly in China production. As previously discussed, the first trials in 2020 yielded promising results, as the first run of a platinum bath produced samples reaching 200+ micrometers for thickness, excellent surface quality, high brightness, high shine in polish and little signs of brittleness. With methods derived from plating technology, System A operates with much higher measure in every parameter: higher Pt concentration, higher pH, higher temperature, higher current density; as shown in Table 1. This allows the electroforming process to occur with a higher deposition rate, on average achieve 170 micrometers in 10 hours. System A has a much quicker processing time but consequently a much quicker deterioration in bath life. The higher operating parameters contribute to a faster build up of internal stress, and with excess residue from its left over complex, shows accumulative depreciation at every consecutive run. By the 3rd and 5th run, flat surfaces started to show porosity and pox-like bubbles. The cause is a result of the absorption of carbon dioxide and other contaminants from the rapid breakdown of platinum complexes, as well as hydrogen trapped in the process resulting in embrittlement.

Table 2: Comparing performance of electroforming baths

Performance and Results	System A	System B
1. Maximum thickness	300 microns	1000 microns
2. Run time (170 microns)	10 hours	40 hours
3. Bath life	3-5 runs	10+ runs

System B, a proprietary formula developed in Europe, deprioritized the criteria for higher efficiency in attempt to extend the repeated use of the bath. They are working on regeneration of the platinum solution, by developing platinum complex that will not leave contaminants and residues in the bath after electrodeposition. They are also attempting ways to retrieve used complexes from the bath, such as simple carbon treatment to eliminate the residues and excess anion complex. Early trials indicate promising results with a small laboratory setup, having successfully repeated more than 10 runs with the same test bath and the electroforming quality remaining consistent, but yet to be validated for large volume production. As shown in Table 1, the system is required to operate at lower parameters across all aspects: concentration, temperature, pH level. current density, etc., in order to reduce and maintain at internal stress at a minimum. The disadvantage is the lengthy processing time, as it takes 4 times longer than System A to achieve the same desired thickness, so it is less time-efficient for mass production, as shown in Table 2. By operating the electrodeposition process at lower parameters, quality also showed higher consistency and higher metal strength. Electroformed products are annealed after removal of the mandrel to regain some malleability and to reduce brittleness. Samples from System B were annealed and tested through standardized drop tests. Results indicate that operating with reduced stress minimized the occurrence of hydrogen embrittlement and products at 200 micrometers are less likely to break and snap in the drop test.

Figure 8: System B electroformed products, charm from 1st run polished (top left), the 10th run unpolished (top right), the 15th run unpolished (bottom).

Another area of improvement from System B is the ability to deposit platinum layers to unprecedented thickness. Plating technology were developed to create 15 micrometers layers and had problems achieving thickness over 150 micrometers. For platinum electroformed products, ideal thickness is around 250 micrometers; one to achieve structural strength to ensure the surfaces to do not dent; two, to accommodate high polish by manual labour which could potentially break if not carefully handled. Previous trials and production runs created platinum pieces with an average of 200-250 micrometers. Though theoretically thick enough to prevent from breaking, a higher wall thickness could prevent any wear and tear from daily use. System B is currently working on achieving a higher wall thickness, and to date, one sample at 1000 micrometers has been achieved in the laboratory.

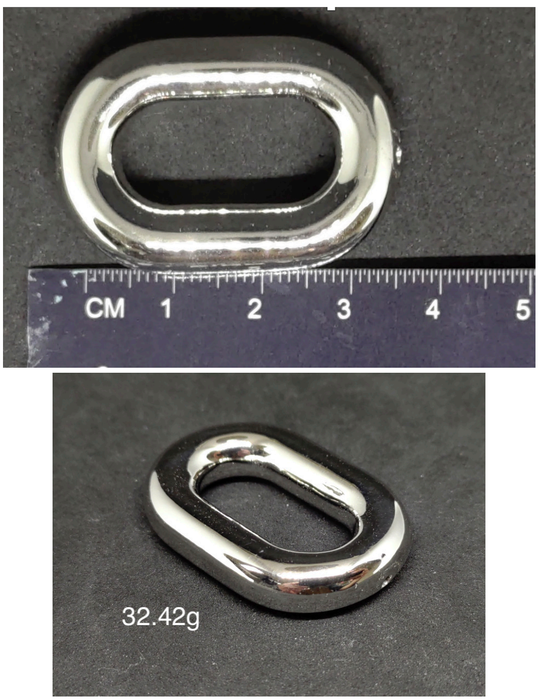

Figure 9: Platinum Electroformed piece of 1000 microns (1mm) thick, weighing at 32.42g

Although both solutions are now commercially available in the market for jewellery production, there are still many areas of potential improvements that can be furthered researched and advanced. For the chemical producers, the greatest driving force for improvement is the interest from the market, as volume will ultimately help fund further trials and produce enough learning from repeated operations. For manufacturers, both System A and System B are viable solutions, as long as product yield, production lead time and labour cost are properly accounted for. And from the perspectives of jewellery retailers and consumers, the greatest incentive to furthering the work on platinum electroforming would be the possibility of creating a novel product that is not achievable by other means of production. At a time when jewellery design trends are increasingly bolder in silhouette and larger in size, when products like industrial styled "hardware" and chunky chains are popular amongst fashion luxury, there might just be that opportunity for platinum electroforming to find a role in jewellery production, to offer an unprecedented product that is high in purity; unfading in shine; and bold yet affordable.

Part 3: Discussion on Design for Electroforming

As an introductory paper on platinum electroforming, there is also the necessity to take the discussion from a purely technical one into area of design and product development. A technology is only a true innovation if its novelty serves the purpose of being useful, functional and able to create value for the trade it serves.[13] Electroforming is a technology that still raises skepticism on many fronts: the environmental impacts previously discussed; the margin it can create for jewellers; the matter of sustainability in production; and on appropriate designs that can best optimize its value. In its early stage development, we saw manufacturers employ the technology to produce charms, rings, bangles and earrings. While some product types can offer platinum the opportunity to expand into new markets, there are some that are collectively perceived as disruptive, namely products that are only aimed at undercutting on price that will consequently impose negative impact to pricing strategy for the jewellery trade at large. This section aims to look at the specific benefits of electroformed products, on how it has created markets for gold jewellery and then to open a conversation on how electroforming should be best employed for the platinum category in current market dynamics.

Distinctive characters of electroformed jewellery

Electroforming offers several distinct benefits for jewellery production, making it a popular technique in the industry. Here are some of the key advantages of electroforming for jewellery in general:

1. Lightweight: Electroformed jewellery can be significantly lighter compared to traditionally cast or fabricated jewellery. The products are often designed as hollow structures with a very thin wall, ideally between 0.25-0.35mm. Hollowness allows designers to create larger, bolder pieces without compromising comfort. This lightweight nature makes electroformed jewellery comfortable to wear, particularly for earrings.

Figure 10: Wall thickness of 0.25mm for hollow structures (top). First electroforming products launched into China market by manufacturer Kingli, large earrings at 6.429g (bottom left) and bangle at 5.225g (bottom right)

2. Unique structure: Due to its hollow structure and the way metal is deposited in layers, electroforming enables the creation of unique aesthetics that may be challenging or even impossible with traditional jewellery-making methods. For example, precise deposition of metal onto the mandrel can give results of intricate details, textures, and patterns over large surfaces without the concern for sprue placements. Interlocking structures are also unique, like chains with large hollow links that can be formed in one step without the need for assembly. These advantages offer unique characteristics that are best optimized by a design approach specific to the electroforming process.


Figure 11: Electroformed chains, unpolish at 7.32g (top); tumble polished at 5.45g (bottom)

3. Cost-effective: Electroforming is a cost-effective method for creating jewellery pieces, especially when working with precious metals like gold or platinum. Since it involves the deposition of a relatively thin layer of metal onto a substrate, it allows for the efficient use of precious metals, reducing material costs compared to solid metal jewellery. As mentioned, a gold electrolyte bath can be regenerated for repetitive use. If platinum can be done at a low recovery and regenerating cost, its cost efficiency can arguably be lower than that of casting or metal printing due to its relatively low metal wastage in the electroforming process.

4. Versatility in design: Electroforming offers versatility in terms of design possibilities. It allows designers to experiment with different shapes, sizes, and textures, giving them greater freedom for creativity. Additionally, electroformed jewellery can be combined with other materials like gemstones or non-metallic elements to add colors and visual contrast.

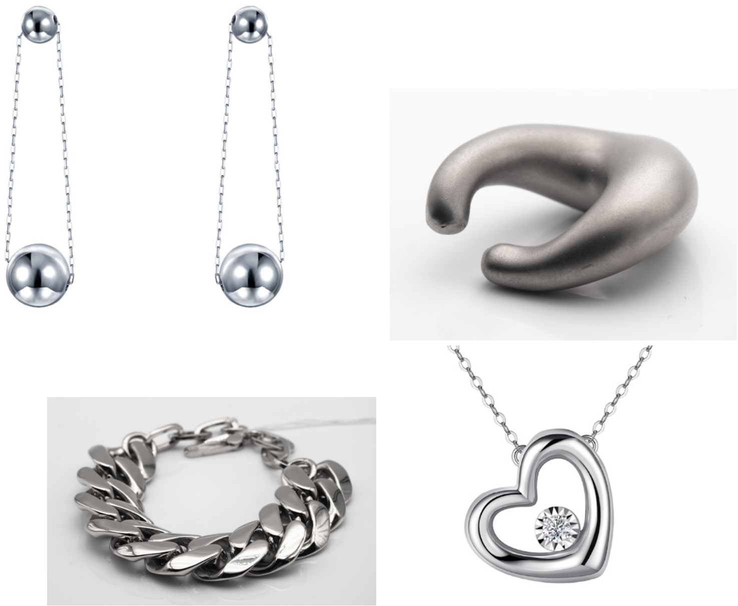

Figure 12, from top left clockwise: Large hollow spheres used for earrings; sculptural ear accessory at 3.16g; electroformed platinum with diamond; chunky hollow chain at 23.34g.

5. High hardness: The electroforming process produces jewellery pieces with extreme high hardness, for gold at 300Hv and for platinum at 350Hv. This reduces polishing time in production and is especially beneficial for the gummy and more labor intensive platinum. The high hardness as a finished jewellery also performs better in scratch resistance which allows it to withstand everyday wear and tear.

It's important to note that while electroforming offers many advantages, it also requires specialized equipment, expertise, and careful control of the process parameters to achieve high-quality results. Consequently, there are also designs that are not suitable for electroforming purposes, and specific structures that are more fitting for casting or 3D printing. Attributes such as thin walls and relatively brittle metal surfaces have little tolerance for ductility, that is contradictory to the common properties of platinum as a malleable, ductile and strong metal. Designs that require a certain level of flex would often snap and break when pressure is applied.

Figure 13: Ear accessory that snapped under pressure, wall thickness at 230micrometers.

While large curved surfaces are most suited for electroforming, large flat surfaces are challenging due to the thinner deposition of metal in flatter areas and the difficulty in polishing such surfaces to a mirror-like finish. (Throwing power of both platinum baths, System A and B, were not measured for the purpose of this paper and would be an interesting area of study in the future). Finally, acute and sharp angles are also hard to achieve as metal deposition will round off sharp ridges and corners. To attract the best and unique value, designs should fully exploit the advantages of electroforming to create jewellery that offers a novel experience and unique position.

Recent development of electroformed products for gold jewellery in China

Before discussing designs for platinum jewellery, it is perhaps relevant to draw reference from gold and how recent product development with the use of gold electroforming created new market opportunities, taking China as a case study. Around 2010, cyanide-free gold electroforming was introduced into the China market. It started a new trend of gold products targeting a younger audience. With modern designs that differentiate itself from traditional goldsmithing, and benefiting from an entry price level, electroformed gold appealed to the interest of younger consumers and opened up a new purchasing segment for the gold category. One of the earliest companies that achieved market success was Hong Kong jewellery brand Chow Sang Sang. They used electroforming to expand on a market positioning explored by the likes of Pandora, whose positioning for the market was "affordable luxury of high-quality jewellery", in particular on the successful concept of charms that are modern and affordable products for the purchasing reasons of gifting or self purchase. Only in place of silver, Chow Sang Sang's Charme collection offers 24K gold, taking "affordable luxury" and "high-quality" to another level, especially when compared with traditional products or with fashion brands.

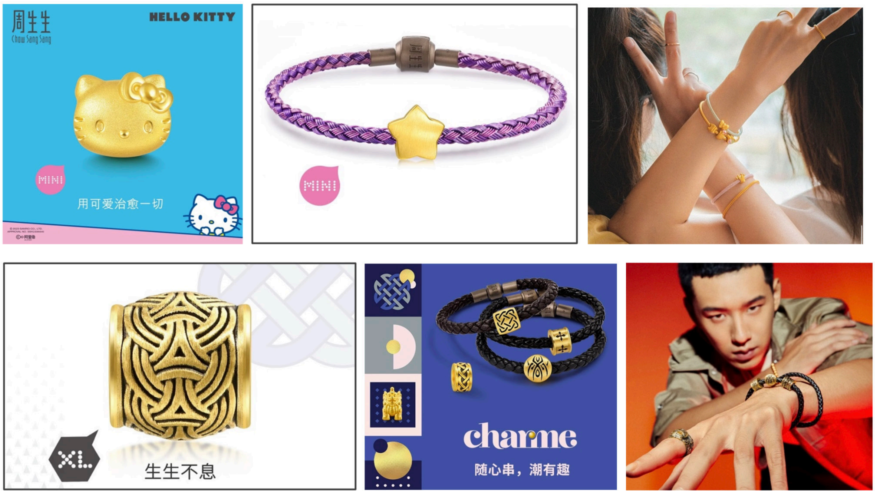

Figure 14: Gold electroformed products in China by Chow Sang Sang targeting young consumers. Products often use collaborated IP such as Hello Kitty from Sanrio on far left. Products targeting young male consumers were also successful, especially for gifting purposes. (bottom row)

Marketed as cyanide-free, produced with precision and quality, playing on a variation of finishes and colors, the novel electroformed gold created a new segment with younger consumers and was a great "additional" purchase with its affordable pricing. Other brands followed quickly and with the technological process exposed, electroformed gold took the market in the mid 2010s in both volume and unprecedented margin for the gold category (as traditional gold products have always been sold by weight in China). With its success to revitalize the gold category, the trade renamed the newly electroformed products as 3D gold; and then 5D gold for products that were produced with the cyanide-free process.

Figure 15: The edition of color to gold electroforming charms, renamed as 5D gold for the consumers.

Market opportunities and product designs for platinum electroforming

When considering design for platinum electroforming products, the first question to ask is: Which targeted consumer segment would bring incremental business, and not disrupt existing purchases with low weight and low pricing? It is only advantageous for a technology to be adopted to market if it creates more value from manufacturing to retail (more margin); and/or it can create new purchasing reasons for a new consumer segment (more consumers); and/or expands market reach or repeated purchases (more pieces sold). From the Chow Sang Sang Charme reference above, the launch of electroformed gold fulfilled all three aspects: it allowed for 24K gold to be positioned as a piece priced product with margin; new designs and affordable pricing attracted a much younger consumer, both men and women, for self-purchase and for gifting purchases; collectibles and stack wearing increased number of pieces sold through repeated purchase behavior. The collection stands alone from existing product categories and does not replace traditional gold purchases within the retailer's portfolio. And due to its affordable pricing, the retail can easily promote the collection as an additional sale, and on electronic transaction platforms. The positioning of Charme is thoroughly an incremental business for Chow Sang Sang.

How do we make the same considerations for platinum? Considering platinum's position as a luxurious precious metal, platinum can certainly be a premium alternative for what is currently now offered in silver. It's metal attributes of non-fading white brilliance offers the consumers longevity in daily wear, fitting for the growing consumer concern of quality and sustainability. On the other hand, considering metal value, platinum is currently at a relatively low spot price, especially compared with gold. This lowers the entry price level for both stocking inventory and for consumers, especially when electroformed products are relatively light; but offers retailers more flexibility in pricing and margin due to consumers' perception of platinum's premium. On the topic of value, electroformed platinum has the purity of Pt999, so it has the potential to be positioned distinctively from current products produced in Pt950. One possible distinction in its product positioning is in the trending category of asset jewellery, where products are made in 24K purity, fashioned in modern designs, but traded with buying and sell back options, targeting the "value seeker" segment of consumers.

From a more functional standpoint, designs should best exploit electroforming's hollow structures and reduced weight to achieve an innovative and unique experience. Platinum with its high density is usually limited in size and shape or it becomes too heavy for comfortable wearing. This is especially the case for product types like earrings or recent popular silhouettes like chunky chains. Electroforming enables platinum to explore these product categories that were previously impractical for platinum use, so thoughtful designs can create a sense of novelty for the consumers. Another functional aspect that can be explored are large areas of flowing high polished surfaces; large areas because this is labour intensive for casting due to sprue placements, while flowing structures should be considered because they best accommodate the integrity needed in its hollow structure. Meanwhile, high-contrast surface finish like high polished platinum should also be taken advantage of as it gives a mirror-like surface, its benefits with other surface textures well explored by designers.[14] And due to a high hardness of 350+ Hv, electroformed pieces offer incomparable scratch resistance, that can best benefit products with a high polish.

Having listed various qualities that can give platinum electroforming products a distinctive position, it is a consideration for brands and retailers to contemplate on how to best utilize these unique qualities to create products that can capture incremental business; by appealing to new consumer groups or by adding a distinctive collection that differs from the existing portfolio. For Chow Sang Sang, it makes little sense to replicate the Charme collection with a platinum electroformed option, since it would merely offer an alternative white colored version of the existing product line. However, for a retail brand that does not have charms as a product and see the Pandora model as a potential market, platinum electroformed charms could perhaps be an attractive solution for new business potential. This paper merely opens up the discussion with perspectives worthy of consideration, as there are many specific consumer segments, product concepts, purchasing reasons or consumer behaviour that can be tapped by electroformed platinum. Decisions will depend on each brand and their current product offering and consumer profile. One thing for sure however, is the strong opposition against designs from the earliest prototypes, products like polished bridal bands, that must be strictly rejected as a product direction because it only disrupts on price and reduces the luxury experience platinum has with consumers.

Conclusion

The rekindling of interest and development of platinum electroforming can bring about new opportunities for the jewellery trade at multiple levels. From the product perspective, hollow structure and the reduction of weight allow platinum to explore larger forms and bolder shapes that are previously deemed "unreasonable" due to platinum's high density. From a market perspective, light weight designs can offer more than just a lower entry price point; it opens up new market potentials that previously see little of platinum as an ingredient, in exciting segments such as fashion luxury with bold statement designs like chunky chains and industrial hardware, or just basic staples like large hoop earrings. For the consumers, platinum products made from electroforming offer unprecedented affordability and comfort for wear. For manufacturers, it's one additional option in the toolbox that enables innovation in design and product development. Finally, from a technical perspective, platinum electroforming is a process with high potential for jewellery production, though there are challenges yet to be addressed. There will undoubtedly be continuous improvements in areas such as efficiency and bath life if it receives adequate support and interest from the jewellery trade.

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