Metals are interesting materials. They show striking similarities as well as surprising differences. You can find liquid metals at room temperature (Mercury) or metals so soft you can literally cut them with a knife (Potassium). On the other hand you can waste your time and tools trying to work the hardest metals, such as Tungsten and Rhodium.

Understanding your metals

Metals can be distinguished from other substances by physical properties. Some of these are of interest to us, and some of them are not. The ones that are of interest to us are the properties that can be determined by the eye: high reflectivity and luster. There are mechanical properties that can be of interest to us when modeling and texturing: ductility and malleability. Ductility is the ability of a substance of bring drawn into threads, while malleability is the ability of being hammered (from the latin *malleus*=hammer) into sheets. We can dispense with the electrical and heat conductivity. As yet, I have found no software that includes an "Electrical conductivity" slider in its texture dialog box.

All metals have a common chemical bonding, called the metallic bonding. This metallic bonding gives metals their common features: electrical and thermal conductivity, malleability and surface sheen. This metallic bonding is caused by the overlapping of atomic orbitals when metals cluster together in closely packed crystalline lattices, or, in English; the metal atoms are so crowded that they begin to promiscuously share electrons, which get spread all over the crystal.

The extent of this packing and bonding varies with the atomic size and lattice structure, as also do the properties of metals. This is why chrome has harder reflections than lead, for example, or why copper is red while cobalt is bluish.

Metal atoms can be made to combine with atoms and molecules present in the environment, forming compounds that lack this metallic bonding. This results in the formation of surface films or deposits of compounds known as corrosion. To be able to create convincing metals, attention must be paid to the way in which they age. Some questions you may want to ask yourself are: Does this metal corrode in ordinary conditions? What color are the salts of this metal? Does it present surface films or salt deposits? Better than just asking, of course, is asking and looking. Be on the lookout for rusty or corroded metal pieces, be it in real life or in photographs. Try to mimic the bumps, colors, diffuse reflections, specularities (or lack thereof) of different metals and start building a library. I had done just that, and then one day I landed an animation for a mining firm that produced gold, silver, copper, selenium molybdenum and other strange metals. I saved myself a big deal of trial and error (and time on a tight deadline.)

Understanding your textures

As we all know, textures are lying attempts to mimic the actual behavior of materials in the real world. Let us have a look at the different variables we will deal with while creating textures.

Ambient Fraction:
Ambient lighting is a non-directional background lighting. You can select how much of this light is reflected by your material. Non reflective materials have high ambient fractions, while reflective materials have lower ambient fractions. For metals, Ambient fractions between 0.5 and 0.7 are common, but do not believe me. Experiment for yourself.

Bump Amplitude:
This value controls how deep are the bumps as set by the bump map, a grayscale image. We will use bumping for hammered, brushed and aged metals. The bump amplitude varies with the hardness of the metal. For lead you will have to use a higher value than for steel, unless you are representing stamped metals, rather than aged.

Diffuse Fraction:
There are two ways in which an object can reflect light. Specular and diffuse. Diffuse reflection is caused by rough, non reflective surfaces. Metals are smooth, reflective surfaces, so the diffuse fraction should be low. Not too low, because it will darken your object too much, turning it into a mirror.

Glow Factor:
This parameter simulates incandescence for objects. It will be of use to us only when making red or white-hot metals.

Reflectivity:
Reflectivity is not to be overdone. A reflective metal rarely reflects more than 25% of the light it receives. Try to keep this value below 0.25, except when dealing with chrome or mirrors.

Index of Refraction:
No use to us here. The refraction index applies to transparent materials only, and I yet have to find a transparent metal.

Specular Fraction:
The other kind of reflection. This one applies to smooth shiny surfaces. Pump it up! give it the full 1.0. Later, we will discuss when to lower it

Transparency:
None for metals, that I know of, at least.

First Smoothness:
Let us stop for a while here. First smoothness controls the size of the spot of light reflected by a surface: the higher the value of this parameter, the smaller the reflected spot. Metals typically exhibit small reflected spots of light. Try values above 100. For soft metals, try lower values. Try not to use too high values. These will lend a plastic look to your metal, and probably you do not want that.

Second Smoothness:
Somewhat more esoteric than the above, Second Smoothness creates a halo around the reflected spot of light. The higher the value, the smaller the halo. Big halos are wanted here, so make it small. 5 is small enough

Second Weight%:
Even more subtle and esoteric than the above. This Second Weight% parameter controls the influence the halo has on the surface reflection. Definitely a doodle and see kind of parameter. May I suggest around 30% for starters?

In this article we shall deal with the most common metals and alloys, plus some not so common metals and finally, with nonexistent metals found in literature. On to gold.

Gold

Let us start with the secret goal of medieval alchemists: Gold, the Noblest of metals (before discovery of Platinum, that is), metal whose symbol was that of the sun itself.

Metallic gold is a soft, bright yellow metal. It is chemically very stable, and does not tarnish. In order to increase its hardness, gold is alloyed with silver and copper, yielding various colors of gold. If the alloy is rich in silver, you will get a pale yellow gold, while, if the alloy is rich in copper, you will get reddish-yellow gold

To convert a base texture into Gold, you no longer need strange apparatuses, ciphered books, and secretive ways. The use of strange symbols and working into the wee hours remain of that ancient practice, though. Let us don our alchemist cape and get started.

Let us open the application, throw in a sphere and ask for a new surface texture. Name it Gold (in a flash of creativity) and select a pure yellow color, with a little tinge of red (pure yellow is usually perceived as greenish.)

Next, we click on the Expert... button and start tweaking parameters to obtain a texture. Let us review the outcome of these fiddlings.

TEXTURE SUMMARY 1: BASIC GOLD TEXTURE

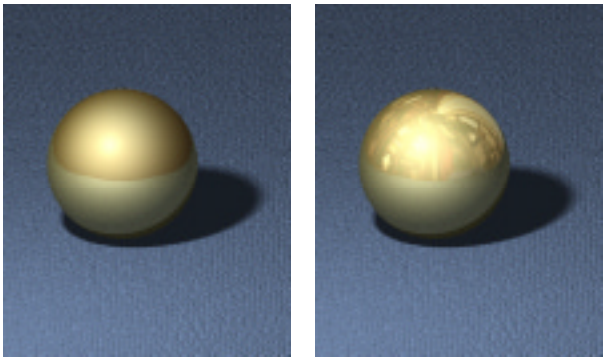
Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	120
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.4	**Color (RGB percentages)**	100-91-39
Index of Refraction	1.0	**Specular Color**	100-100-90
Specular Fraction	1.0	**Maps**	None

Render, and you should now get a pretty gold texture.

"But..."– I hear you say... –"that does not seem right." Right! it is not as right as it could. Why? Because the metal´s surface is highly reflective, and in the real world metal objects are surrounded by other objects which get reflected. The previous figure reflects the default reflection that Vision uses, the dark-purple gradient. Now, if you go to CMD-H and change Default reflected by Room reflected, the material acquires

new life as shown here. The picture in the left is a sphere with our new texture and default reflected environment. The sphere in the right has the same texture but the Room reflected environment. Quite a change, eh?

FIGURE 1: BASE GOLD TEXTURE WITH DIFFERENT REFLECTED ENVIRONMENTS



You can achieve the same effect with more control in Studio Pro 2.0 or higher assigning an environmental reflection directly to the material. Just click in the Environment... button and select one of the proffered maps or load one of your choice.

Surface finishes

We have our basic gold texture, but gold typically receives a lot of different surface treatments. Make a new texture, name it Gold-hammered, and Copy From Gold.

Instead of sharp and dangerous scratching and bludgeoning tools, we shall use PhotoShop. Request a 400x400 pixel grayscale document, throw in some noise and then apply the Crystallize... filter. Blur it a bit, and make it tileable (Offset...filter plus some rubber stamping) Paste this as bump map in the new texture, and set the bump amplitude to a decent value. I used 3.0 for this example. Map to taste, and here we are.

Brushed gold is similar. Just a bump map, but this time we also fiddle with the texture´s parameters. Let us make ourselves a map.

Again a 400x400 pixel grayscale document in PhotoShop. Apply noise to a thin rectangular selection, then stretch it to cover all the document. This should elongate the noise pixels into lines. If lines are not long enough, repeat the process. Another option for this is using the Motion Blur filter.

TEXTURE SUMMARY 2: GOLD – HAMMERED

Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	3.0	**First Smoothness**	120
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.3	**Color (RGB percentages)**	100-91-39
Index of Refraction	1.0	**Specular Color**	100-100-90
Specular Fraction	1.0	**Maps**	Hammered

Make the map tileable and paste as bump map. OK; this map suggests brushing, but the map alone is inadequate. If you look attentively to a brushed gold object, you will see that the lines are very, very thin. Thinner, indeed, than what is possible for us to render with maps. To make up for this limitation, we increase Ambient and Diffuse and decrease Specular, Reflectivity, First Smoothness and Second Smoothness. Thus, we simulate the loss of shininess and reflectivity the brushed surface suffers. The first and second smoothness values simulate the softer sheen a brushed metal piece has.

TEXTURE SUMMARY 3: GOLD – BRUSHED

Ambient Fraction	0.7	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	60
Diffuse Fraction	0.5	**Second Smoothness**	2
Glow Factor	0.0	**Second Weight%**	65
Reflectivity	0.2	**Color (RGB percentages)**	100-91-39
Index of Refraction	1.0	**Specular Color**	100-100-90
Specular Fraction	0.8	**Maps**	Brushed

FIGURE 2: HAMMERED AND BRUSHED GOLD TEXTURES

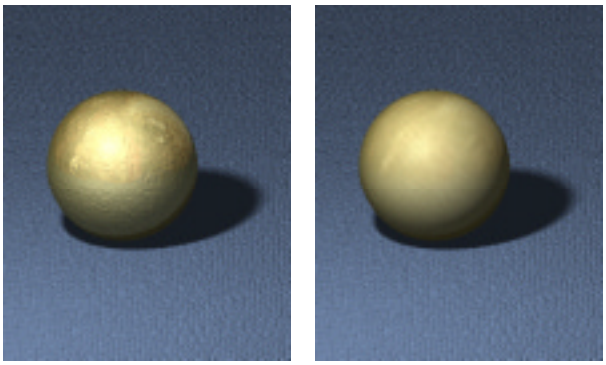
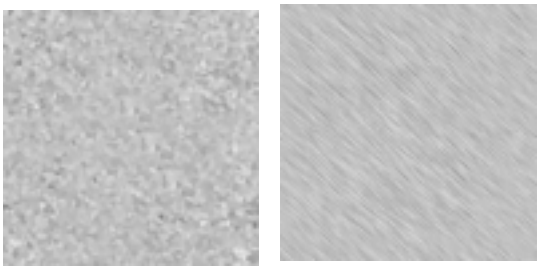


FIGURE 3: BUMP MAPS FOR HAMMERED AND BRUSHED METALS



Gold alloys

We now have obtained a typical 24-karat Gold texture. Please compare it with actual samples of gold objects to see how well it fits, and please note that most objects are of a redder hue than what we have. Alloys are to blame.

Most of the time you will find gold alloys instead of pure gold. Gold is alloyed to harden it, for pure gold is much too soft to work upon. In most cases, Gold is alloyed with Copper and Silver to yield 18k and other commercial varieties of it. To change our pure gold into 18k gold, make the color a little redder and set a slightly pinkish Specular color

TEXTURE SUMMARY 4: GOLD – 18K

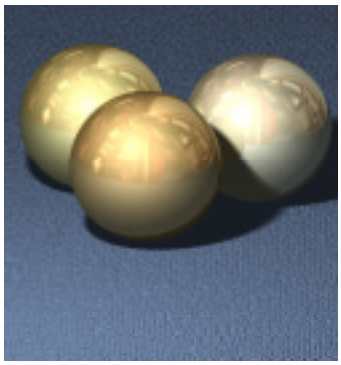
Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	0.0	**First Smoothness**	120
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.4	**Color (RGB percentages)**	100-88-37
Index of Refraction	1.0	**Specular Color**	100-94-84
Specular Fraction	1.0	**Maps**	None

Another common alloy of gold is Electrum, about 50/50 gold/silver. Turn your texture color to a pale yellow to attain it

TEXTURE SUMMARY 5: ELECTRUM

Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	120
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.4	**Color (RGB percentages)**	100-96-70
Index of Refraction	1.0	**Specular Color**	100-99-90
Specular Fraction	1.0	**Maps**	None

FIGURE 4: DIFFERENT GOLD ALLOYS



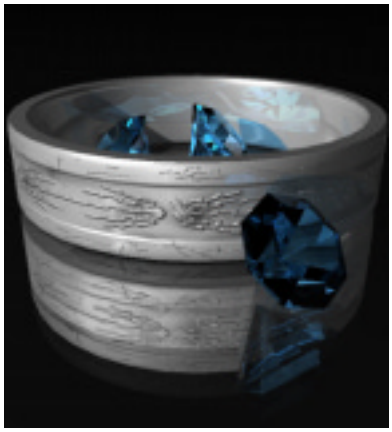
That is a basic approach to gold textures. There are other less common gold alloys, such as green gold, gold-iron alloys or a japanese Copper-gold alloy that rusts to a deep purple color. *Quaerendo Invenietis*. Seek and ye shall find

Now, let us climb a period in the periodic table and go to number 47: Silver.

Silver

Silver, the metal of the moon. White, cold. Less impervious to external agents than gold, but noble nevertheless.

FIGURE 5: SILVER RING

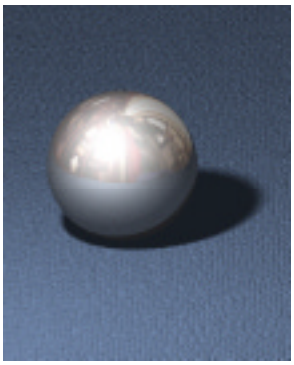


The texture for silver is very similar to that of gold, only without the yellow color. Some differences do apply, though. Silver is more reactive than gold, and thus, it fogs and tarnishes with relative ease. To account for this, let us use slightly lower reflectivity and specularity values than for gold (0.3 and 0.95 will do). There we are. If you are working on a model that includes granny´s silverware, burnished into someting more reflective than a mirror, go for one of many chrome textures, or crank the specular/reflectivity values to a lot and increase First and Second smoothness and decrease a little the Ambient and Diffuse fractions.

TEXTURE SUMMARY 6: BASE SILVER

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	100
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.35	**Color (RGB percentages)**	95–95–95
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.95	**Maps**	None

FIGURE 6: BASE SILVER



Finishes

As with Gold, you can treat the surface of a silver object in many ways: brushing, hammering, stamping and others, all apply to silver; the difference is again centered in the reactivity of silver. The depressed areas will become black with time, due to the oxidation of silver into black compounds, such as sulfides. This is fairly easy to simulate with reflectivity, specular and color maps. For further detail you can throw in Ambient and Diffuse maps as well. The examples show hammered and brushed silver, and a texture with a Celtic motif in bas relief, conveniently blackened.

FIGURE 7: SILVER– SURFACE FINISHES

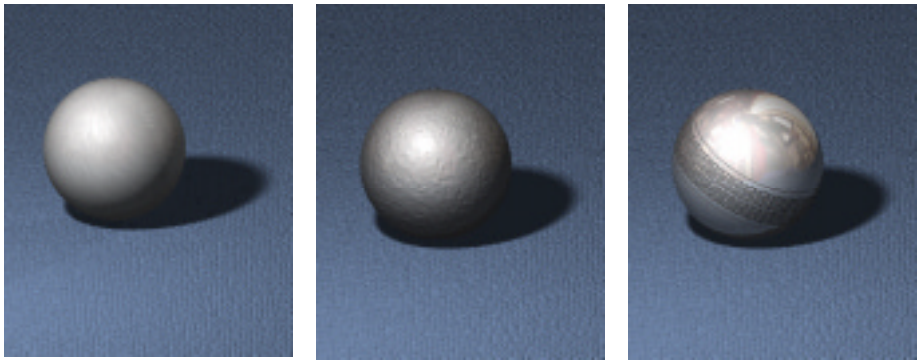
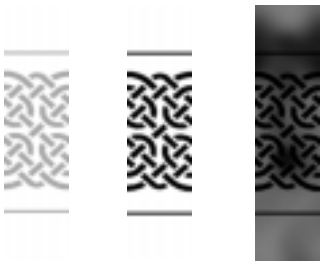


FIGURE 8: AMBIENT/DIFFUSE/SPECULAR, REFLECTIVITY AND BUMP MAPS WITH A CELT MOTIF



TEXTURE SUMMARY 7: BRUSHED SILVER

Ambient Fraction	0.7	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	25
Diffuse Fraction	0.6	**Second Smoothness**	2
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.1	**Color (RGB percentages)**	95-95-95
Index of Refraction	1.0	**Specular Color**	100-100-90
Specular Fraction	0.7	**Maps**	Brushed

Aging

Silver ages gracefully. At least for us 3d doers. Silver gets fogged with ease, and tarnishes to a brownish gray, opaque material, again thanks to sulfides and others.

To simulate fogged silver, a grayscale jack-of-all-trades map will do. Just render BW clouds in PhotoShop, set the darkest gray to 50% using curves, and make the texture tileable (Offset filter plus lots of rubber stamping). Then use this map as Ambient, Diffuse and Reflectivity. Set reflectivity to around 0.15 and there you are! Somewhat neglected silverware is yours!

TEXTURE SUMMARY 8: SILVER–FOGGED

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	100
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.15	**Color (RGB percentages)**	95-95-95
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	10.95	**Maps**	Clouds (ADR)

Tarnished silver should be used with care. It takes long neglect to let silver fall into dull-gray tarnish. Useful for archaeological scenes and Tomb-despoiling games, though. The same grayscale jack-of-all-trades map is again called into play, in the same positions that it occupied in fogged silver plus Specularity. Turn Reflectivity to almost zero or zero, Specular fraction to 0.8 and First smoothness to 35. Voila!

TEXTURE SUMMARY 9: SILVER–TARNISHED

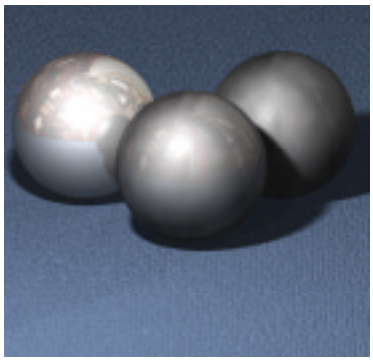
Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	75
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.05	**Color (RGB percentages)**	90-90-90
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.8	**Maps**	Clouds (ADRS)

Silver becomes a matt black material after either very long neglect or chemical treatment. It is not at all uncommon that jewelers play with these opposite surfaces in their works. This is accomplished by inmersing the finished silver piece in an oxidising bath in the presence of sulfides and polishing the piece.

TEXTURE SUMMARY 10: SILVER–OXIDIZED

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	75
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.05	**Color (RGB percentages)**	90-90-90
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.8	**Maps**	Clouds (ADRS)

FIGURE 9: CLEAN, FOGGED AND TARNISHED SILVER

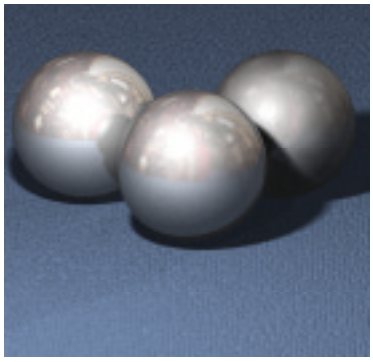


Most of the time, tarnish is accompanied by scratching. Not in the sense of an even brushed finish, but irregular, random scratches. These scratches are made along time. Tiny scratches build up, and big scratches are "eroded" by friction and wear. The way I found to accomplish this look is to work in PhotoShop with the pencil tool set to 1 pixel wide and an action that lightens the image using curves and blurs. Between these and the Add Noise filter, I was able to create a very useful map that works as a multimap, but mainly as bump map. Examples below.

TEXTURE SUMMARY 11: SILVER–SCRATCHED

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	2.5	**First Smoothness**	100
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.1	**Color (RGB percentages)**	95-95-95
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.9	**Maps**	Scratched (BD)

FIGURE 10: CLEAN, SCRATCHED AND TARNISHED SILVER



Copper

The alchemic symbol for copper is the same that for planet Venus; the one we now use for woman. Red metal. Malleable, excellent conductor, when corroded forms very interesting green-turquoise salts. It is not a metal frequently used for actual jewelmaking, but it may come in handy. Besides, I live in a country that is one of the biggest copper producers in the world.

I just said copper is red, a sudued red, not a furious red, with low Diffuse Fraction and First Smoothness values, plus a light orange Specular color.

TEXTURE SUMMARY 12: COPPER–BASE

Ambient Fraction	0.4	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	25
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.2	**Color (RGB percentages)**	88-34-20
Index of Refraction	1.0	**Specular Color**	100-84-77
Specular Fraction	1.0	**Maps**	None

FIGURE 11: BASE COPPER

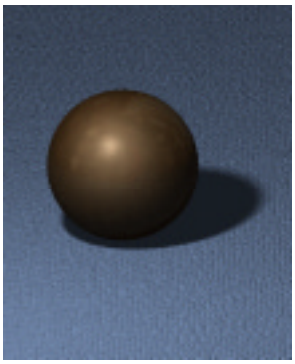
Aging

Copper starts aging horribly. I have in front of my eyes a copper piece I did in my early jewelmaking classes and it IS unappealing (the shape is beautiful, nevertheless). Because it is a soft metal, copper scratches easily. A Scratch map will do wonders to enhance the aged look of copper. Slight variations on the Bump Amplitude as well as slight color changes can convey a wide spectrum of differently aged copper objects.

TEXTURE SUMMARY 13: COPPER–OLD

Ambient Fraction	0.4	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	100
Diffuse Fraction	0.4	**Second Smoothness**	7
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.1	**Color (RGB percentages)**	75-38-24
Index of Refraction	1.0	**Specular Color**	92-85-75
Specular Fraction	0.8	**Maps**	None

FIGURE 12: OLD COPPER

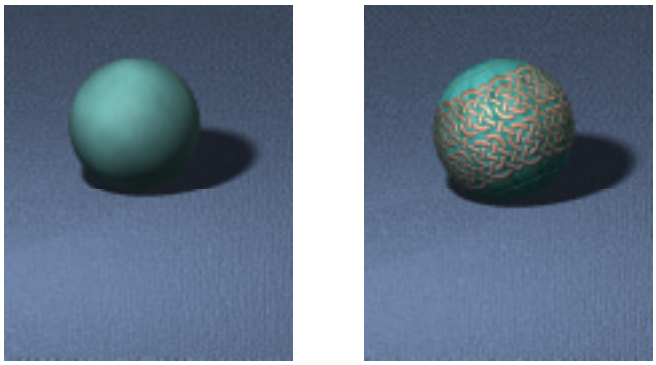


Fortunately, after a couple hundred years, your lack of cleanliness begins to pay off. Copper salts are beautifully colored in the green-turquoise range. These salts often cover the whole surface of the metal, which loses its metallic appearance. This oxidation color is used deliberately as a decorative surface finish. Of course, the process is hastened

TEXTURE SUMMARY 14: OXIDIZED COPPER

Ambient Fraction	1.0	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	25
Diffuse Fraction	1.0	**Second Smoothness**	7
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.0	**Color (RGB percentages)**	55-89-88
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.1	**Maps**	None

FIGURE 13: OXIDIZED COPPER



Brass/Bronze

Copper alloys. Brass with Zinc and Bronze with Tin. Virtually indistinguishable outside the laboratory.

The Preset Brass texture is great. In my humble opinion, the best achieved texture of all that come with the program. Even though eschewing presets is a (sometimes necessary) badge of accomplishment for 3d software, this texture does the job perfectly.

Aging

In much the same fashion as the first stage of copper, but preserving the differences due to color. Then, surprisingly, it becomes like a bronze statue; a dark gray, unreflective material that does not have much to do with the original material.

TEXTURE SUMMARY 15: OLD BRASS

Ambient Fraction	0.4	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	120
Diffuse Fraction	0.4	**Second Smoothness**	7
Glow Factor	0.0	**Second Weight%**	33
Reflectivity	0.07	**Color (RGB percentages)**	40-40-40
Index of Refraction	1.0	**Specular Color**	80-100-80
Specular Fraction	0.6	**Maps**	None

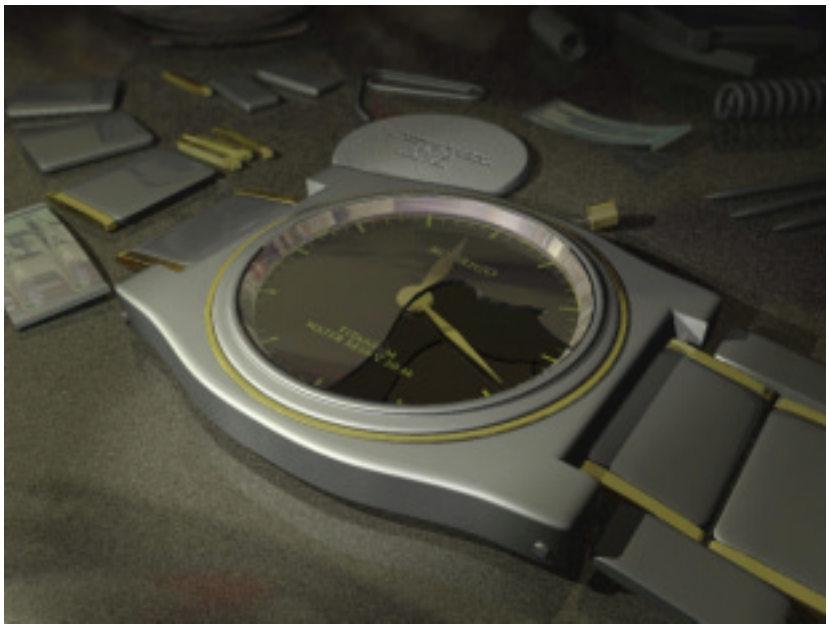
FIGURE 14: OLD BRASS/BRONZE

Titanium

Titanium is a very light and useful metal, discovered last century, and widely used only since the 50´s decade. Titanium is a white metal, but its most common incarnation is the one seen in titanium watches and the like. It is a gray, somewhat graphite like material, not reflective, and with a slightly textured surface.

A multimap is all you´ll need here. Again, a 400x400 document in PhotoShop, plus add noise with amount set to 50. Now copy this map into the clipboard and paste as Ambient, bump and diffuse.

FIGURE 15: TITANIUM WATCH

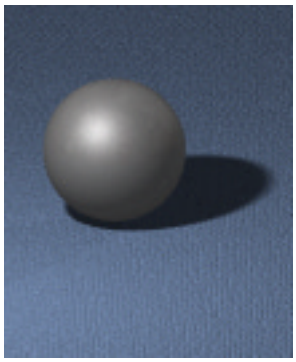


TEXTURE SUMMARY 16: TITANIUM

Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	120
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	30
Reflectivity	0.4	**Color (RGB percentages)**	100-91-39
Index of Refraction	1.0	**Specular Color**	100-100-90
Specular Fraction	1.0	**Maps**	None

A particular behaviour of Titanium is that it becomes coloured when heated. This is due to the formation of surface layers of oxides, which refract light, acting as prisms, lending this interesting play of colors to the surface. To achieve this effect, I used a 400 x 400 texture created with KPT Texture Explorer, blurred and color corrected. That is the color map. The rest remains untouched.

FIGURE 16: TITANIUM



Titanium can be heat-treated to achieve surface colours due to surface layers of oxides. This is an effect much used for ornamental purposes. To achieve this effect a colour map is all you need. Get a nice texture from KPT Texture explorer or fiddle around a bit with different Difference clouds in PhotoShop... and thy map is ready.

TEXTURE SUMMARY 17: COLORED TITANIUM

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	25
Diffuse Fraction	0.5	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.15	**Color (RGB percentages)**	100-91-39
Index of Refraction	1.0	**Specular Color**	100-100-90
Specular Fraction	1.0	**Maps**	Clouds

FIGURE 17: COLORED TITANIUM

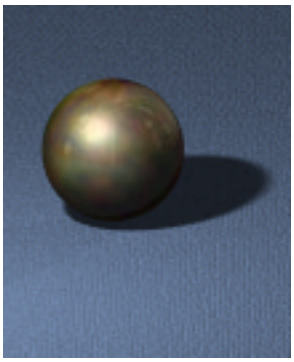
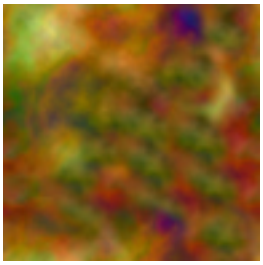


FIGURE 18: COLOR MAP FOR COLORED TITANIUM



Chrome

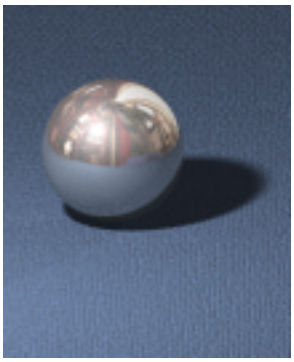
A white, shiny, hard and brittle metal. It is very resistant to corrosion, and this is why it is electroplated over less resistant metals to protect them from scratching or corrosion.

The metal itself has high reflectivity, consequentially low ambient and diffuse fractions and high Smoothness values.

TEXTURE SUMMARY 18: CHROME

Ambient Fraction	0.4	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	300
Diffuse Fraction	0.4	**Second Smoothness**	15
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.6	**Color (RGB percentages)**	100-100-100
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	1.0	**Maps**	None

FIGURE 19: BASE CHROME



Aging

Since chrome is a very corrosion resistant and brittle metal, the most common way in which it ages is chipping off the surface it covers. To simulate this, cunning mapwork is called into play.

The idea here is to simulate two metals–chrome and the metal on top of which it is plated in one single texture. Fortunately, we can handle almost everything with maps. Only the three Smoothness parameters remain inalterable for the whole texture.

Let us create a new document in PhotoShop (400x400 as always), whether RGB or Grayscale depends on the base metal. Paint the exposed area in black over a white background with a hard brush (square brushes are most useful here). Now, with a single-pixel pencil paint faint black cracking lines going into the white. Now add a little noise and maybe some motion blur to the black area. There you are. A bump map. It is important that this map is hard–edged to suggest two layers of material.

Metals are chrome plated to prevent corrosion, so it is reasonable to suppose that the exposed base metal is somewhat oxidized already. This probably means low reflectivity and specularity; and a bit higher ambient and diffuse values. So now follows the reflectivity map. It can even be the same map as the bump map. Make a gray and white version of the bump map to use as a specularity map (levels/curves).

TEXTURE SUMMARY 19: CHIPPED CHROME

Ambient Fraction	0.7	**Transparency**	0.0
Bump Amplitude	2.0	**First Smoothness**	200
Diffuse Fraction	0.9	**Second Smoothness**	7
Glow Factor	0.0	**Second Weight%**	33
Reflectivity	0.6	**Color (RGB percentages)**	100-100-100
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	1.0	**Maps**	Colour, bump, reflectivity, specularity

FIGURE 20: CHIPPED CHROME

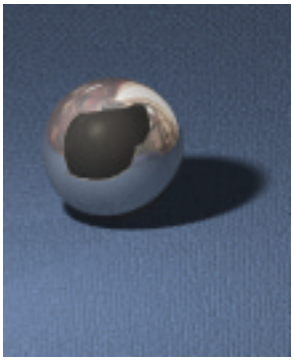


FIGURE 21: COLOR/SPECULAR, DIFFUSE/AMBIENT, BUMP/REFLECTIVITY AND SPECULAR MAPS FOR CHIPPED CHROME

Pewter

Originally, an alloy of lead and tin; replaced during the XVIII century by Britannia metal; an alloy of copper, antimony and tin. Both terms are used interchangeably now.

It is a gray, rather dull metal. It has, nevertheless, high reflectivity. It also has little holes on its surface.

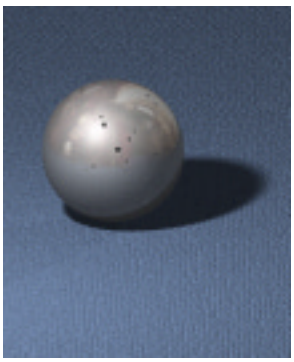
This metal calls for mapworking. Little holes are simulated by bump, specularity, reflectivity and color maps, not forgetting ambient and diffuse, of course!. To make small, random holes appear in the surface, I rendered gray/white clouds, to which I added a little noise, plus some Gaussian blur, and then converted to Bitmap using the 50% threshold option. Then back to grayscale, slight blurring, some tileabilitization, and we have the base map.

TEXTURE SUMMARY 20: PEWTER

Ambient Fraction	1.0	**Transparency**	0.0
Bump Amplitude	2.0	**First Smoothness**	35
Diffuse Fraction	1.0	**Second Smoothness**	4
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.25	**Color (RGB percentages)**	100-100-100
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.7	**Maps**	See text

FIGURE 22: MAPS FOR PEWTER: COLOR/ BUMP/ REFLECTIVITY/ SPECULAR, AMBIENT, DIFFUSE

FIGURE 23: PEWTER



Tin

Alchemic Jupiter. A chemical cousin of lead, tin is a useful metal, known since who knows when. Tin was much appreciated in the antiquity, causing Phoenician merchants to visit such faraway places as the British Isles to get it. It fell from its popularity when different peoples began entering the Iron Age.

Never put your tin in the deep freezer! Tin undergoes a change of crystalline forms at low temperatures, ant the stable form at -20 degrees Celsius is a gray powder. Imagine the surprise and disappointment of german troops in the battle of Stalingrad, when they were supplied with tin buttons for their uniforms. They were unable to face the enemy with elegance! So, when modeling subzero scenes, go for other metals.

Tin is also alike to lead in appearance. Gray, low melting point, not exceedingly shiny.

TEXTURE SUMMARY 21: TIN

Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	25
Diffuse Fraction	0.4	**Second Smoothness**	6
Glow Factor	0.0	**Second Weight%**	45
Reflectivity	0.1	**Color (RGB percentages)**	100-100-100
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.85	**Maps**	None

FIGURE 24: TIN

Graphite

Graphite is not a metal, although it shares some common features with them. It has the "metallic" sheen and it is a conductor, but it lacks the mechanical properties of true metals. This similarity in difference is because graphite has a delocalized bonding similar to that of metals, but with a laminar covalent backbone.

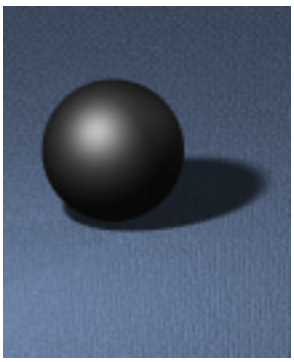
It is a dark gray material, visually similar to lead, and also similar to lead in the fact that it "writes", being so soft that it can be rubbed onto surfaces. Think, if you will, why lead pencils are called lead pencils. The old word in Spanish for graphite is also related to Lead (*plombagina* v/s *plomo*), for example, and in German the same etymology holds.

Now to the texture: Dark, unreflective, specular, with low First and Second Smoothness values.

TEXTURE SUMMARY 22: GRAPHITE

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	15
Diffuse Fraction	0.5	**Second Smoothness**	4
Glow Factor	0.0	**Second Weight%**	33
Reflectivity	0.0	**Color (RGB percentages)**	33-33-33
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.75	**Maps**	None

FIGURE 25: GRAPHITE



Iron

Mars, the symbol for man. An undisputed technological advantage some 3,500 years ago and instrumental in the spreading of the patriarchal system. This gray, easily rusted metal has quite a few possible representations. The metal itself is white and shiny. It is quite reactive (powdered iron burns in contact with moist air!), so it quickly becomes gray and rather dull

TEXTURE SUMMARY 23: IRON

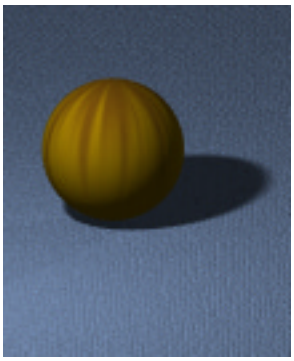
Ambient Fraction	1.0	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	50
Diffuse Fraction	0.4	**Second Smoothness**	15
Glow Factor	0.0	**Second Weight%**	33
Reflectivity	0.2	**Color (RGB percentages)**	80-80-80
Index of Refraction	1.0	**Specular Color**	97-97-97
Specular Fraction	1.0	**Maps**	None

FIGURE 26: IRON

Aging

Iron ages interestingly. Iron can be oxidized to iron(II) or iron(III). Iron(II) is green in colour and is unstable, oxidizing rapidly to iron(III). This is our well-known rust coloured ion. The iron oxides that form on the surface of the metal do not prevent further oxidation, as is the case with aluminium, so our piece of metal quickly becomes fully rusted. The surface of rusty iron is not smooth, but granular, so this calls for a bump map. Also a color map in shades of ochres and oranges is needed.

FIGURE 27: RUSTED IRON



Steel

Iron with a twist, steel is one of the most widely used metals. You find steel everywhere in your day to day life. Gray, shiny metal. It has hard reflections.

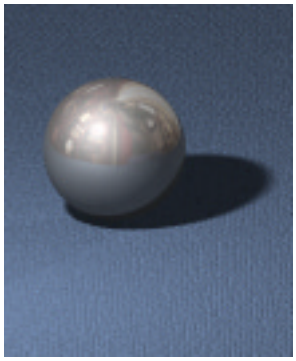
TEXTURE SUMMARY 24: STEEL

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	300
Diffuse Fraction	0.5	**Second Smoothness**	8
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.3	**Color (RGB percentages)**	90-90-90
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	1.0	**Maps**	None

Steel is made by adding small amounts of carbon to iron. This addition greatly improves the mechanical properties of iron. There are many other elements that can be added besides carbon,each yielding special kinds of steel. For example, if you add Chrome or Vanadium, you will

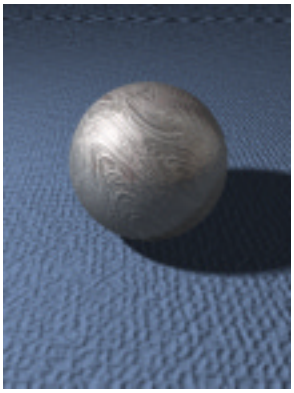
get Stainless steel. If you add Tungsten, you will get very hard steels. The list could go on forever. These additions, however, do little to change the appeaance of our metal.

FIGURE 28: STEEL



An interesting variation of steel is Damascus-pattern steel. It was and is still used for making blades, swords and other assassination devices. It can be represented by an iron or steel texture with another similar metallic texture layered on top Remember to use a Stencil map for this one. The random pattern was created by adding noise to a PhotoShop Document and then converting to polar coordinates, plus some ripples and ocean ripples. A grayscale version of the map was used for bumps and a high-contrat version was used as Stencil.

FIGURE 29: DAMASCUS PATTERN STEEL



Lead

Saturn of the alchemists, Lead is an increasingly unpopular metal in these environmentally conscious days. It forms highly poisonous compounds; one of them, lead acetate, because of its sweet flavor, has found use as a poison. If you ever receive a sachet labeled $Pb(CH_3COO)_2$ – sweetener, think twice before sweetening your coffee or tea with it.

Lead is a gray, soft metal with a low melting point. It is easily tarnished to a dark gray, opaque surface. Because of this softness we shall apply bump maps liberally here. Let us copy a silver texture and change some parameters, let us also darken the color to a 25% black and we should be ready.

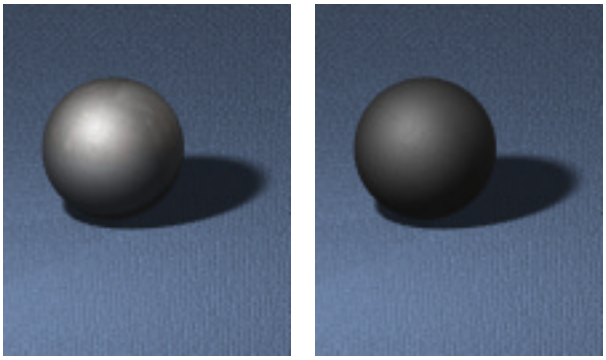
TEXTURE SUMMARY 25: LEAD–NEW

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	25
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.1	**Color (RGB percentages)**	75-75-75
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.8	**Maps**	Scratched (BD)

TEXTURE SUMMARY 26: LEAD–OLD

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	2.0	**First Smoothness**	25
Diffuse Fraction	0.3	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.0	**Color (RGB percentages)**	75-75-75
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.4	**Maps**	Scratched (BD)

FIGURE 30: LEAD



Aluminium

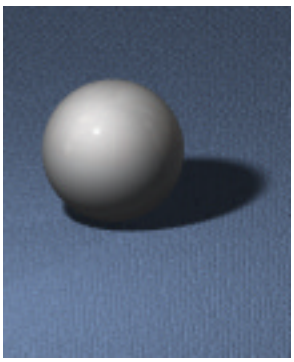
The most abundant of metals, but also a difficult one to refine. This lightweight, most versatile metal can be found in many alloys and surface finishes. Let us get acquainted with the basic aluminium texture first.

We are presented by the software with a preset Aluminium, but it is too reflective and bluish for my taste. Let us embark in a base aluminium, Aluminium is a very reactive metal. As a matter of fact Aluminium powder reacts violently with water, and is used as an incendiary device sometimes. Fortunately for us, the oxide layer that coats aluminium is very inert chemically and prevents further oxidation of the metal. This oxide layer gives aluminium its sheen and lack of reflectivity.

TEXTURE SUMMARY 27: ALUMINIUM

Ambient Fraction	0.7	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	150
Diffuse Fraction	0.65	**Second Smoothness**	5
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.2	**Color (RGB percentages)**	95-95-95
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.75	**Maps**	None

FIGURE 31: ALUMINIUM



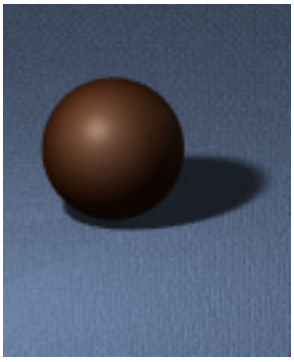
Finishes

Aluminium, of all metals, is abusively anodized. To anodize a metal is to electrically create a porous surface layer that absorbs pigments. Many colors can be obtained by anodizing, but the most common is brown (besides, my window frames are brown anodized aluminium, so I have a ready reference)

TEXTURE SUMMARY 28: ANODIZED ALUMINIUM

Ambient Fraction	0.7	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	50
Diffuse Fraction	0.7	**Second Smoothness**	4
Glow Factor	0.0	**Second Weight%**	50
Reflectivity	0.1	**Color (RGB percentages)**	42-20-8
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.5	**Maps**	None

FIGURE 32: ANODIZED ALUMINIUM



Fantasy metals

Literature has some metals in store for us, also. The attempt to render these metals is easier and harder at the same time. You read the description of a metal, create an (to your understanding of the description) suitable texture, show it to a fellow reader and the feedback is: "That is not Mithril!"

The advantage: No standards to compare with.

The disadvantage: No standards to compare with.

Let us undertake some metals found in literature. I found that the greatest metals inventor seems to be J.R.R. Tolkien.

FIGURE 33: THE RINGS

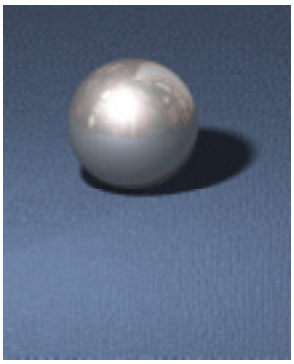
Mithril

Mithril or truesilver, mined in Khazad-Dûm. Those who have read The Lord of the Rings may have wondered about the physical appearance of Mithril, a metal both light and hard, ideal for chain mail. Even though the book says it was very like common silver, you may be inclined to think otherwise. Small changes that may seem inconsequential are a slight glow factor and harder reflections. Maybe elvish chainmail would better highlight the differences?

TEXTURE SUMMARY 29: MITHRIL

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	200
Diffuse Fraction	0.4	**Second Smoothness**	10
Glow Factor	0.075	**Second Weight%**	75
Reflectivity	0.3	**Color (RGB percentages)**	100-100-100
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	1.0	**Maps**	None

FIGURE 34: MITHRIL



Ithildin

Ithildin is a material derived from Mithril. Its main feature is that it glows in moonlight, and can even be set to glow on certain nights and under certain conditions. It appears in The Lord of the Rings, when the company tries to open the doors of Moria

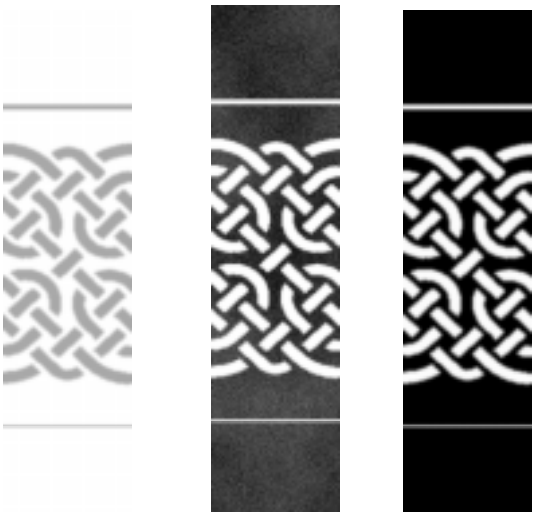
This material was accomplished by the use of maps for ambient, diffuse, reflection and specularity, plus the use of glow factor. The metallic areas of the sphere have a glow of 0.3, while the rest have none. Compare with the silver sphere in the same diminished light. Please also note the recycling of maps. It is not uncommon that ambient and diffuse maps happen to be the same, and the same happens to specular and reflectivity maps.

TEXTURE SUMMARY 30: ITHILDIN

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	3.0	**First Smoothness**	100
Diffuse Fraction	0.4	**Second Smoothness**	5
Glow Factor	0.3	**Second Weight%**	75
Reflectivity	0.35	**Color (RGB percentages)**	95-95-95
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.95	**Maps**	Celt motif: ambient, bump, diffuse, glow, specular, reflectivity

FIGURE 35: ITHILDIN AND NORMAL SILVER, IN EQUAL LIGHTING CONDITIONS

FIGURE 36: AMBIENT/DIFFUSE, BUMP AND GLOW/SPECULAR/REFLECTIVITY MAPS FOR ITHILDIN



Galvorn

Again Tolkien´s work. This time it is The Silmarillion, chapter 16: Of Maeglin.

> *"...and he devised a metal as hard as the steel of the Dwarves, but so malleable that he could make it thin and supple; and yet it remained resistant to all blades and darts: He named it Galvorn, for it was black and shining like jet, and he was clad in it..."*

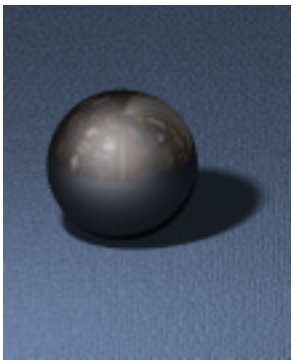
From this description I say, translating from English into Stratish: "Black in color, of course, highly reflective and with First and Second Smoothness values like those of metal." But first attempts produce a plastic-like material; the black color to blame. After some tests, I find that a high First smoothness (500) and a low Second smoothness (4) do the trick.

Finally, I obtain an acceptable material, which shall bear further investigation applied to suitable models with suitable reflected environments.

TEXTURE SUMMARY 31: GALVORN

Ambient Fraction	0.5	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	500
Diffuse Fraction	0.4	**Second Smoothness**	4
Glow Factor	0.0	**Second Weight%**	75
Reflectivity	0.25	**Color (RGB percentages)**	0-0-0
Index of Refraction	1.0	**Specular Color**	100-100-100
Specular Fraction	0.95	**Maps**	None

FIGURE 37: GALVORN



Tilkal

Yet another metal from Tolkien´s works. This time it is "The Book of Lost Tales 1", Chapter 4: The chaining of Melko.

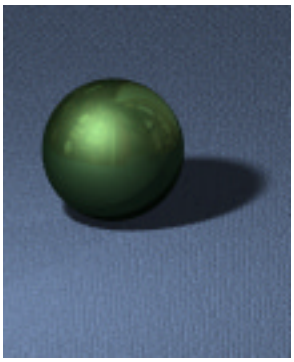
> *"Behold, Aulë now gathered six metals, copper, silver, tin, lead, iron and gold, and taking a portion of each made with his magic a seventh which he named therefore tilkal, and this had all the properties of the six and many of his own. Its color was bright green or red in varying lights and it could not be broken, and Aulë alone could forge it. Thereafter he..."*

This one should look easy at first sight. Grab an existent metallic texture and give it a bright green color, or red in varying lights... well... we cannot control that directly, so I arbitrarily decided to simplify things and that Tilkal is green under all visible light.

TEXTURE SUMMARY 32: TILKAL

Ambient Fraction	0.4	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	12
Diffuse Fraction	0.2	**Second Smoothness**	3
Glow Factor	0.0	**Second Weight%**	33
Reflectivity	0.2	**Color (RGB percentages)**	0-19-0
Index of Refraction	1.0	**Specular Color**	75-100-65
Specular Fraction	1.0	**Maps**	None

FIGURE 38: TILKAL



Rearden Metal

Let us at last abandon Mr. Tolkien´s prolific smithy and let us busy ourselves with Rearden Metal, from Ayn Rand´s masterpiece Atlas Shrugged.

> *"The links were heavy, crudely made, the shining metal had an odd tinge, it was greenish-blue"*

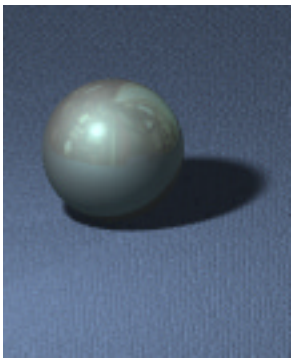
"Not difficult that"– I say – "just apply an adequate specular color to Granny´s silverware texture". But the results were unsatisfactory.

I ended up fiddling with values a lot more than just that. Finally I achieved something that did look fine.

TEXTURE SUMMARY 33: REARDEN METAL

Ambient Fraction	0.6	**Transparency**	0.0
Bump Amplitude	1.0	**First Smoothness**	150
Diffuse Fraction	0.5	**Second Smoothness**	6
Glow Factor	0.0	**Second Weight%**	45
Reflectivity	0.22	**Color (RGB percentages)**	87-87-87
Index of Refraction	1.0	**Specular Color**	65-100-93
Specular Fraction	0.9	**Maps**	None

FIGURE 39: REARDEN METAL



Interesting effects

The previous description was a sample of the more common metals, some more versatile or likely to be used than others. But depicting, rusting and tarnishing our metals is not enough. The basic metallic textures we just explored often need to be reworked to fit a particular purpose. To illustrate this, We will undertake a damasked piece of jewelry. Damasking (originally *Damasquinado*) is a technique developed in Spain, based on the techniques of the arab invaders. Damaskng consists in creating motifs in gold and silver over a blackened iron or steel base.

To accomplish this, we may work in the same order that the real pieces are made. First, the iron or steel base, then separate gold and silver layers. This effect can easily be achived by layering textures (Studio Pro 2.0 or higher only). Adapting some of the textures we already have discussed and using a couple of Stencil maps, we should have no problem. For the piece shown, an almost black texture with a granular bump map and low specularity was created. On top of it, a gold texture was layered, The gold wa smodified with a Stencil and a bump map. On top of

the gold, a silver texture was layered, also with Stencil and bump maps. The gold bump was made to be convex and the silver bump was made to be concave.

FIGURE 40: DAMASKED PIECE

Summary

There. We have scratched the surface on the creation of metallic textures (make that a bump map). Endless looking will be needed to expand our metals library to an extent that will suit all our needs. Here we have used only PhotoShop to create our textures, but scanning of actual samples will ensure (as always) the best results.

These general guidelines will serve only as a basis. You will se that you will have to modify your textures heavily for different pieces. The appearance of steel in a fork is not the same as on a monkey-wrench. Best of luck and may the Polygons be with you.