FOILING: PAST, PRESENT, AND FUTURE

Jeannette K. Caines

Many nearly forgotten ancient metalsmithing technologies are still very relevant for metalsmithing practice today. This is an examination of gemstone foiling techniques from ancient times to the present. This highly effective technique has been largely forgotten by today's metalsmiths and is due for a revival. The modernization of diamond cutting led to foiling becoming a forgotten technology, despite the large number of metalsmiths who use gemstones besides brilliant cut diamonds. Modern foiling methods are an easy and effective way to improve the light reflection in gemstones and this skill should be a part of the modern metalsmithing lexicon.

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Using metallic foils to reflect light and improve the color of gemstones is a concept that began, no doubt, almost concurrently with the use of transparent gemstones and closed settings. No metalsmith could fail to notice how much transparent stone's visual impact is affected by a reflecting surface. As long as there have been valuable and prized materials, there have been attempts to improve their appearance and value. The foil is either applied directly to the stone or is held inside the setting and the term foiling is used interchangeably for both.

The desire to improve and enhance the appearance of gemstones can eventually slide over the line into fraud. Fraud is not the main focus of this paper. However, where the line between fraud and normal setting practices is has been interpreted very differently by different cultures and I believe that is one of the reasons why modern metalsmiths have forgotten about foiling as a legitimate technique to improve the look of closed setting gemstones.
The historical use of foiling is today often lumped in with fakes and imitation gemstones likes rhinestones. The 1974 edition of Shipley's dictionary of gems and gemology puts foiled gemstones in three categories:

1. Genuine foil backs: to improve the performance of a gemstone
2. False foil backs: to give a different color to a gemstone so to mimic another
3. Imitation foil backs: the same as a false foil back, but applied to glass (for example a chaton)

I will be focusing on genuine foil backs in this paper. Before we go into the history of foils to reflect light through gemstones, we should discuss a bit of the process behind how light operates in gemstones. Since I am neither a gemologist, nor a scientist, but

a goldsmith, I will discuss this in laymen's terms. For transparent and translucent stones, how bright and sparkly a gemstone looks depends on a few different factors:

- Lustre or luster relates to how light reflects from the surface of a crystal, rock, or mineral.
- The brilliance of a stone is the amount of light reflected back to you and is measured by total internal reflection and how much of the light entering the stone bounces back toward the eye. This is the main contribution of the foil, most of the light that travels through the stone and hits the foil is bounced back through the stone to the eye, greatly increasing the total internal reflection. This increase in light would be lost in a normal closed setting without internal polishing.
- Dispersion is the process whereby light is broken up into its component colors before being reflected back out to the viewer's eyes. This is primarily visible in clear gemstones with a high refractive index, like diamonds. The fewer the number of internal reflecting surfaces (facets),or the use of foil as a reflector, the less dispersion takes place, and the less fire will be visible. The diamonds used during the historical periods I will cover would display little to no fire.
- Refraction occurs when light travels from the air into a denser material. As light passes from the air into the denser material of the gemstone, it is bent. The amount of bending depends upon the refractive index of the material. High refractive index materials like diamonds and zircons bend the light more.
- Scintillation is the effect of flashing lights seen within a gemstone as the stone, the light source or the viewer's eyes are moved. The effect can be described as being the lustre, fire and brilliance all in motion. This effect is caused by the changes in the angle of the gemstone relative to the light source or viewer's eyes. In the case of a white diamond, the effect is mainly seen as white. In colored gemstones, the effect tends to be of a similar but brighter color than the base color of the gemstone.

Modern gemcutters well understand these principles and can use the science of critical angles and the refractive indexes of respective stones to cut gemstones for maximum scintillation. This information has only become perfectly understood in the last 100 years, so gemstones were cut without this complete knowledge

during all of the historical periods I will be covering. Additionally, many gemstones available today are not cut perfectly according to the scientific principles of maximum scintillation. There are many other factors that go into the decision-making process of the lapidary; maximum yield and the fashions of the moment often taking precedence. Gemstones are still being cut today with a jamb-peg and by eye so one cannot assume a modern cut gem has been cut "perfectly". Additionally, even a modern, "perfectly" cut gemstone's light performance can be improved by the use of foil in a closed setting. Although ancient lapidaries and goldsmiths might not have known exactly how to cut gemstones for maximum scintillation, they had the use of their own eyes and ingenuity to discover how to best show off the gemstones they had. Enter the use of foiling to increase the beauty of gemstones by goldsmiths.

Ancient sources like Pliny the Elder (23/24 AD- 79 AD) have cited that the first documented use of metal foil behind rock crystal gemstones was from Minoan era graves from approximately 2000 BC and thus were already an ancient technique in the time of Pliny. In Ball's translation and expansion of Pliny's *A Roman Book on Precious Stones*, Pliny writes: "The art of the use of foils is an old one. The Minoans made a gaming table decorated with strips and discs of rich crystal. The latter was alternately backed by silver plaques and blue vitreous paste."

I believe he must be referring to a gameboard like the one housed in the Heraklion Archaeological Museum on Crete, from the Palace of Knossos.

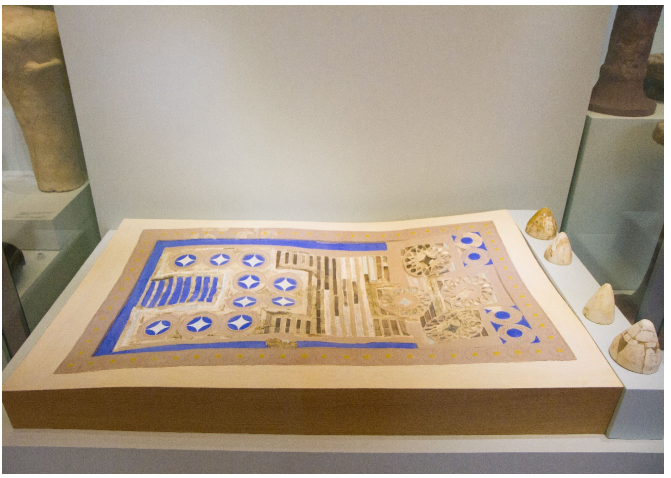


Figure 1: From The Museum of Heraklion -Luxurious gaming board resembling a draughtboard. The original rectangular base of the game, probably of wood, has not survived; it may have formed the cover of a table or chest. The frame of the board is made of ivory plated with gold leaf and decorated with carved rosettes with rock-crystal inlays in their centres. The surface consists of rock-crystal plaques set into blue glass paste and silver foil, separated by ivory inlays. Four conical ivory objects, found just a few metres from the rest of the game, were probably the gaming pieces, as we see from their size, exactly matching the four large circles on the board. Similar games have been found in Egypt and the Near East, but none is as large and elaborate as the Knossos draughtboard. Unfortunately, we do not know exactly how it was played or if it had some special symbolism beyond the game. Its luxuriousness highlights the wealth of the palace of Knossos, the high living standards of its inhabitants and the artistic skill of the palace workshops.

Apparently, there are not any other surviving boards just like this but that was no doubt different in Pliny's time. Pliny does not say much about the methods of the goldsmith in setting gems but there are a few mentions of using foils behind gemstones:

- The chrysolithos (topaz) if fine was set a jour in an open bezel, if of inferior quality its color was heightened by a foil of aurichalcum (a copper compound). The beauty of sarda (carnelian) was in some instances, increased by the use of silver foil and in others of gold.
- In resume, there is nothing more difficult than to attempt to distinguish these various kinds of carbunculi from one another. Further, they are easy to counterfeit and falsify by the art and skill of lapidaries and goldsmiths who put a foil

beneath them to make them brilliant and glitter like fire.

- It is said that the Persians got sarda here, but the mine is now practically exhausted. It is, however, found in many other places including Paros and Assos. From India three different kinds are sent, namely the red, the suet-like variety (called demium) and a third which ordinarily has a silver foil placed beneath it to add to its lustre.
- The Indian sarda is transparent and light passes through it; the Arabian is less transparent. Others are found in Egypt and a gold foil is normally used with them.
- The worst of all varieties is that of Arabia, for it is not only mottled in color, but turbid and flawed, and such radiant luster as it has is interrupted with clouds or spots; and if by chance it is in other particulars clear, yet one looking at it would say that it was full of its own dust. The best chrysolithi (Topaz)are those which, being mounted in gold, by comparison cause the latter to appear of a whitish hue like silver. Such as are clear and transparent, jewelers mount in a hoop of gold so that both top and bottom may be seen. The others require a foil of a copper compound, or a related substance, to give them luster.

Although Pliny does not go into detail about the methods of foiling used, clearly it was an expected and commonplace occurrence used with many varieties of gemstones and already practiced for thousands of years. Fortunately, there would be other historical sources that describe the process in detail. During the next two millennia, foiling was standard practice when setting gemstones and only fell out of common use after the end of the Victorian Era (Jun 20, 1837 – Jan 22, 1901). Mass production of jewelry became the norm and closed settings became rare, the basket type of open setting with prongs for faceted gemstones became the standard. The use of foiling greatly declines after the Victorian Era and today is primarily practiced by studios like mine, that specialize in ancient jewelry making techniques and is otherwise mainly seen on rhinestones or crystals.

There are two main time periods in this history between Pliny's time and ours where foiling was particularly essential to the Art and practice of goldsmithing, The Anglo-Saxon Period or the so-called Dark Ages (approximately 5th Century AD until 1066 AD), and the Renaissance (Fifteenth and Sixteenth Centuries AD). In both of these time periods, foiling was an essential technique in the masterpieces of the time and took on a greater importance than simply a best practice when setting gemstones.

During the Anglo-Saxon period in modern day Britain a distinctive style of ornament evolved using garnet inlay to masterful effect. The two most significant finds were the Staffordshire Hoard and the Sutton Hoo burial site.The level of workmanship found in these pieces has never been matched in modern goldsmithing. Precisely patterned gold foil was used underneath the garnets to reflect light and make the garnets glow.

Figure 2: Buckles from Sutton Hoo

Figure 3: Purse lid from Sutton Hoo

Figure 4: Closeup of garnet inlay, Sutton Hoo

Without the use of foils, the garnets would have been too dark to make much of a showing, except perhaps in direct sunlight.
The Staffordshire Hoard is the largest hoard of Anglo-Saxon gold and silver metalwork yet found. The first pieces of the hoard were discovered in 2009 by local metal-detectorist Terry Herbert on farmland close to his home in Hammerwich parish, near Lichfield in Staffordshire. It consists of almost 4,600 items and metal fragments, amounting to a total of 5.1 kg (11 lb.) of gold, 1.4 kg (3 lb.) of silver and some 3,500 pieces of garnet cloisonné items. None of the pieces were specifically jewelry, they were all related to swords and other battle gear. Apparently, all the references to giving of gold by the King in Beowulf was not just literary hyperbole. The hoard was most likely deposited between 650–675 CE, and contains artefacts probably manufactured during the 6th and 7th centuries. The workmanship and techniques used in the pieces found in Sutton Hoo and the Staffordshire Hoard are so similar that it is extremely likely that they were made in the same workshops in East Anglia. Where stones and foils are missing, the paste filler at the base of the cells is visible. A study by the British Museum of objects from the hoard has established the basic mix was of beeswax and a proteinaceous material, probably animal glue.

Here are some foil closeups from The Staffordshire Hoard. The line spacings vary between 3.5 and 5.5 lines per mm(!) but the most common spacing is 4 lines per mm.

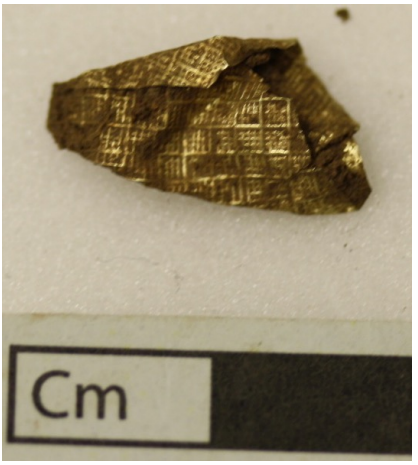


Figure 5: Foil closeup from the Staffordshire Hoard

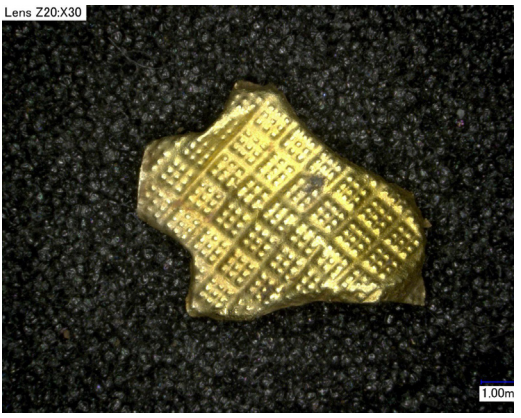


Figure 6: Foil closeup from the Staffordshire Hoard

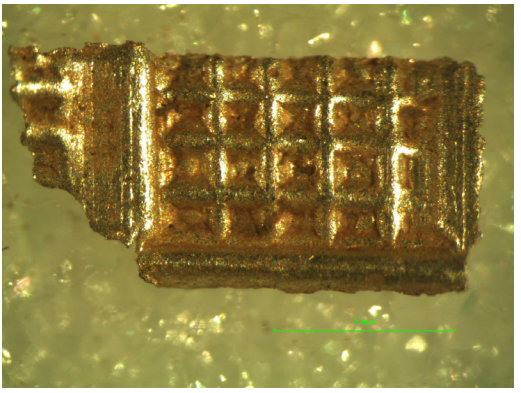


Figure 7: Foil closeup from the Staffordshire Hoard

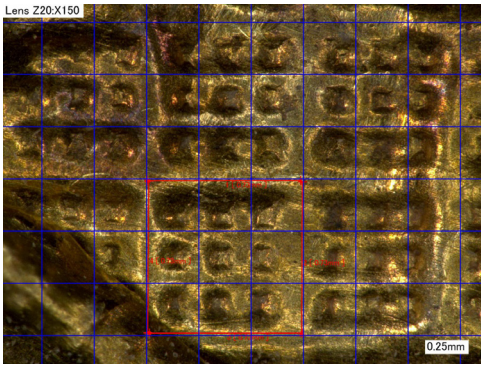


Figure 8: Foil closeup from the Staffordshire Hoard

Figure 9: Foil closeup from the Staffordshire Hoard

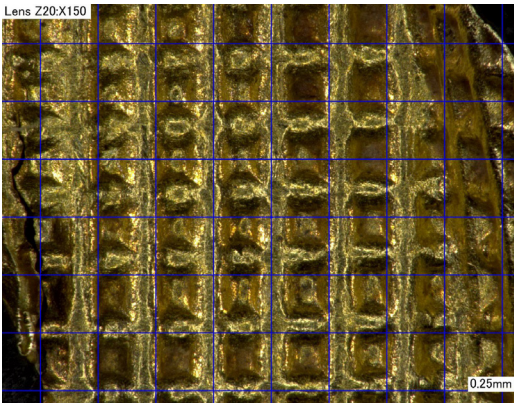


Figure 10: Foil closeup from the Staffordshire Hoard

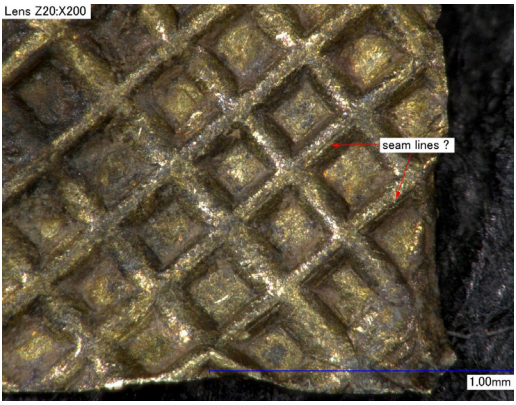


Figure 11: Foil closeup from the Staffordshire Hoard

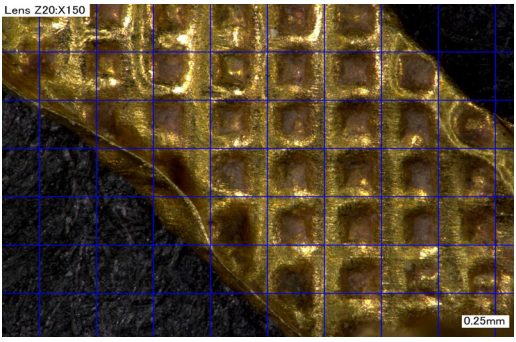


Figure 12: Foil closeup from the Staffordshire Hoard

The most common thickness for the gold foils is .025 mm but foil as thin as .01 mm has been documented. There are a few different patterns in the foil based on a series of lines, as fine as 5.5 lines per mm. The gold alloy varied between foils but in each, the amount of copper was 1 percent or less. The gold foil was essentially electrum, a mix of gold and silver, extremely ductile and perfect for making thin sheet and getting a crisp impression from the die.

A few researchers have posited the making of a die cutting jig based on the principle of proportional reduction to cut the dies precisely enough to produce such a perfectly regular and tiny pattern. These same principles were understood and employed in the making of looms during this period so it isn't much of a stretch to conclude they might have been used here. The extreme regularity of the pattern would seem to rule out the hand cutting of the dies. No dies have survived but brass or bronze is the most likely material, although Ivory also held up well in tests by Meeks and Holmes.

Figure 13: Example of stamped gold foil from Staffordshire Hoard

This piece from the Staffordshire Hoard shows a few varieties of stamped gold foil. For a researcher such as myself, I get the most excited about damaged pieces. Damage gives access to details impossible to see in an intact piece.
The Sutton Hoo treasure, like the Staffordshire Hoard does not contain foil backed garnet inlay jewelry items per se but the buckles, sword fittings, purse lid, etc. found in both use the identical techniques and designs of garnet inlay as are used in the jewelry of the period without any differences of note. The one possible exception is that the likely King's possessions of the Sutton Hoo burial tend to be a somewhat higher gold karatage that the jewelry of the same period but the foils and garnet techniques appear identical so this fact isn't relevant to this paper.
Although the two most well-known finds are the Sutton Hoo Burial, (found 1939) and Staffordshire Hoard (found 2009) there are multiple surviving jewelry pieces from Anglo-Saxon period worthy of study.

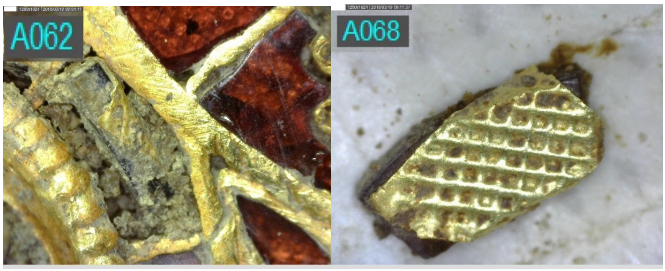
The Winfarthing Pendant, found by a metal detectorist in a Norfolk field in 2015, was part of a 7th century grave assemblage that included a necklace made up of two gold beads, two pendants made from identical Merovingian coins and a gold cross pendant inlaid with delicate filigree wire.

Figure 14: Winfarthing pendant in situ

Some of the inlay areas are less than 1mm. The Conservation Department at Norfolk Museums Service was kind enough to share macro photos of their repair work where garnets had come loose from their cells.

Figure 15: Winfarthing pendant fully restored

Figure 16: Areas that required repair



Figures 17 and 18: Foil was wrapped around the garnet to be wedged into the cell.

Very recently found in 2022, a stunning gold and garnet necklace in central England in an early Anglo Saxon burial site under a construction project. The find is being heralded as Britain's most significant female pre-Christian burial place, according to the Museum of London Archaeology (MOLA). The right image is the projected view of how the necklace would have looked when new. Amazing pieces continue to be discovered from this period but they all share the same central techniques, just executed with slightly differing level of skills.

Figure 19: Harpole necklace

Beyond the so-called Dark Ages, I have not found any other examples in jewelry employing the use of textured foils. Foiling continued to be used under gemstones but I haven't yet found any patterned examples. So many amazing Metalsmithing techniques are simply forgotten as styles change, this informs the ongoing research at my studio. The closest related technique is guilloche, texturing metal to reflect light and pattern, often used under enamels.

Benvenuto Cellini (November 1500 – 13 February 1571) is the most famous goldsmith of all time, due to him writing *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture* and his autobiography. In his *Treatises*, the very first advice he gives in his chapter of How to Set a Ruby is about choosing the right foil to complement the gemstone:

So let us place our fine ruby into its bezel. In order to what is technically called 'set' it, we must provide ourselves with four or five ruby foils of which some should be of so deep a glow that they seem quite dark, and others differing in intensity till they have scarce any red in them at all. With all these different specimens of foils before us, we take hold of the ruby with a piece of hard black wax well pointed, pressing the wax upon one of the projections of the stone. Then your good jeweller tries his ruby now upon this foil, now upon that, till his own good taste determines him which foil will give most value to his stone. Sometimes the jeweller will find it may help him to move the stone to and from the foil, but he has to recollect that the air between the foil & the stone will always give an effect different to

that afterwards given when the stone is set in the bezel where no air passes behind. Therefore, your capable man places the cut foil in the setting, at one time bringing it close, at another interposing a space. Thereupon let him set his jewel with all the care, taste & delicacy of which an able man is master.

Clearly using foils was an essential part of showing off a gemstone to its best effect. Cellini also relates a story about a dispute between him and some fellow goldsmiths in his community:

NOW, as to the emerald and the sapphire, the same skill must be used with the foils adaptable to them as with those of the ruby. And because I consider that practice always has come before theory in every craft, and that the rules of theory, in which your skillful craftsman is accomplished, are always grafted on to practice afterwards, I will give you a case in point of what once happened to me when I was setting a ruby of about 3000 scudi in value. This ruby had, when it came into my hands, been very well set at different times by some of the best known jewellers of the day. So I was incited to work at it with all possible care. Seeing that I could in no way satisfy myself with the result of my efforts, I locked myself up somewhere where no one could see me; not so much because I did not wish my secret to go further, but because I did not want to be caught trying so mean an experiment upon so goodly and wonderful a gem. I took a little skein of silk stained with Kermes(a red die derived from the crushed bodies of insects found on Mediterranean oak), and with a pair of scissors cut it carefully, having previously spread a little wax in the bezel. Then I took the tiny bit of silk and pressed it firmly on to the wax with the point of a small punch. Then did I put my ruby upon it, and so well did it make, and such virtue did it gain, that all the jeweller folk who had seen it first, suspected me of having tinted it, a thing forbidden in jewellery except in the case of diamonds, of which more anon. But for this ruby, some of the jewellers asked me to say what kind of a foil I had put behind it, upon which I answered that I had put no foil behind it. At this reply of mine, a jeweller who was with the gentleman to whom the ruby belonged, said, ' If the ruby has no foil, you can't have done anything else but tint it in some way or other, and that you know is forbidden.' To which I replied again that I had neither given it a foil, nor done anything forbidden to it. At this the jeweller got a little nasty and used strong language, at which the gentleman who owned the ruby said, 'Benvenuto, I pray you, be so good, provided I pay you for it, to open your setting and show it to me only, I promise you I'll not tell anyone your secret.' Then said I to him that I had worked several days on the job, and that I had my living to earn, but that I would willingly do it if he paid me the price of the setting, and, moreover, do it in the presence of all of them, because I should be much honoured in thus

being able to teach my teachers. When I had said this, I opened the bezel and took out the stone in their presence. They were very much obliged, we parted very good friends, and I got very well paid. The ruby in question was a thick one, & so limpid and luminous that all the foils you put beneath it gave it a sort of uncertain flash, like that which shimmers from the girasol opal, or the cat's eye, two kinds of stones to which the dunderheads, of whom I told before, would also give the name of gems.

Cellini was a proud and quarrelsome man, every story he relates in his *Treatises* and his autobiography is similar to the one above, with his mastery being first doubted, then publicly proved and ultimately agreed to by dunderheads. His blowhard tendencies make for an entertaining read and his desire to document his "victories" has provided fascinating details of his studio practices that we would not have otherwise been privy to. He also has provided detailed descriptions of how to make foils:

IN order to make good foils for jewels it is essential to have steel tools, and all of the best and of the most finished description. Then, as you may suppose, for an undertaking of such importance you need the greatest possible care and patience, together with the greatest possible neatness. Long ago, when I was a lad of fifteen and began to learn goldsmithery, I knew a master in the art whose name was Salvestro del Lovecchio.This man only did stone-setting, and specialised on the making of his own foils for all sorts of gems. Though the foils from France and Venice and other places often showed up more splendidly, experience proved that they were not as lasting as Lovecchio's, which were always thicker. For this reason, the setting of the gems upon them was often more difficult than on the foreign foils, but so strong were they, and so telling to the gems, that as soon as they became a bit known, he got orders from all over the world and soon had no time for anything else but foil-making. Indeed it requires all a man's energies to do this, so I thought I would give a few facts about it for the benefit of anyone anxious to learn. The first foil is called the common foil, it is of a yellow colour and is used for many jewels and transparent stones.

Cellini gives recipes for four foils, a red, green, blue, and a yellow "common" foil. In our studio practice today, we generally think of foils simply to reflect light, rather than adding color. The choice of gemstones was far more limited in Cellini's time and jewelers were often tasked with using the patron's stones, rather than choosing them themselves. This is also just a reflection of the times; each era develops its own set of mores about industry practices. I have always considered using a colored foil underneath a gemstone in a

piece to be over the line but this was standard practice in Cellini's day and his clients were Kings and Popes.

A contemporary of Cellini's in Italy, Vannoccio Biringuccio wrote De la Pirotechnia, the first known printed book on metallurgy, published in 1540. Vannoccio mainly documented mining, assaying and smelting rather than specific goldsmithing techniques but in his chapter on goldsmithing he notes:

Having told you the general facts concerning this art of working with gold and silver, I think I have said enough about it. All the rest that is necessary depends entirely on ingenuity and practice. But surely a very ingenious and beautiful thing in this art that should not be left unrelated is the discovery of making the foils that are put under gems to enhance their beauty by revealing their virtues of limpidity and color. This composition was discovered through observing the art of tempering, but employs also the virtue of great heat and various fumes used for this in addition to the elemental mixture and composition of the material.

Biringuccio here alludes to the use of fuming to form patinas on foils to enhance a gemstone's beauty when set. Cellini does not mention fuming specifically but he does describe heating the foils in a fire until the desired oxide color is achieved. Biringuccio's book was written as a compendium as opposed to Cellini's more personal style, so it can be inferred that forming patinas on foils by heating and/or fuming was a widely practiced technique in this era. It is also notable that Biringuccio makes only the briefest mentions of such essential skills as soldering but counts making foils as a skill as even more important and essential. Renaissance goldsmiths considered foiling an essential skill, more worthy of discussion and study (and argument!) than any other goldsmithing discipline.

The way that we practice foiling at Jewelry Arts is quite simple. I have always felt that colored foils are over the line, but I have had Cellini's foil recipes on my to-do list for quite some time. Maybe by the time I present this paper, I will have made some up and tried them out as compared to the fine silver sheet we normally use.

As an example of our process, I will use a pair of 22K wire mosaic bird earrings I made with white sapphire rose-cut gemstones. Although all translucent or transparent gemstones are brighter and more appealing in closed settings using foil, I find rose-cuts are particularly enhanced with this method. It has the visual effect of adding a pavilion so it reflects far lighter, like a full faceted cut than a rose-cut.

Figure 20: Caines' 22K wire mosaic bird earrings

OUR PROCESS

We use 30-gauge fine silver sheet; it is less fussy and easier to handle than foil and the difference in price is negligible. I normally prepare an inch or two at a time and pull it out when needed rather that preparing a small amount every time I set.

1. First, I hand sand one side of the sheet so that all the scratches are consistent and heading in the same direction. Shine is created by reducing the individual scratches much smaller than the eye can detect. If any scratches are more visible than others, you won't be able to get a really even, high shine. I normally start with 400 grit sandpaper and then progress to the 400 through 1200 or 4000 micropaper. These leave a fine, consistent finish the tumbler won't have any trouble shining up.

Figure 21: Sanding one side of the sheet

Figure 22: Finer sanding

2. I then throw my pre-sanded sheet into a regular rotary tumbler for an hour or so. This produces a highly polished sheet ready to be used. If my piece requires any inner bezels, I will usually tumble them as well to produce a high shine. The more reflection of light inside the setting, the better. Any polishing method is fine, but it is much easier to polish a larger section of sheet, however you choose to polish.

Figure 23: Ready to tumble

Figure 24: In the tumbler

Figure 25: Highly polished inner bezels and sheet

3. I trace out how much of the shiny silver I need to cover the bottom of my setting and cut it out using shears.

Figure 26: Mark and cut out sheet to fit inside the bezel

4. I place the sheet at the bottom of the setting and then my inner bezel on top and I am ready to set. This is a fast and easy process and greatly enhances the look of the gemstone.

Figure 27: Sheet placed beneath the inner bezel

Unfortunately, I do not have any way to quantify how much the return of light is improved but it is very easy to see.
We have also been experimenting with making textured foils with bronze dies, similar to those used by the Anglo-Saxons. They work beautifully under gemstones and transparent enamels. This is an ongoing project, so I will have more to share in a few years.

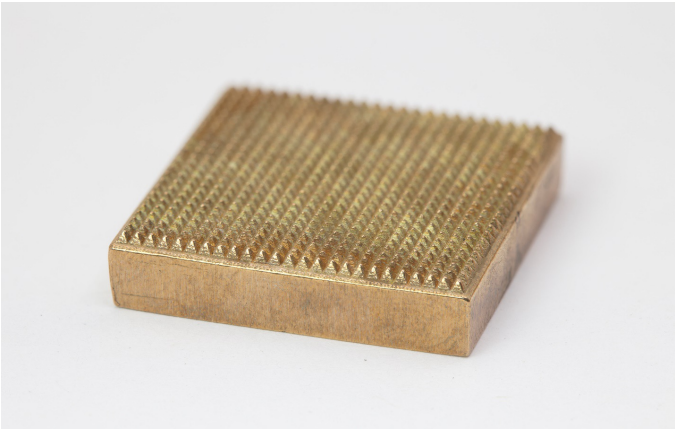


Figure 28: Bronze texture die prototype

Figure 29: Small sections cut out for placing under enameled sections by my colleague, Valerie Blum.

No matter how many thousands of years go by, the principles of optics do not change. Metal foils remain the best way to light up gemstones set in closed settings and therefore it is a technique all modern metalsmiths should be acquainted with. The more scintillation your stone displays, the happier the client, the same in 2000 BC as today.

BIBLIOGRAPHY

Books
Robert M. Shipley, *Dictionary of Gems and Gemology*, 6th edition, (GIA, 1974)

Peter G. Read, *Dictionary of Gemmology*, (Butterworth Scientific, 1982)

Kurt Nassau, *Gemstone Enhancement*, (Butterworth Scientific, 1984)

Max Bauer, *Precious Stones*, Vol. I, (New York: Dover Publications, 1968)

Benvenuto Cellini (translated by C.R. Ashbee), *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture*, (Dover Publications, 1967)

Pliny the Elder, *National History*.

Donald B. Hoover, *Topaz*, (Butterworth Scientific, 1992)

Herbert Tillander, *Diamond Cuts in Historic Jewellery 1381-1910* (Art Books International, 1995)

Vannoccio Biringuccio, *The Pirotechnia*, (New York: Basic Books Inc, 1959)

Journals
Anglo-Saxon Studies in Archaeology and History, 4 (Oxford University Committee for Archaeology, 1985)

The Sutton Hoo Garnet Jewellery: an examination of some gold backing foils and a study of their possible manufacturing techniques. Nigel D Meeks, R Holmes. Anglo-Saxon Studies in Archaeology and History. 4: 143-157. 1985

Papers
"Contextualising Metal-Detected Discoveries: Staffordshire Anglo-Saxon Hoard." (Project 5892) Version 4, Submitted 9th January 2015 H.E.M. Cool, Barbican Research Associates

"The Staffordshire Hoard: An Anglo-Saxon Treasure", Edited by Chris Fern, Tania Dickinson, & Leslie Weber, Scientific Advisory Editor: Marcos Martinon-Torres, Research Report of the

Society of Antiquaries of London No. 80, First edition, Society of Antiquaries of London, 2019, Burlington House, Piccadilly, London

Online Sources

https://www.langantiques.com/university/gemstone-surface-enhancements/#Foiling

https://alldiamond.co.uk/a/blog/the-beauty-of-gemstones-the-science-of-shine-and-sparkle

https://www.gemsociety.org/article/does-refractive-index-affect-gemstone-brightness/

https://archive.org/stream/RomanBookOnPreciousStones/ball-s-roman-1950-RTL000188_djvu.txt

https://www.goldsmiths-centre.org/resources/knowledge-dig-early-medieval-jewellery-and-other-finds-sutton-hoo/

https://archaeologydataservice.ac.uk/archives/view/staffshoard_he_2017/downloads.cfm?group=1100&sn=1&CFID=9235a6e3-97c9-4a09-90f1-1fdcaf67b99f&CFTOKEN=0

ttps://nmasconservation.wordpress.com/2019/03/22/conservation-of-the-winfarthing-anglo-saxon-pendant/

https://archaeology.co.uk/articles/features/secrets-of-the-staffordshire-hoard-skills-of-the-saxon-smiths-revealed.htm