# ***Damagane*tm:**

## The Research by Gene Anthony Bereza

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***Damagane*™:**

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## *Damagane*tm:

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### Introduction

*Damagane*tm is the result of my graduate research concerning the combination of the laminated metals, Damascus steel and mokume gane. Craftsmen have used Damascus steel and mokume gane as counter-part material in many works of art throughout the ages. Once this ambitious bladesmith became familiar with how to create both Damascus steel and mokume gane, it wasn't long before the idea to "bond" these two inherently different and beautiful laminated metals together manifested itself. The metal laminate *Damagane*tm features the warm colors of mokume gane and the unmistakable coolness of Damascus steel.

The marriage of different metals is an important aspect to my personal work. As individuals, we are all the result of two different "parent stock," so too is the laminated metals commonly known as Damascus steel and mokume gane. Therefore, *Damagane*tm is the granddaughter of the original ferrous and non-ferrous metals.

Not only does *Damagane*tm have a unique aesthetic character but it's also superior in strength to any laminate of non-ferrous metal due to its Damascus steel heritage. The advantage of the steel element allows for "welding" of the laminate. The presence of steel also offers the option of incorporating magnets.

1.

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**Damascus steel**

Damascus steel is the first ingredient of *Damagane*tm. Damascus steel can resemble "wood grain" or other fliud patterns. Damascus steel is made of at least two different steels and sometimes iron as well. The level of "carbon" in each type of steel is what actually appears as the different "stratified" layers.

***Terry's Chopper***
Damascus steel, sterling silver, antler
8" x 1 3/4" x 3/4"

Acids like nitric or ferric play an important role in the development and final appearance of Damascus steel. The steel with the higher amount of carbon tends to resist the acid, retaining its solid surface integrity. The steel with lesser carbon receives an acid "bite" and gets eaten away at its surface level. The undulating surface is the result of the various rates of steel resistance.

After the steel has been etched a coloring solution is applied to this surface, typically *gun blue*. This will contrast the different steels. After the solution is dried and the extraneous portion wiped away, a light sanding with a smooth grit sand paper cleans the "high" areas and leaves the low lying areas dark, thereby revealing the pattern of dark and bright (sanded) steel.

Damascus steel in the laminated form became possible only after the discovery of permanently bonding physically separate pieces of iron. This is known as *fusion welding*. This technique became known to blacksmiths as *fire welding* or *forge welding* because the separate pieces of iron to be welded were taken directly from the forge fire to the anvil for striking in a quick, light manner. Subsequent heatings in the forge fire led to the building up of *carbon*. The percentage of carbon present is the key to is what transforming iron into the more durable metal known as *steel*. It's believed that this momentous technique was first developed about 1000 BC in the Middle East, hence the name Damascus steel.

**Mokume gane**

The other part of *Damagane*tm is mokume gane made of non-ferrous metals: comparatively, non-ferrous metals are much softer than ferrous(steel) metals. It's the carbon present in ferrous metal that gives *steel* its superior strength.

Mokume gane is a laminate of *non-ferrous* metals. The metal that has been used in making mokume gane billets is copper and its alloys, gold, silver, and platinum. In this example, a billet is a solid piece of metal made up of various individual layers in which in cross section is relatively square and the overall shape is rectangular.

Mokume gane has its ancient beginnings in Feudal Japan. It was invented by Denbei Shoami (1651 - 1728). Appropriately named, *mokume* means "wood grain" and *gane* means "metal'.[1] Although mokume gane was developed in 17th century Japan, it wasn't until the 19th century, when mokume is first thought to have entered the Western world.[2]

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### Elements of Damagane

Because *Damagane*tm is the combination of Damascus steel and mokume gane it has the unmistakable traits of both metals. As an emerging professional metalsmith specializing in bladesmithing, I'm not much different from the early smiths that forged weapons and tools to not only survive but to develop and maintain a community , a civilization. My survival will be in a post-graduate world of the accomplished artist-craftsmen. It was in in my pursuit of bladesmithing that I first became familiar with Damascus steel. A longing for more color in my work pointed me to mokume gane.

**a. Aesthetic**

After I became familiar with the creation process of mokume gane I really gained an appreciation for the material. The organic-complex patterns of mokume gane were compatible and complementary to those of Damascus steel that I had come to admire. Apparently I wasn't alone in the allure of the Damascus and mokume gane. Craftsmen have incorporated both as part of their works of art, but never bonding the two metals as I have done with *Damagane*tm. I questioned why I hadn't seen evidence that anyone had bonded the two laminated metals together before? Was it simply impossible? Had anyone even tried it? If I was going to unite a ferrous metal to a non-ferrous metal without braze or solder, how was I going to approach it? An immediate concern was the fact that the non-ferrous metal could never withstand the intense temperature to forge-weld steel. Therefore, the only option was to make the ferrous metal respond to non-ferrous fusing techniques.

**b. Structural**

The steel ingrained in *Damagane*tm offers strength next to the softer non-ferrous mate. This pairing is both a blessing and a curse as far as the bonding process is concerned. the heat must be sufficient for the steel but not extreme for the non-ferrous element of the billet. The process of creating a *Damagane*tm billet can be a truly "liminnal experience". A successful *Damagane*tm billet results when the craftsman follows careful procedure and is of good mind and heart. A billet must go through the precise requirements in order to achieve the vibrant contrasting qualities or end up as merely seperate metal layers without unification.

**c. Spiritual**

My aspiration to make unique blades with aesthetic, structural, as well as, spiritual integrity led me to develop *Damagane*tm. The visual aesthetic is the first quality that becomes apparent to the observer. The lines and random patterns almost become like all the different paths and directions in life that are before each of us: the various shades of the non-ferrous metals contrast vibrantly with that of the steel. Visually, steel holds a brightness that rivals that of silver or copper when treated with a high polish.

To me, the spiritual aspect of *Damagane*tm comes from that unification of diverse material that creates beauty and collaboration. I have trained as an artist-metalsmith under master craftsmen of both ferrous and non-ferrous medium. *Damagane*tm is a way I can continue to work with these two traditional metalsmithing materials simultaneously.

## II. Creation of *Damagane*tm

The creation of *Damagane*tm is very much like making mokume gane. The laminates are not joined by *brazing*, *soldering*, or *welding* ( in the forge, gas, or electrical sense) but rather are fused together, similarly to "traditional" mokume. The metallurgical term for this type of "weld" is *Liquid Phase Diffusion Bonding*. Liquid Phase Diffusion Bonding is when through diffussion, a third alloy is formed between the two different parent metals (stacked up) at the planes of contact. This alloy liquifies and fuses the layers together. By adding the steel or the Damascus element to to the billet a more complex mokume gane billet is being created. Therefore, the metals should consist of ferrous and non-ferrous in an alternating orientation or at least different metals next each other(copper and brass). It is this alternating of material that results in the sharp visual contrast.

### A. Materials

In the illustration shown, brass, and stainless steel were used. The individual layers of 16 guage non-ferrous metal measured 1 1/2" x 1 1/2". The stainless steel measured 1/8" thick and 1 1/2" x 1 1/2"sqaure. Due to grinding, filing the 1 1/2" square measurement will end up being slightly less.

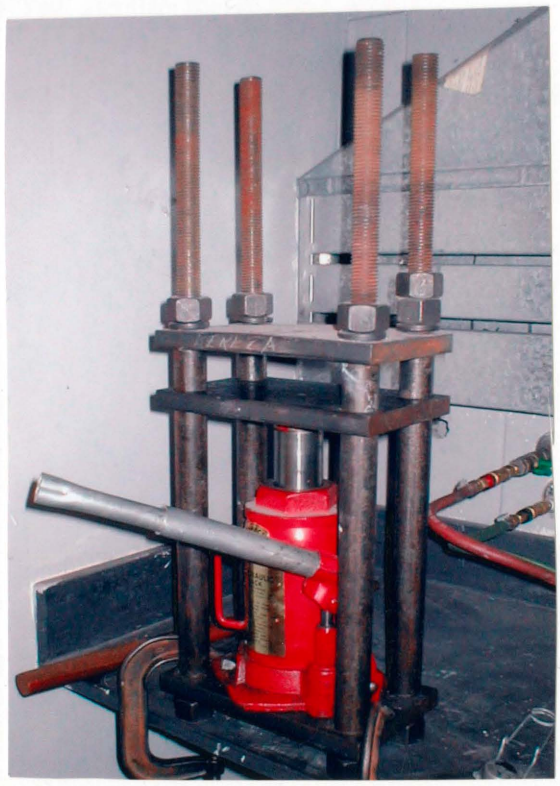
If a specific dimension is required, removal of material during refinement should be taken into consideration.

A modified "C "- clamp with a one-inch long rod welded to the stationary end of the clamp will hold the billet in place during the firing process.

Mini-kiln and C-clamp

Immediately following the firing process, the billet will need to be evenly compressed. For this I use a hydraulic press (courtesy of metalsmith Diane Townsley) outfitted with a twenty-pound hydraulic jack. The jack is available at most automotive/ hardware stores. Plans for building an adjustable press can be found in *Hydraulic Die Forming for Jewelers and Metalsmiths* by Susan Kingsley. A heavy-duty bench vice could serve this compression function as well.

20-pound jack and hydraulic press



A temporary *mini kiln* contains the "C "-clamp holding the billet in it's jaws. This "kiln" is temporary but when treated with care can serve in the fusing of many billets. Other great ideas for making a small kiln can be found in *Mokume Gane: A Comprehensive Studywritten* by Steve Midgett.

The mini-kiln I used was made by using a pair of standard sized soft fire bricks and some thin guage steel that was welded to form a tray around each brick. Iron binding wire is used to keep the two halves together while firing.

**B. Preparation**

To make the "mini kiln", a small cavity is carved out of the center of both halves of the bricks and the C-clamp. Also a hole for the primary torch tip is needed as well as a hole for a secondary torch tip. The hole for the secondary torch tip can be also used as a "peep-hole" to see how the billet is progressing.

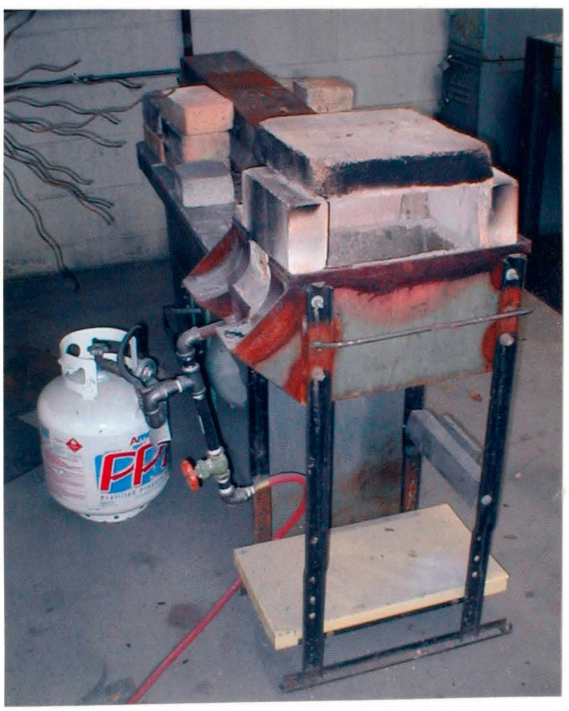
Absolute contact between the metal layers is crucial for bonding. There's no braze or solder here to fill in any "close" gaps. Clean flat pieces of metal should be used when starting out a billet. The smaller the billet, the easier it will be to maintain control the heating of the billet. It is important to avoid "under- firing" the billet that would result in an "incomplete" fusing. Just as important is to not "over-fire" the billet. Over-firing could result in melting of the non-ferrous metals. The fusing of the layers is all about achieving the correct temperature for the *Liquid Phase Diffussion Bonding* to begin and to sustain that temperature. For more interesting visual enhancement it is important not to place the same metal next to each other.

**C. Firing**

The size of the kiln will dictate the dimensions of the billet that can be effectively laminated together. I recommend using natural gas or propane fueled torches as a heat source, since acetylene creates an atmosphere that is not appropriate for the fusing process.

Propane gas forge

**10.**



## III. Manipulating *Damagane*tm

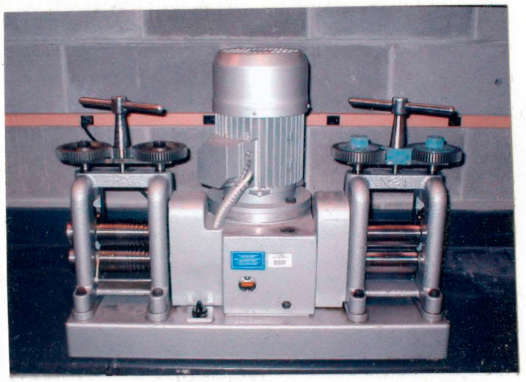
Once the individual layers are fused together without any imperfections, the billet can be manipulated to the desired final shape or dimension by lightly forging, filing, grinding, or cutting.

Forging *Damagane*tm can be very difficult. The difficulty is in the means of fusing the laminates. The metal that turned liquid and filled the area between the two metal laminates is most suseptible to shearing as it gives way under the hammer's blow. A similar condition applies when two non-ferrous metals are brazed (soldered) together. Hammering over the solder is difficult, it will be the first section to tear or crack.

If forging by hammer is *focused* striking compression between two concentrated points (hammer and anvil), then the use of the hydraulic press is the *consistant* overall compression within two planes.

The hydraulic press is a great tool to use in this process. When compression is needed this tool will deliver the pressure required at an even and consistant rate. Hydraulic presses are available commercially or can be homemade.

Another tool that comes to mind for controlled commpression is the *rolling mill.* I do not use a rolling mill because the non-ferrous metal would expand while the steel would not. Thereby, causing great risk of shearing between the laminates. In addition, the rollers could be damaged by the hardness of the steel.



## IV. Applications

### A. Bladesmithing Hardware

The decisive point of issue for me to develop *Damagane*tm was for hardware that I could use in my bladesmithing endeavours. Up to that point, I never heard of anyone bonding steel and non-ferrous metal together.

*Damagane*tm can be attached to steel or other materials using ferrous and non-ferrous metal working techniques, such as welding , brazing, soldering, riveting, tapping, etc. A lot of high quality blades have been made of various materials. *Damagane*tm is another laminated metal material that can be incorporated in any fine instrument of cutlery. It could even provide the cutting edge itself.

**B. Jewelry**

Throughout the ages humans have used just about every material attainable for the making of jewelry. Be it organic, found object, by- product of animal or human. Now there is *Damagane*tm, revealing the qualities of both Damascus steel and mokume gane. *Damagane*tm can be reduced into more intimate denominations for the applications that jewelry may require.

**V. Conclusion**

The creation of *Damagane*tm is a material for and of the ages, the result of an inexhaustible search for an innovative combination of materials that could be admired for qualities of aesthetic and structural integrity. A certain achievement of spirituality also factored in to the creation of this new material.

The enduring laminated metals of Damascus steel and mokume gane are the "parental" metals of Damagane.

The artist-craftsman can manipulate *Damagane*tm using various metalsmithing techniques.

The new laminated material can be used as bladesmithing hardware, jewelry material or whatever the modern metalsmith can envision. Imagine all the splendor of two unique laminated metals in one. This is *Damagane*tm.

## Work Cited

Midgett, Steve. *Mokume Gane: A Comprehensive Study.* Franklin, N.C., Earthshine Press 2000.