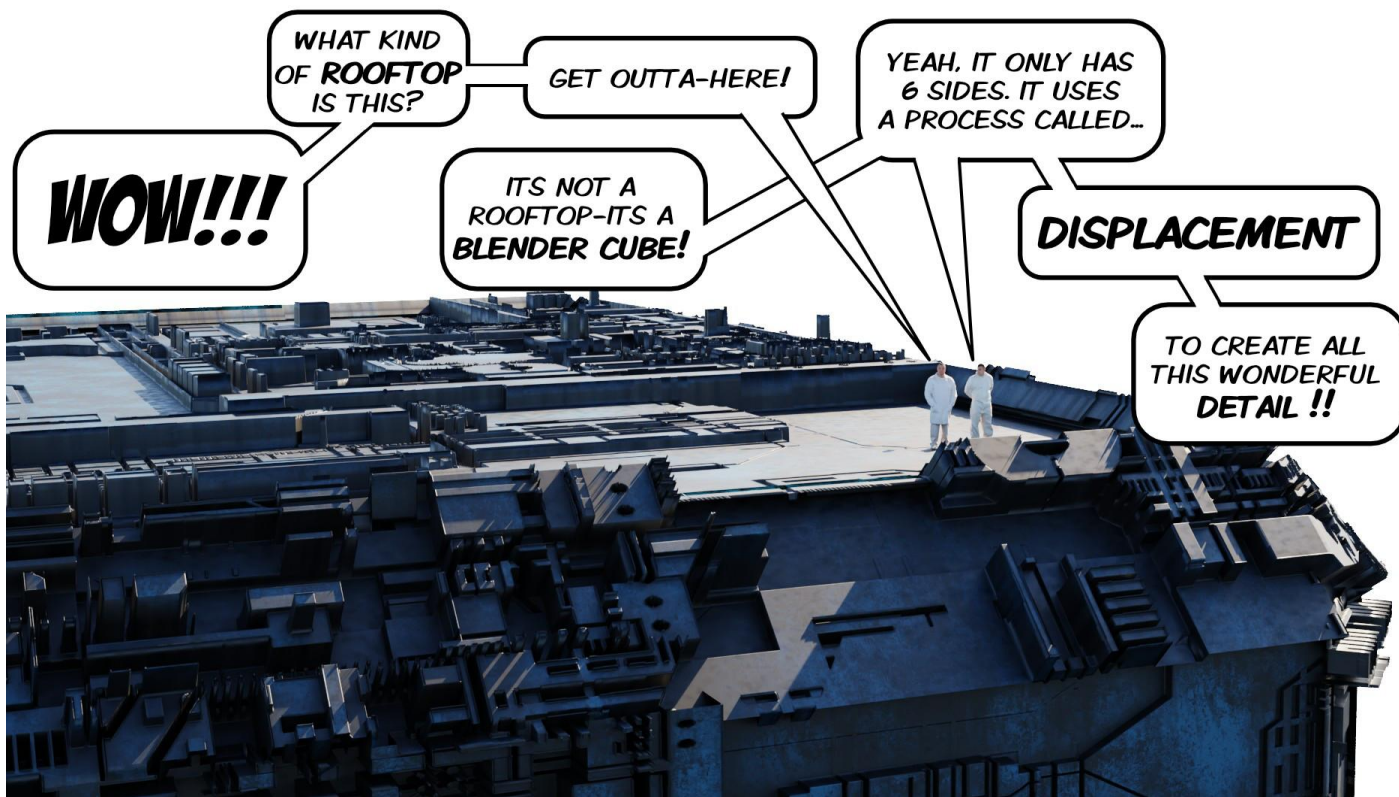




DISPLACEMENT PRIMER

Chipp Walters April 2021

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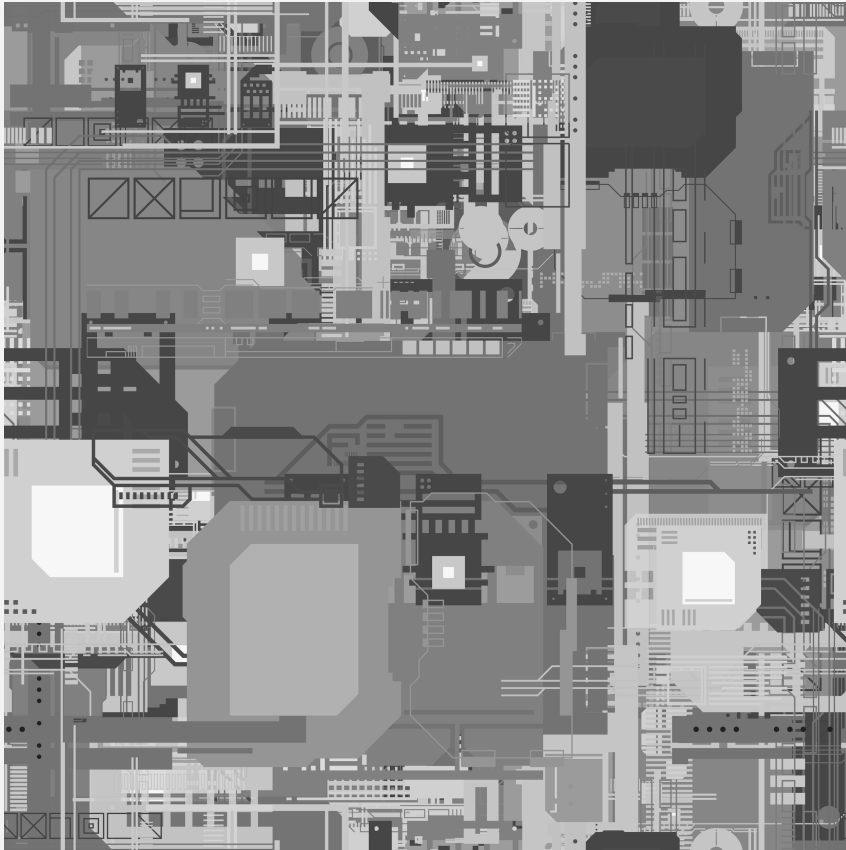
Table of Contents

Displacement Overview	2
What is it?	2
Important Considerations	3
ONE	3
TWO	3
Types of Displacement	3
PROs of regular displacement	3
PROs of microdisplacement	3
CONs of regular displacement	4
CONs of microdisplacement	4
Setup for displacement material	4
Node setup for displacement	5
Material Setup	6
Setting up your model for regular displacement	7
MICRO DISPLACEMENT	10
Displacement vs Microdisplacement test	11
Notes	13
Microdisplacement issues	13
Box (sometimes called Tri Planar) vs UV projection	14
Tri planar projection on radiused cube	14
UV Mapped Setup	16

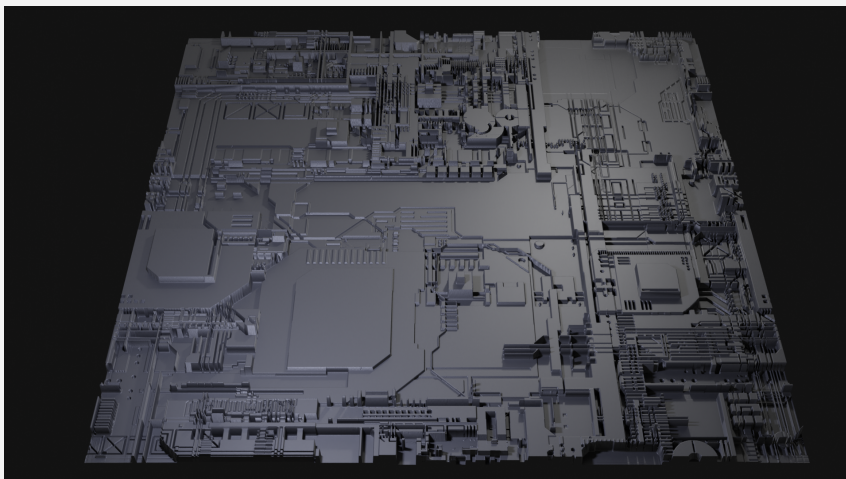
Displacement Overview

What is it?

Displacement is where you use a grayscale image to generate significant typography.



Here is an example of a grayscale “map.”



You can see, when a displacement map is applied correctly, the light areas in the grayscale image are “higher” than darker areas.

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Displacement only works when there is enough geometry (faces) on the object surface to be able to move the individual vertices up or down based on the color of the pixel in the height map. So, in the example above, we needed around 500,000 faces to create that level of detail.

Important Considerations

So, there are some important things to understand when using displacement maps.

ONE

Displacement and displacement maps **only work with Cycles** (and other Path Tracers, like Octane) and **do not work with EEVEE**. I know there are plugins which say they work, but I've tried them and for the most part they come nowhere close to matching the quality shown above.

TWO

Rendering displacement maps can take a much longer time than regular rendering. It uses a huge amount of memory and can frequently run out of memory when trying to render huge scenes.

Types of Displacement

In Blender, there are two different types of displacement: Regular displacement and microdisplacement.

So, as mentioned before, you need a super high number of faces in order for Cycles to render displacement properly. So, either you can manually subdivide your meshes, or you can choose to use microdisplacement (adaptive subdivision), which will subdivide for you at render time. One of the interesting features of adaptive subdivision is that the closer the object is to the camera, the more subdivisions it will create.

PROs of regular displacement

1. Faster to render
2. Fast viewport display once setup
3. Easy to setup and test

PROs of microdisplacement

1. Most always higher quality
2. Can zoom way in on a mesh
3. No need to subdivide before you apply (most times, see appendix)
4. Can be faster but only in some situations
5. Better for animations because the scene has fewer faces

CONs of regular displacement

1. Need to create tons of faces even when not needed

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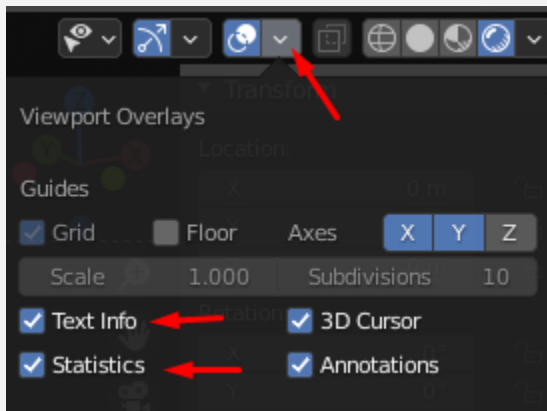
2. Cannot zoom way in on a mesh.
3. Need to decide what resolution to subdivide your mesh before you render. Lot's of back and forth figuring this out.
4. Typically not as high quality of displacement

CONS of microdisplacement

1. Huge memory overhead. Can sometimes just not render. Optix crashes a lot so many times you have to use Cuda to render.
2. Can take a really long long time to pre-process render.
3. Can be confusing to set up.
4. Need to run in Experimental mode

Conclusion: Microdisplacement works best BUT can take longer and sometimes just won't work.

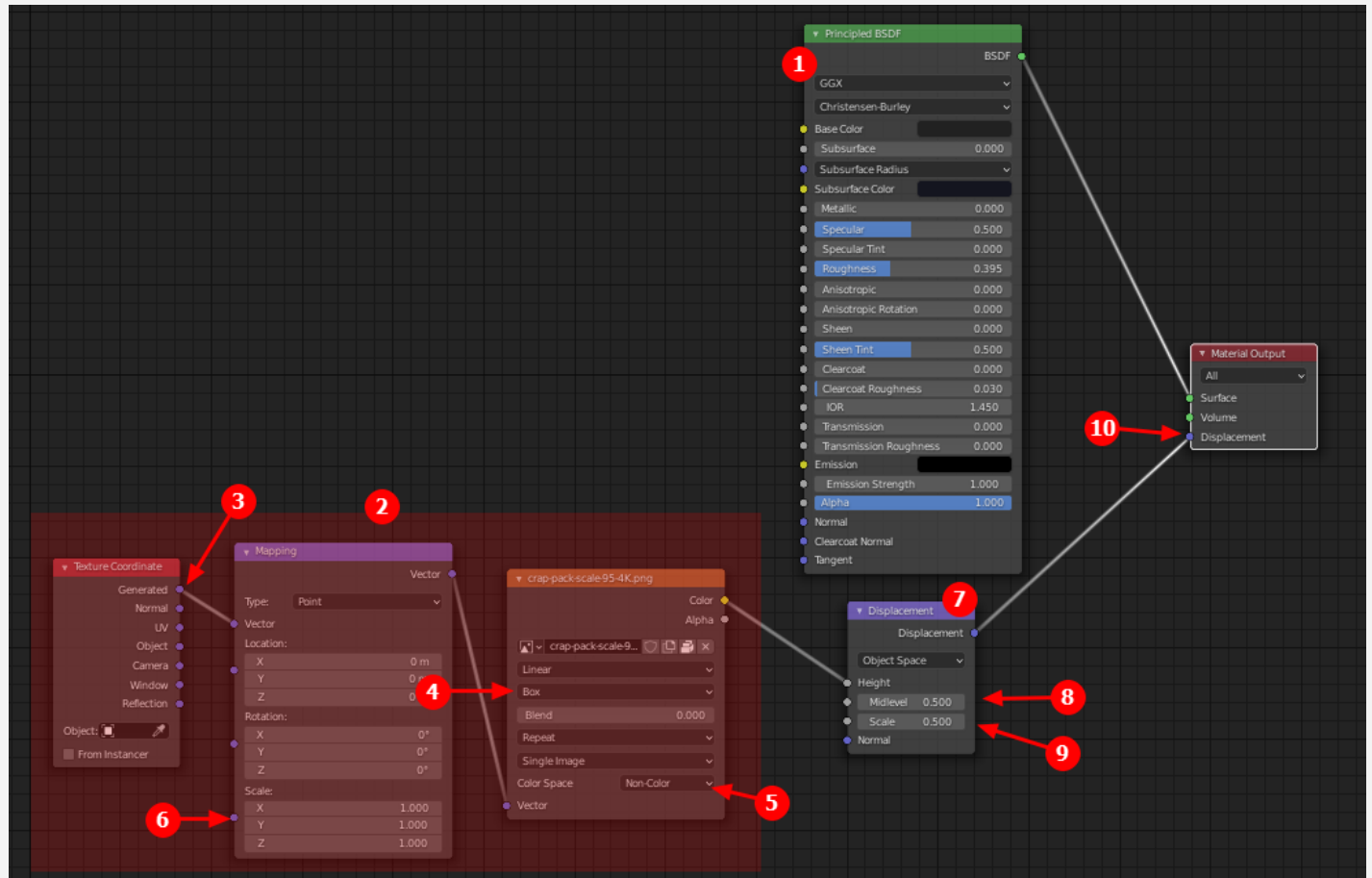
Setup for displacement material



On screen details

Good idea to first set these. These will allow you to see what's going on during a Cycles Viewport preview rendering

Node setup for displacement



Here is a basic node setup for a displacement material

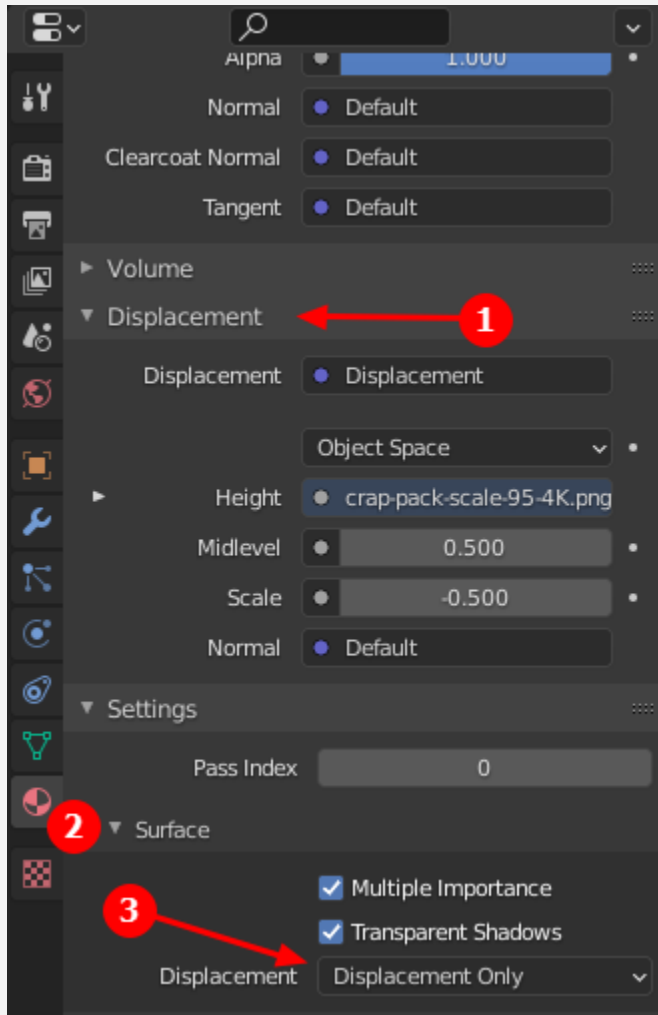
1. Use whatever material shader you want to use. Typically it's a Principled BSDF
2. This is the image texture node group consisting of Texture, Mapping and Texture Coordinate nodes. If you use UV, and don't intend to ever add scaling, then no need for the Mapping and Texture Coordinate nodes.
3. If you are not using UV, and you want this texture to stretch 1 to 1 across the object, use Generated. This will create a different sized texture for each object. So, if you use this material on a large space station and a small craft entering a docking bay, the texture will be much smaller on the craft than on the space station. Conversely, if you want the same size texture on all objects, no matter what size, set the Texture Coordinate to Object.
4. Load your texture in this node. If using Generated or Object Texture Coordinate, change this to Box (or Sphere or Tube) depending on the overall object shape.
5. Make sure this is not sRGB and set it to Non-Color
6. Here is where you can set the scaling of the texture. If it's more than 1, then your original map should be a tileable image.
7. This is the Displacement node which connects between the Texture node and the Displacement socket

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on the Material Output. It allows you to control the Displacement.

8. The Midlevel setting tells you where a middle gray (50%) will be for the displacement. A setting of 0.500 tells Blender to keep it at the current object surface.
9. The Scale setting controls how much to raise or lower the vertices based on the grayscale map. A higher number equates to a larger displacement. You can also use a negative number to displace downward (which would be the same as inverting the image).
10. Hook the Displacement node up here.

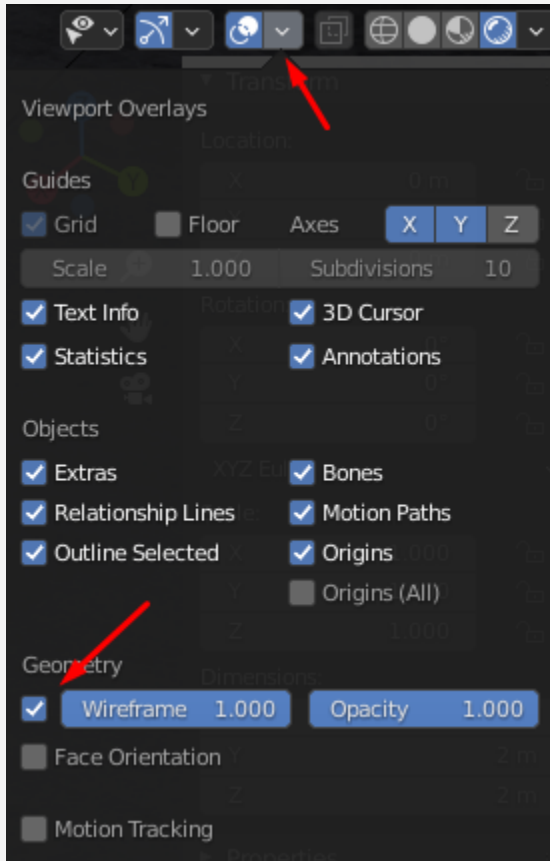


Material Setup

With Cycles set as the default rendering engine, go to the Material Settings (not #1 but rather #2) and set the dropdown to #3 Displacement Only. There are reports that the Displacement and Bump does not work correctly in some cases.

You are now ready to work with regular displacement in Cycles rendering. Don't forget to add enough subdivisions to your mesh in order to render your displacement map correctly.

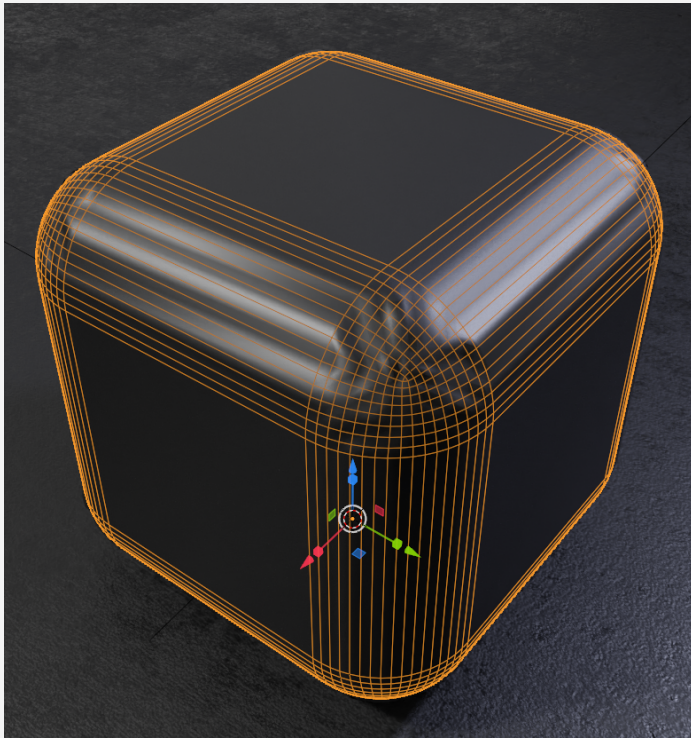
Setting up your model for regular displacement



Turn ON wireframe display. I set this to a Q key.

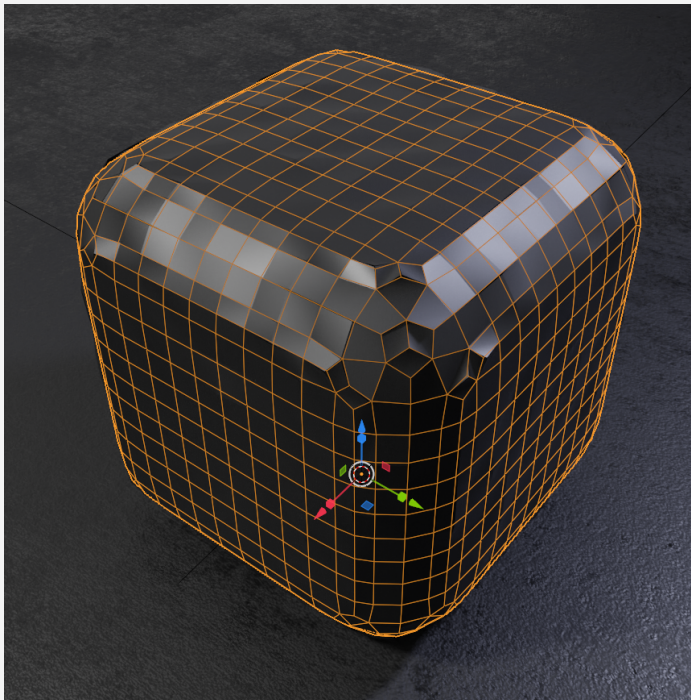
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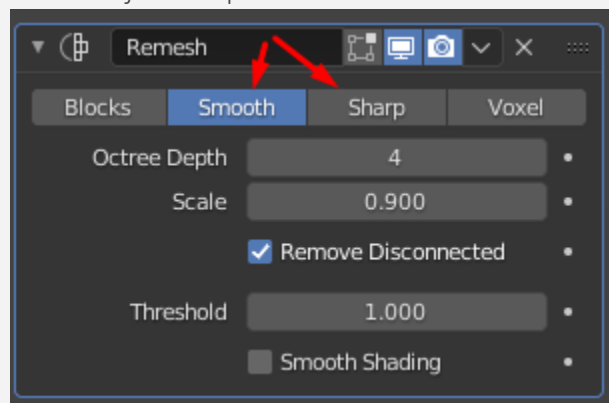
Here is the base object. You'll typically have many faces that do not have equal mesh density, such as this radiused cube.

For regular displacement, we'll need to optimize the mesh which means we want to have a more regular density than shown here.



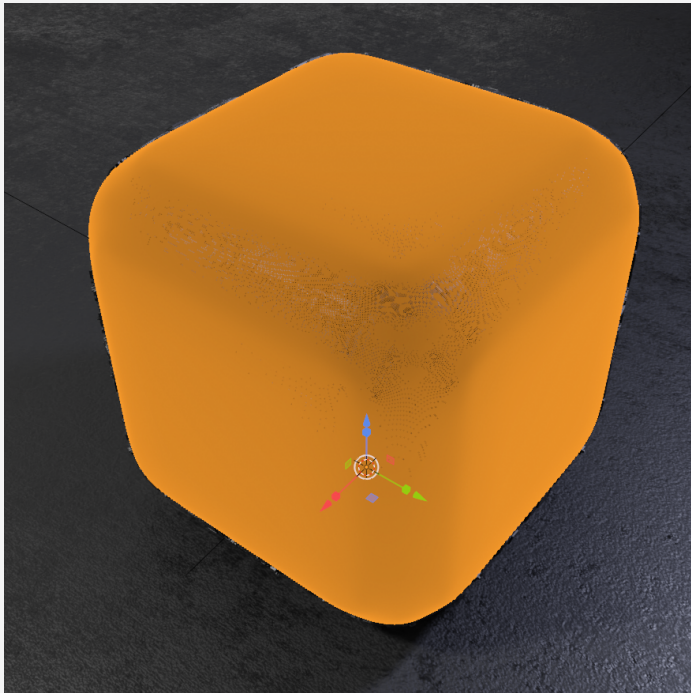
It's important to have similarly sized faces for displacement to work.

Add Remesh modifier first so that you get the same sized faces (mostly). Use Smooth or Sharp depending on the object shape

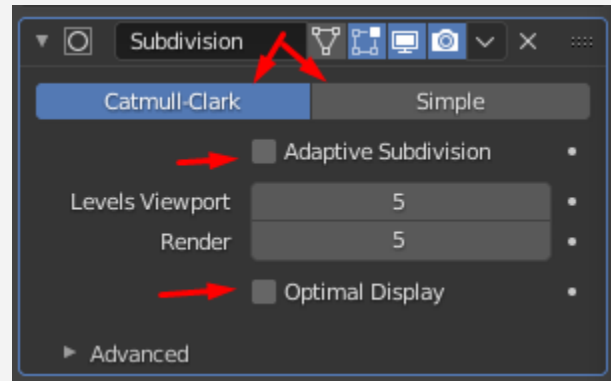


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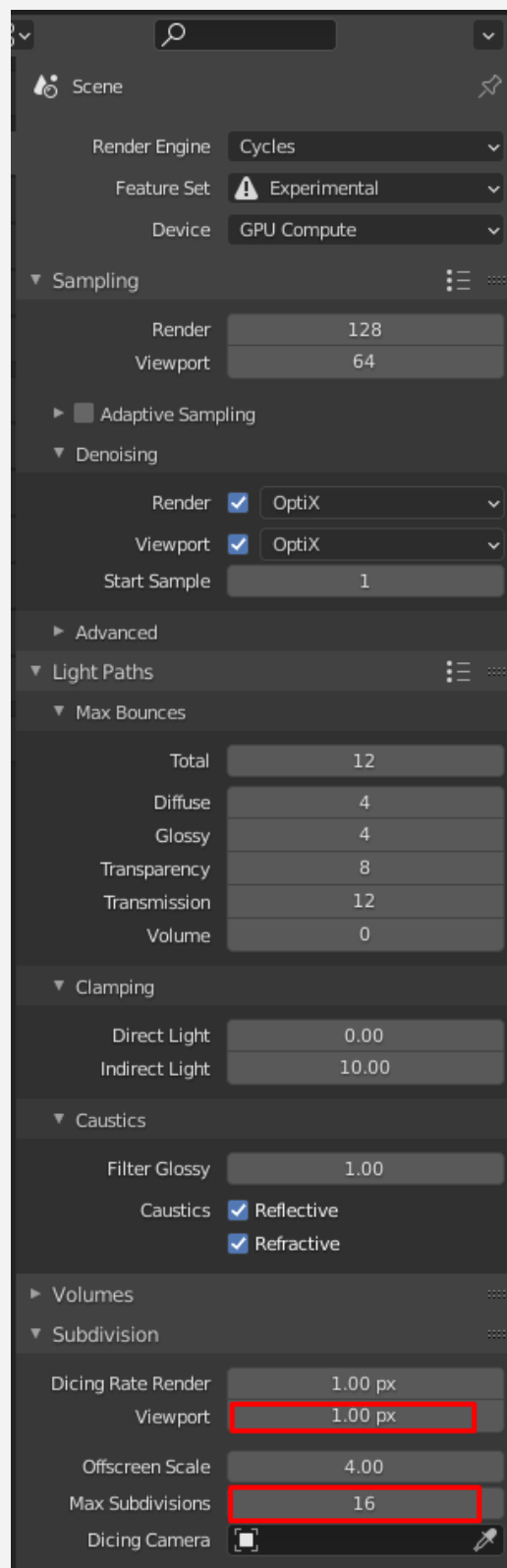
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Add Subdivision modifier next and increase levels until the mesh is barely visible. Catmull-Clark if a smooth surface, and Simple if a more flat rectangular surface. Adaptive Subdivision is OFF and Optimal Display is OFF so you can actually see the mesh.



MICRO DISPLACEMENT

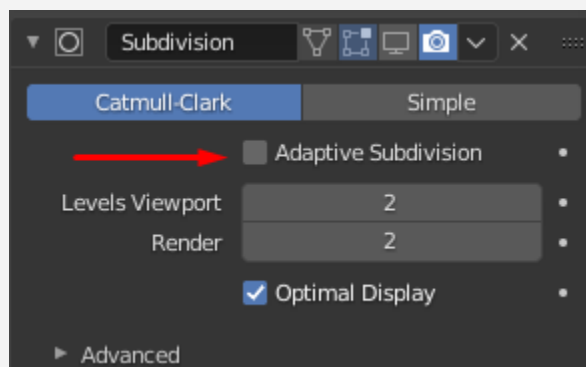


These are the Cycles settings for micro displacement TO START WITH.

The Viewport should be set to 1 or 2 (faster but less accurate) and it says how many pixels to evaluate for each displacement calculation.

The Max Subdivisions is normally 14 and upping it to 16 seems to make a big difference.

Then select your object, and add a SubD modifier to it and check "Adaptive Subdivision"



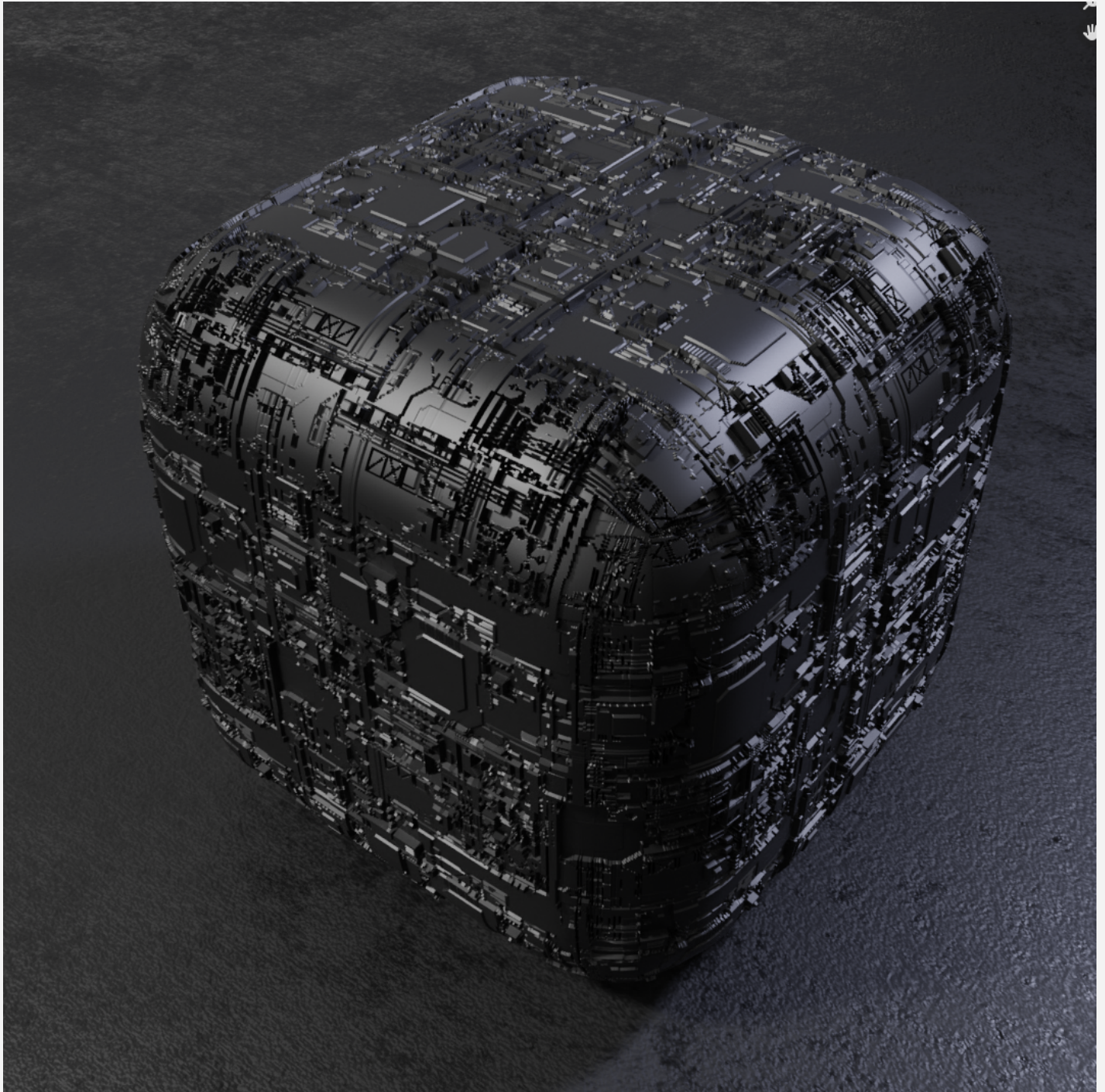
There are many times when the microdisplacement just doesn't look good, even with the best settings of Dicing 1 and 16 Max Subdivisions.

In those cases you'll need to add more geometry. See the [NOTES on Micro Displacement issues](#).

NOTE: If you have an Nvidia 3090 or equivalent, you may wish to set the Dicing number to 0.5 and it will look better.

You can also turn OFF Optix rendering and use Cuda with 0.5 as well. This is much slower, but can work when you're running out of memory.

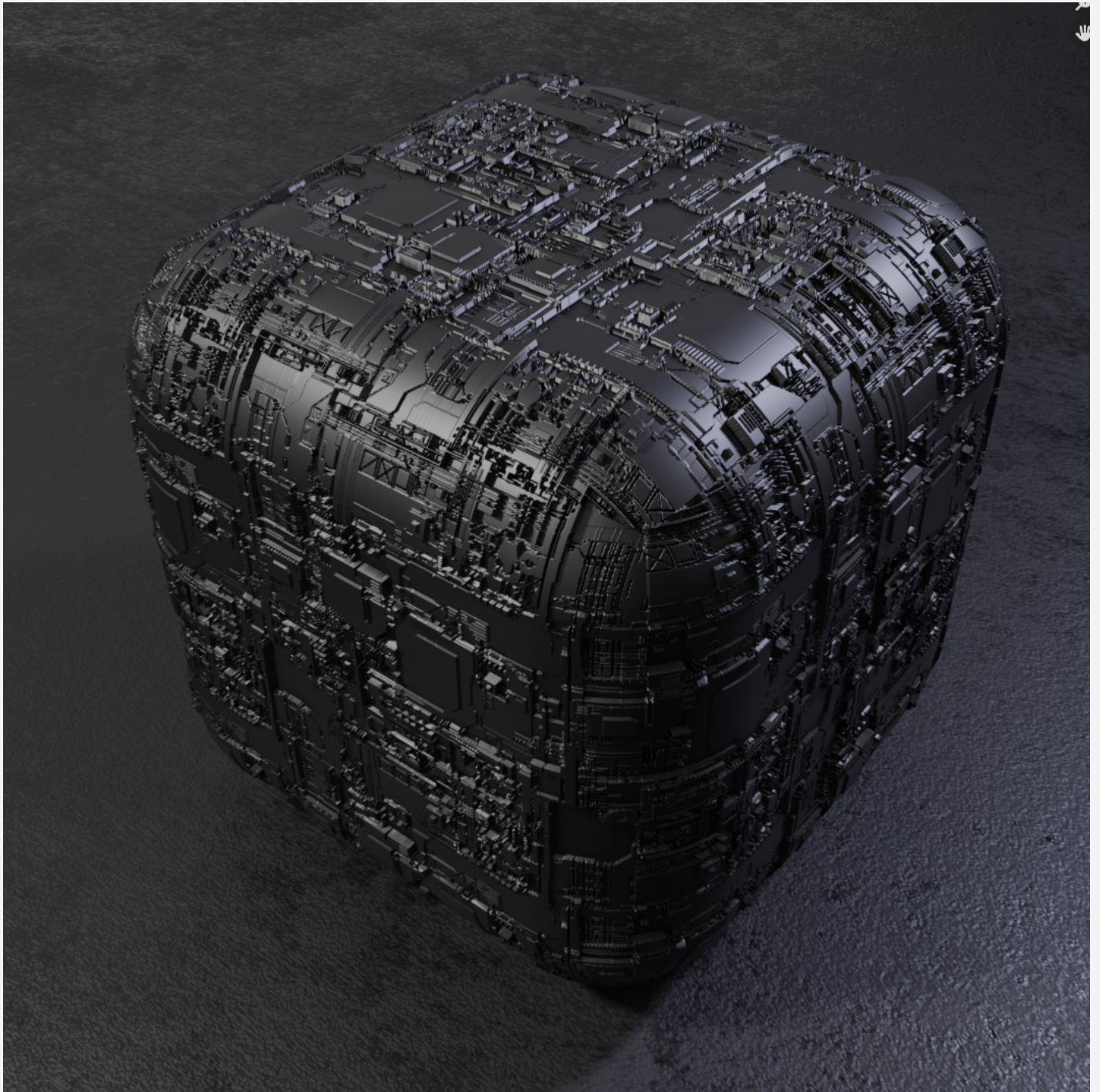
Displacement vs Microdisplacement test



Regular Displacement based on settings above: ~12 seconds

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Microdisplacement using adaptive subdivision: 1 Dicing and 16 max Subdivisions ~11 seconds (no Remesh modifier)

Notes

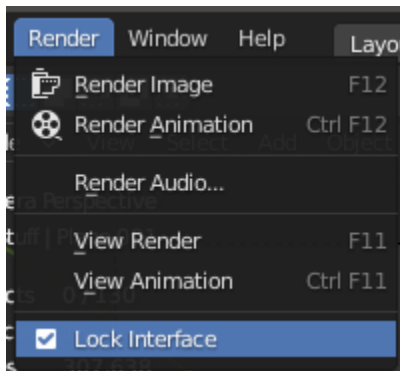
Microdisplacement issues

Sometimes when using large displacements which fill up the camera view, the Dicing resolution of 0.5 won't work as it will throw an OPTIX error, and in those cases, it can be a good idea to set Max Subdivisions to 16 and use a Remesh modifier in front of the Subdivision (with Adaptive turned on) to make the faces smaller and then subject to more subdivisions even at a Dicing scale of 1.0 (not 0.5).

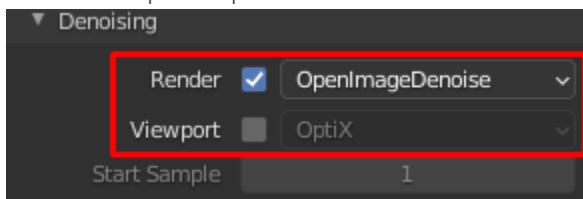
The other way to do this would be to turn OFF Optix in prefs, keep the 0.5 Dicing and use OpenImageDenoiser. It will be a bit slower, but will work OK.

If you get an Optix error during rendering, it may be because you've run out of memory. So, to go over the remedies, do one of the following:

1. Make sure and "Lock Interface" to free up more memory for rendering:



2. Adjust Dicing to a higher number (but more than 1 may not look good)
3. Adjust Max Subdivision to a lower number.
4. Use a Remesh Modifier in front of the Subdivision modifier to create smaller faces to begin with. This will allow you to keep the Max Subdivisions lower.
5. You can also manually knife through the mesh to create smaller faces to keep Max Subdivisions lower.
6. Don't use Microdisplacement and instead use regular displacement (see settings above)
7. Turn OFF Optix in preferences and switch to these settings::



NOTE: typically the mesh geometry in the object does not matter as far as quads or equal sized faces for microdisplacement. But, if you're encountering memory errors, subdividing the geometry will allow the displacement to start to work at a smaller scale and it won't have to generate as many subdivisions.

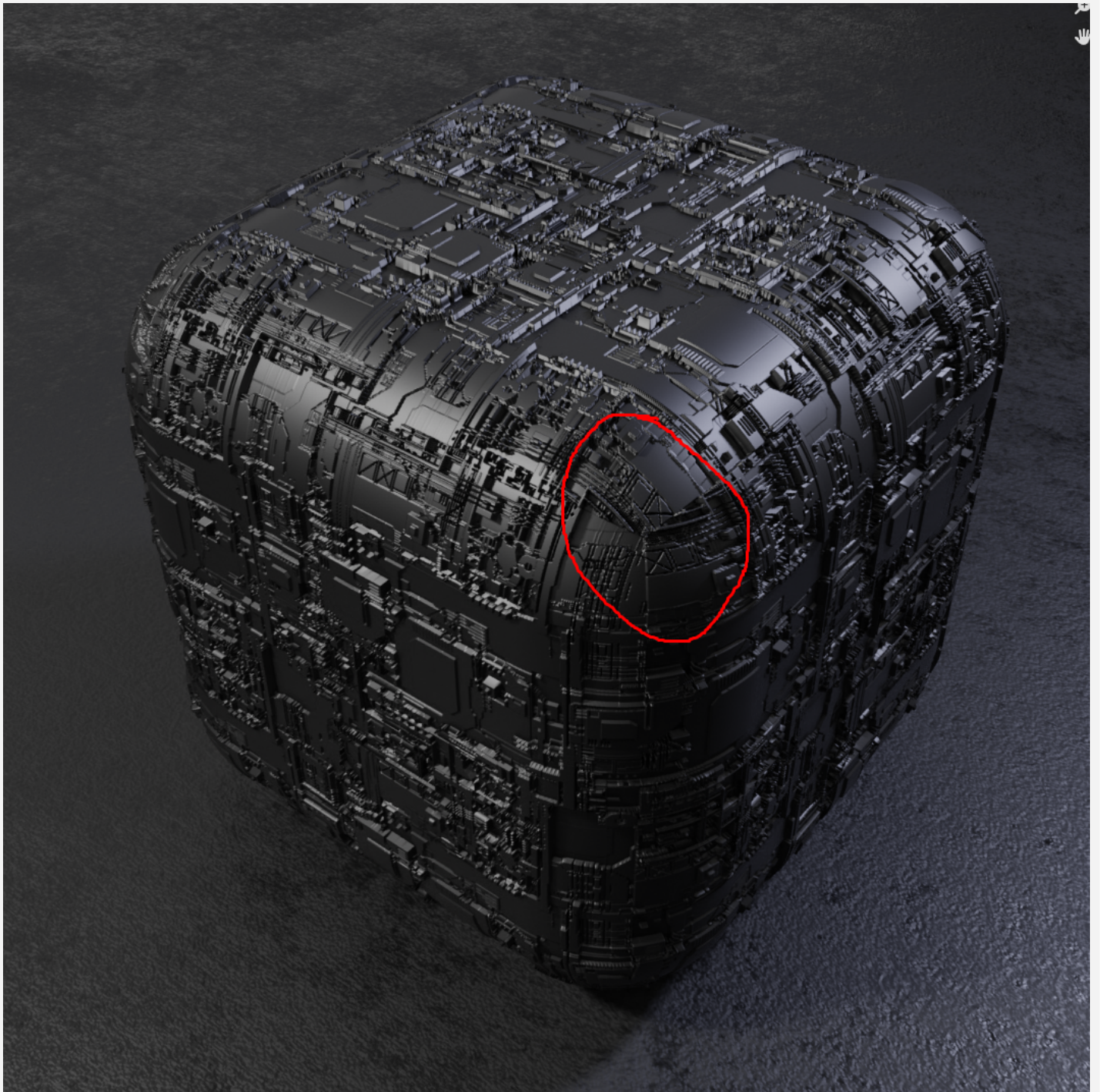
NOTE: You'll want to be sure and turn OFF Cycles in your viewport as it will also eat up your GPU memory and leave less for your final render.

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Box (sometimes called Tri Planar) vs UV projection

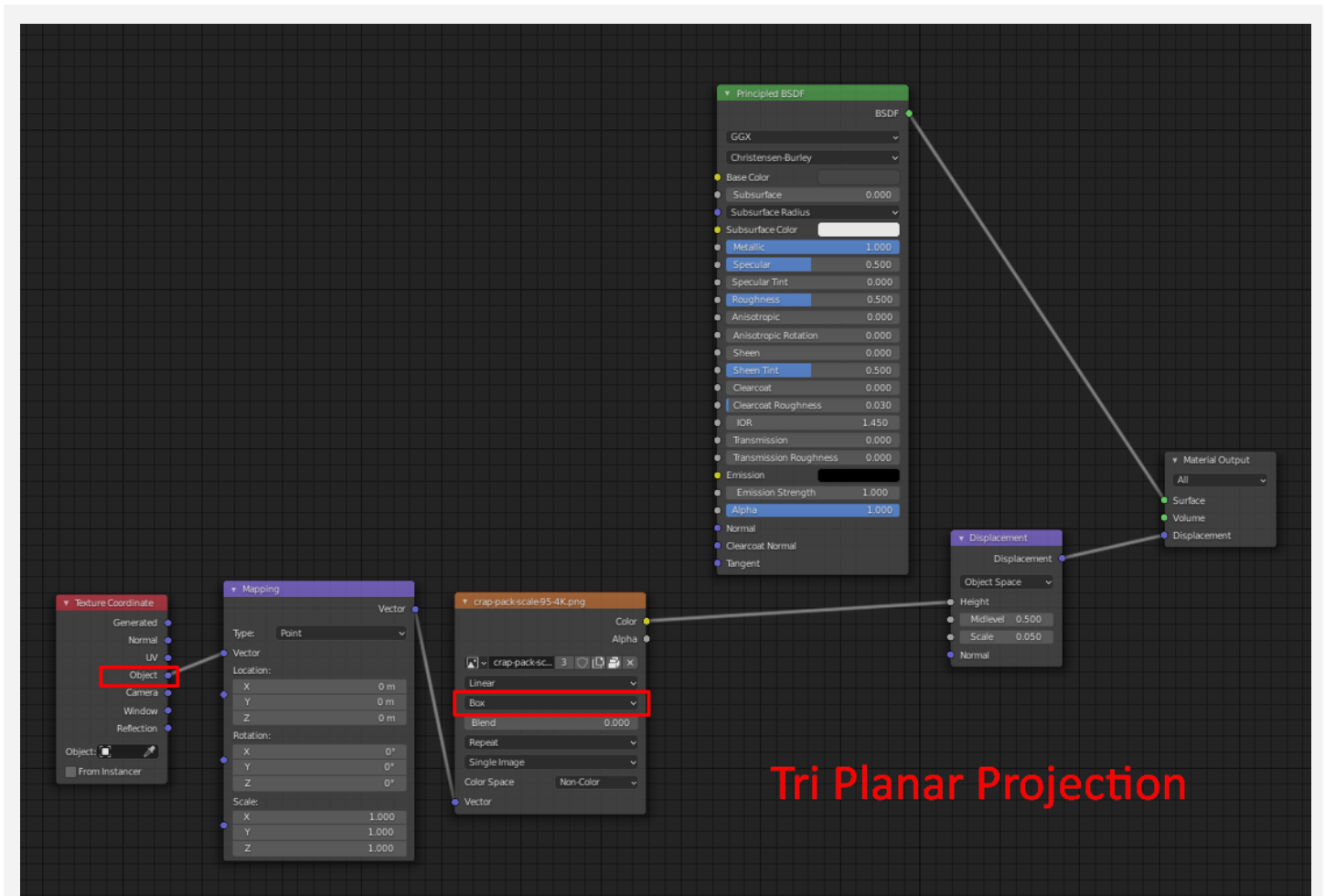
Tri planar projection on radiused cube



Note funky corner. UV projection will help here

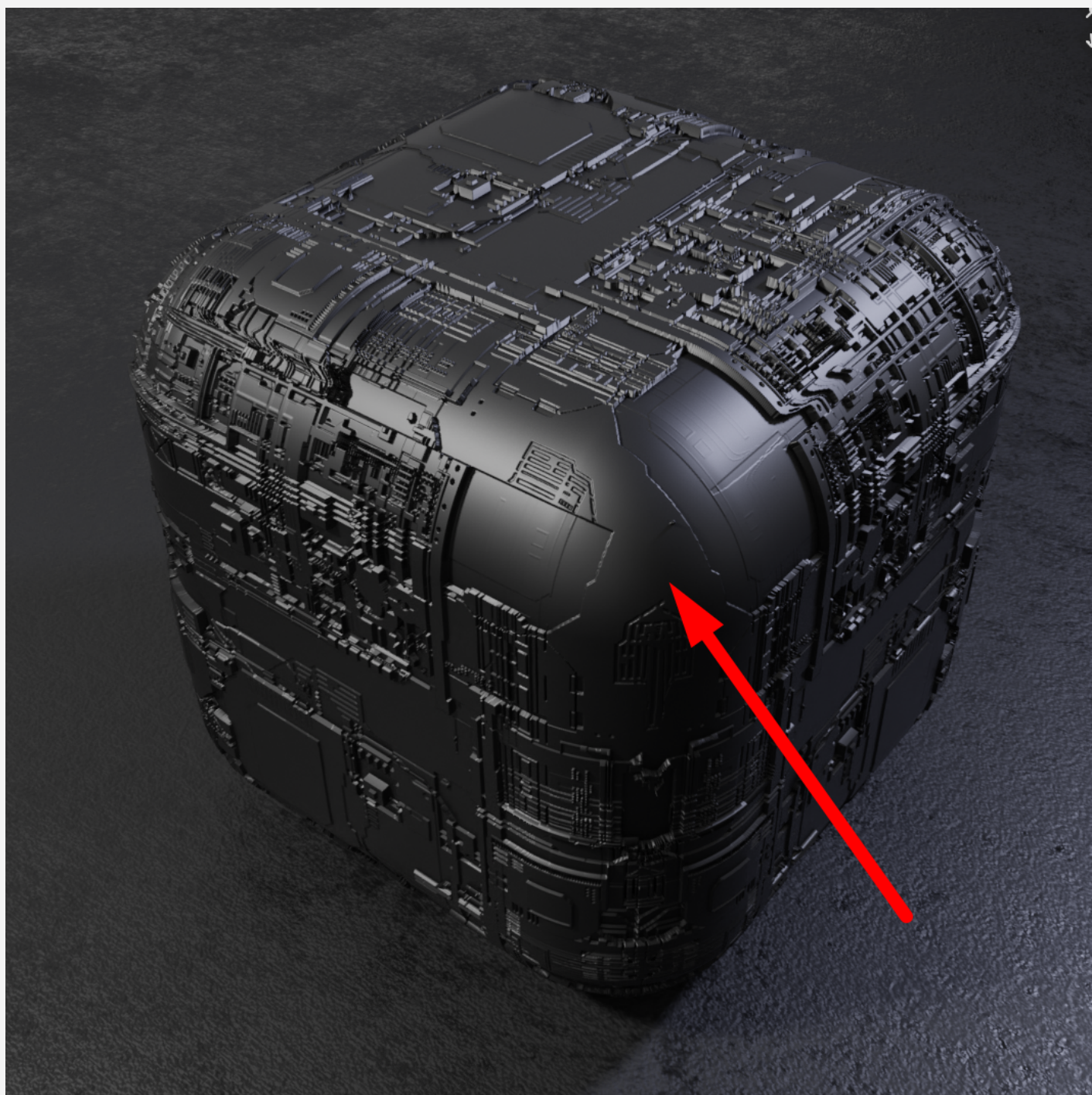
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Tri Planar Projection

UV Mapped Setup



Better

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