PBR: Implications of its application to Unreal 4 engine map and material creation

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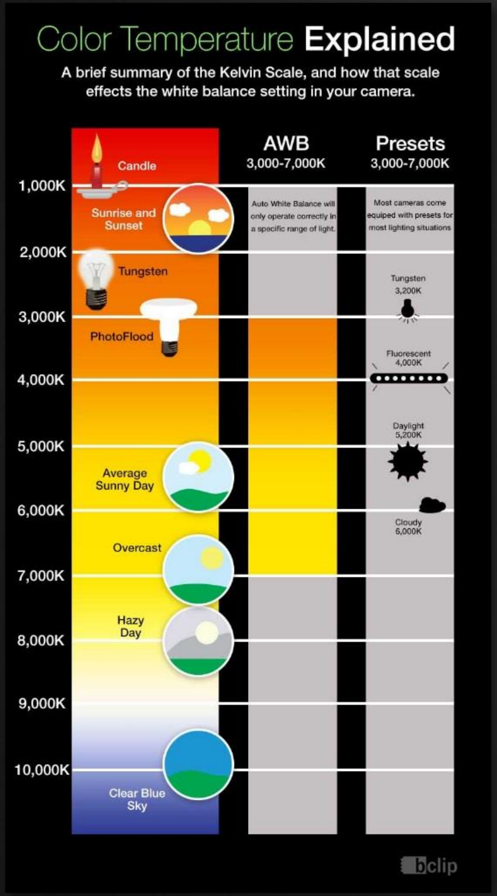
UNREAL ENGINE

Real World Properties

- Light source
- Linearity, high dynamic
- Diffuse and specular reflections
- Insulator and conductor
- Behavior after lighting on object
- Refractivity/reflectivity
- microfacet
- Color
- Energy preservation
- Fresnel phenomenon

Properties of light: color, brightness, attenuation, intensity, shape

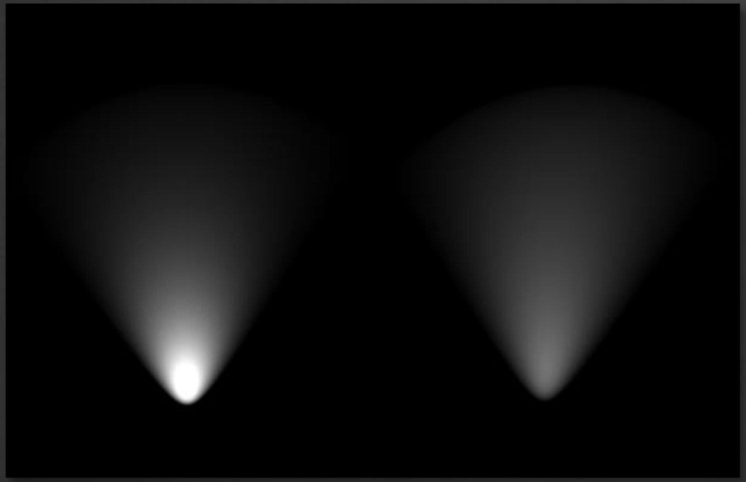


Color Temperature Explained

A brief summary of the Kelvin Scale, and how that scale effects the white balance setting in your camera.

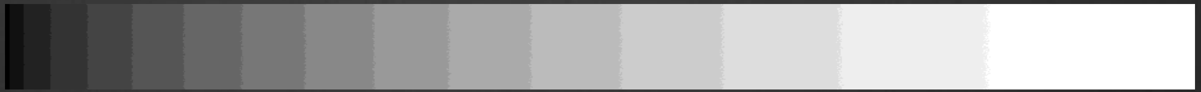
Auto White Balance will only operate correctly in a specific range of light.

Most cameras come equiped with presets for most lighting situations



Multiple light sources

Linearity, high dynamic



$$F(x+y)=f(x)+f(y)$$

Insulator and conductor/electrolyte and non-electrolyte/non-metal and metal

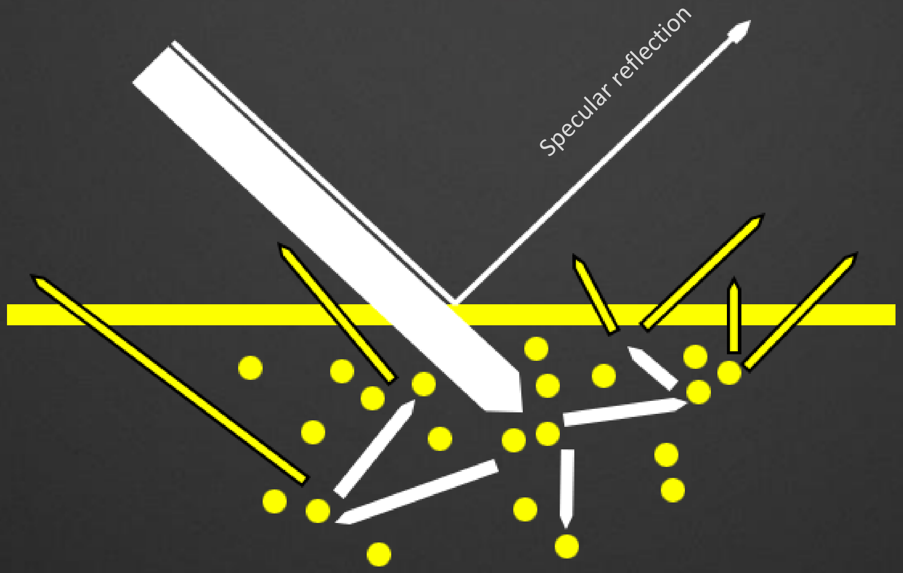
Diffuse reflection and specular reflection

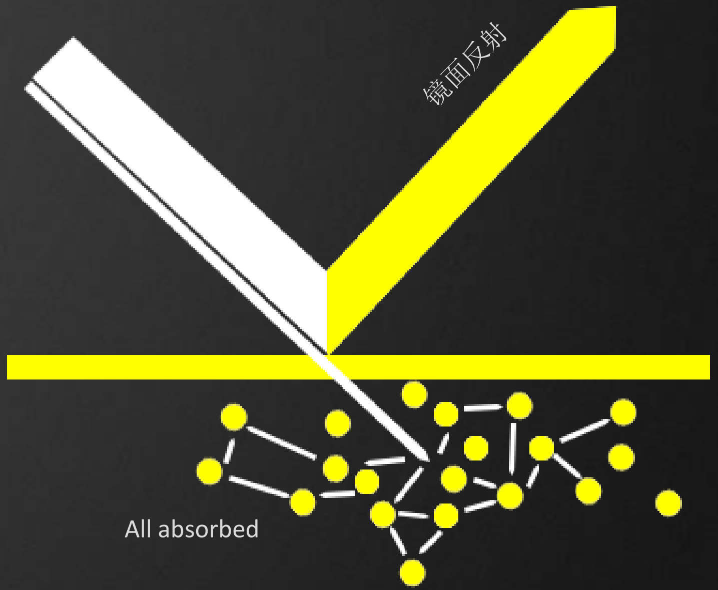
Color

- The metal has a strong reflective rate of 70-90%, and the rest part of light is completely absorbed. In case of absorbing specific wavelength, the reflection will have a color

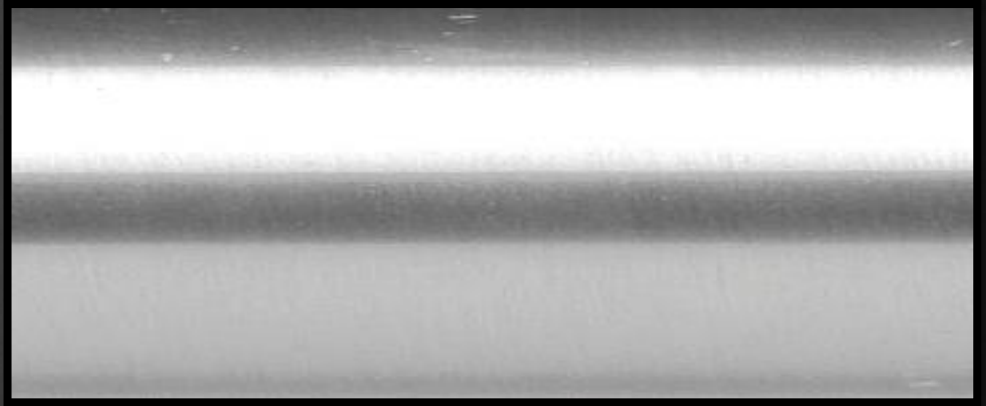
- Non-metal has a low reflective rate of 4% and reflects same color light; for the rest part of light, some will be absorbed, some will be discrete (diffuse reflection). In case of absorbing specific wavelength, diffuse reflection will have a color

Reflection, absorption, discrete





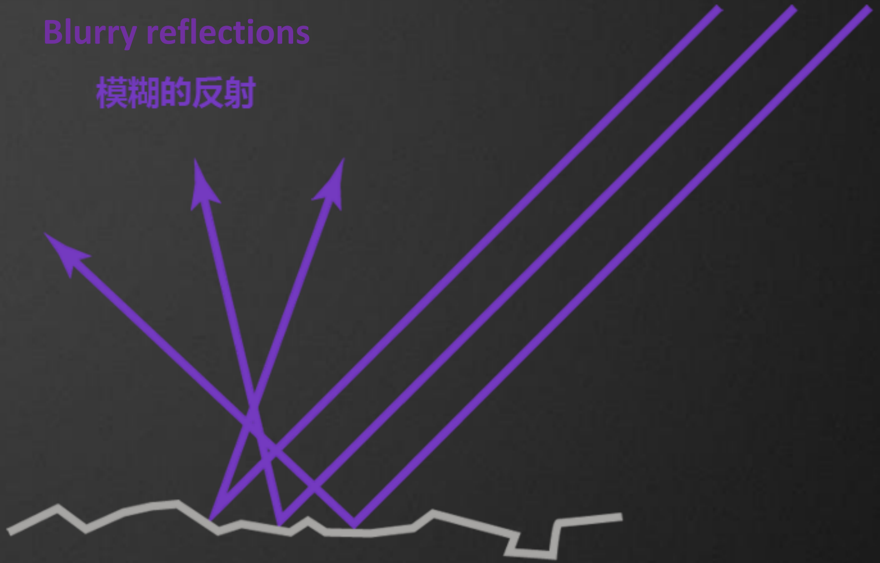
Real World Properties



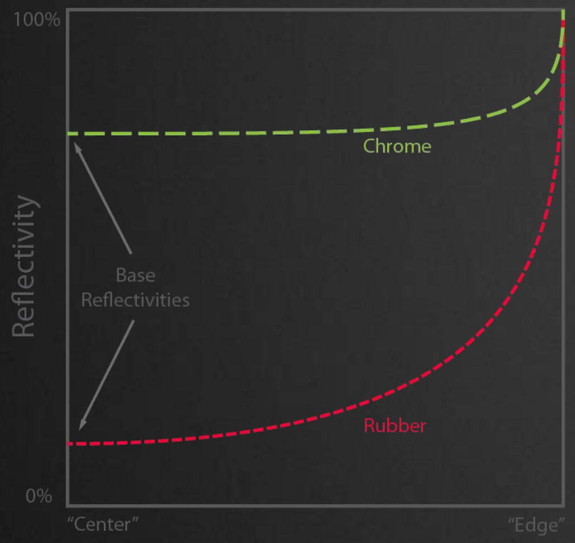
Real World Properties

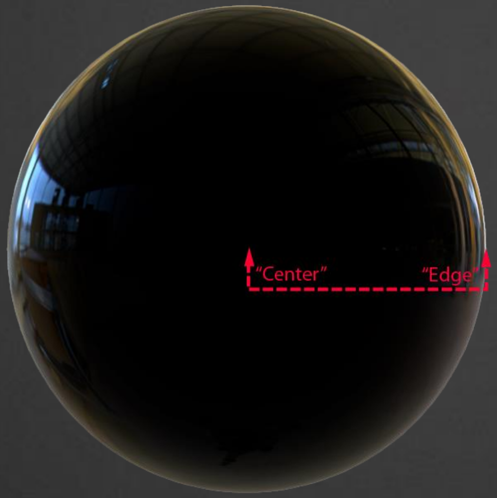
Microfacet

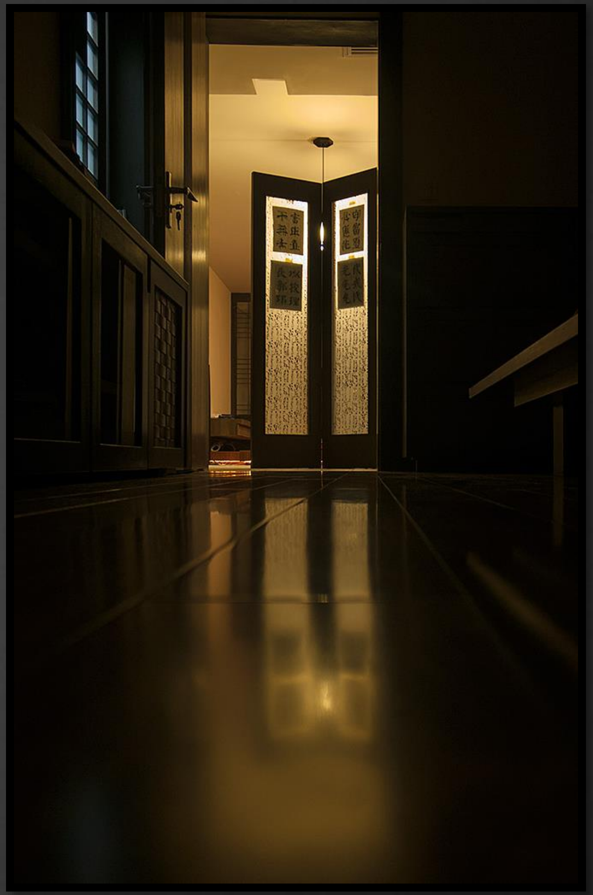
Glass under the microscope



Fresnel phenomenon





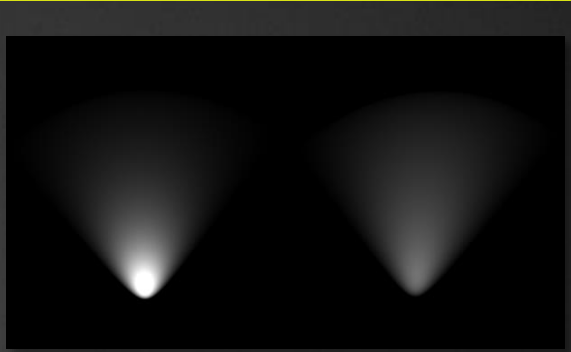


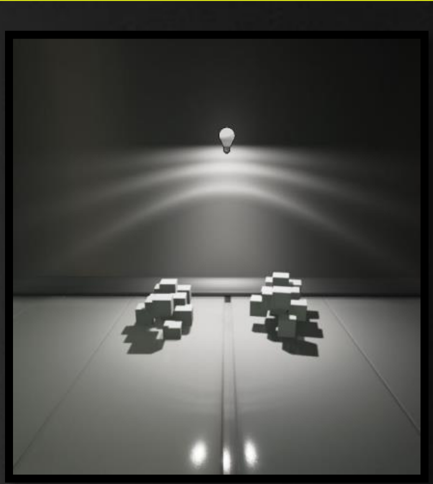
Real World Properties

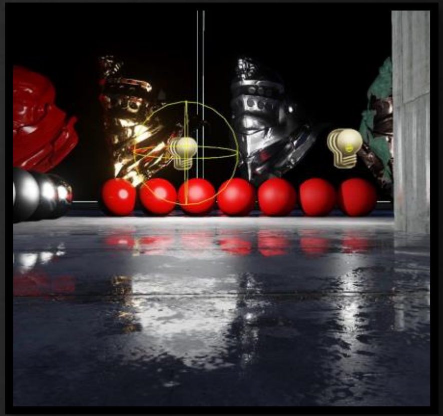
How to simulate in UE4

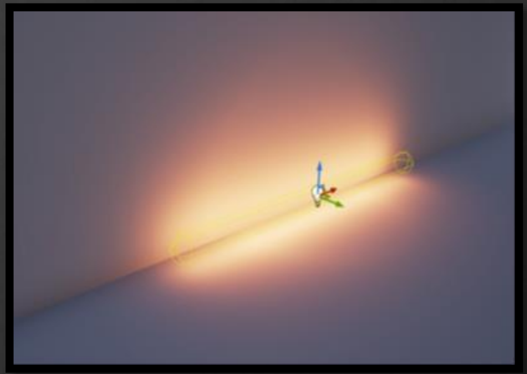
Lighting:

- Attenuation
- Regional lighting unit: Lumi
- Non-point light source: surface light source / wavelength light source
- Color temperature control
- High-Dynamic Range (HDR) non-direct specular reflectance and specular
- IBL









Brightness

Diffuse BRDF

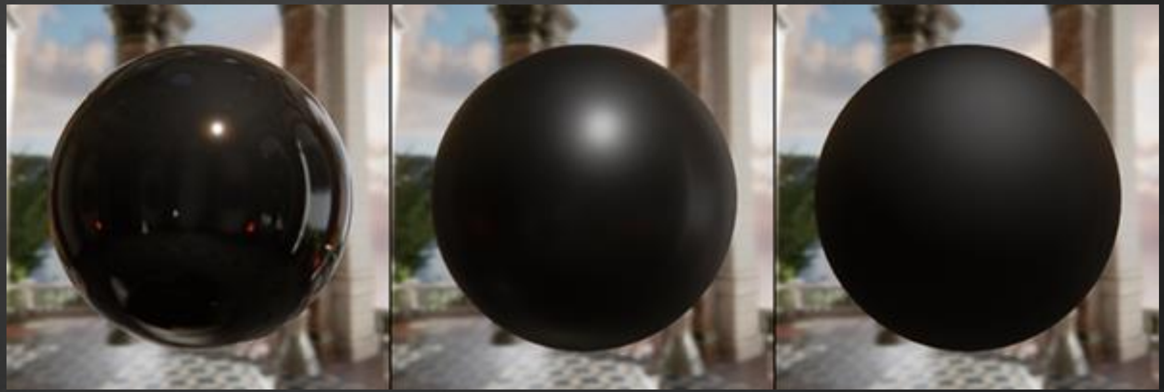
Specular BRDF

Specular Distribution

Geometric Shadowing

Fresnel

Image-based Lighting

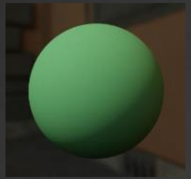


How to simulate in UE4

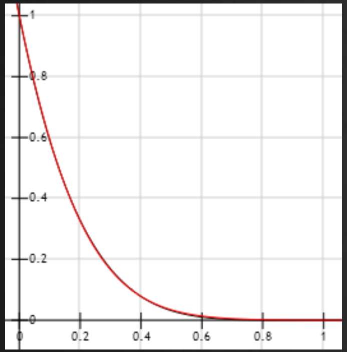
How to simulate in UE4

Specular distribution:GGX

Diffuse BRDF



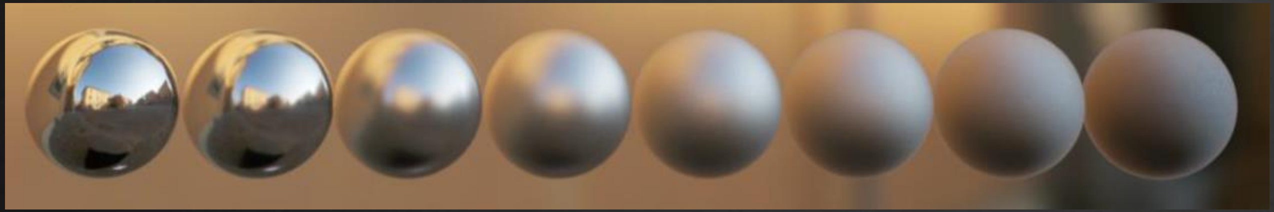
Fresnel: Schlick

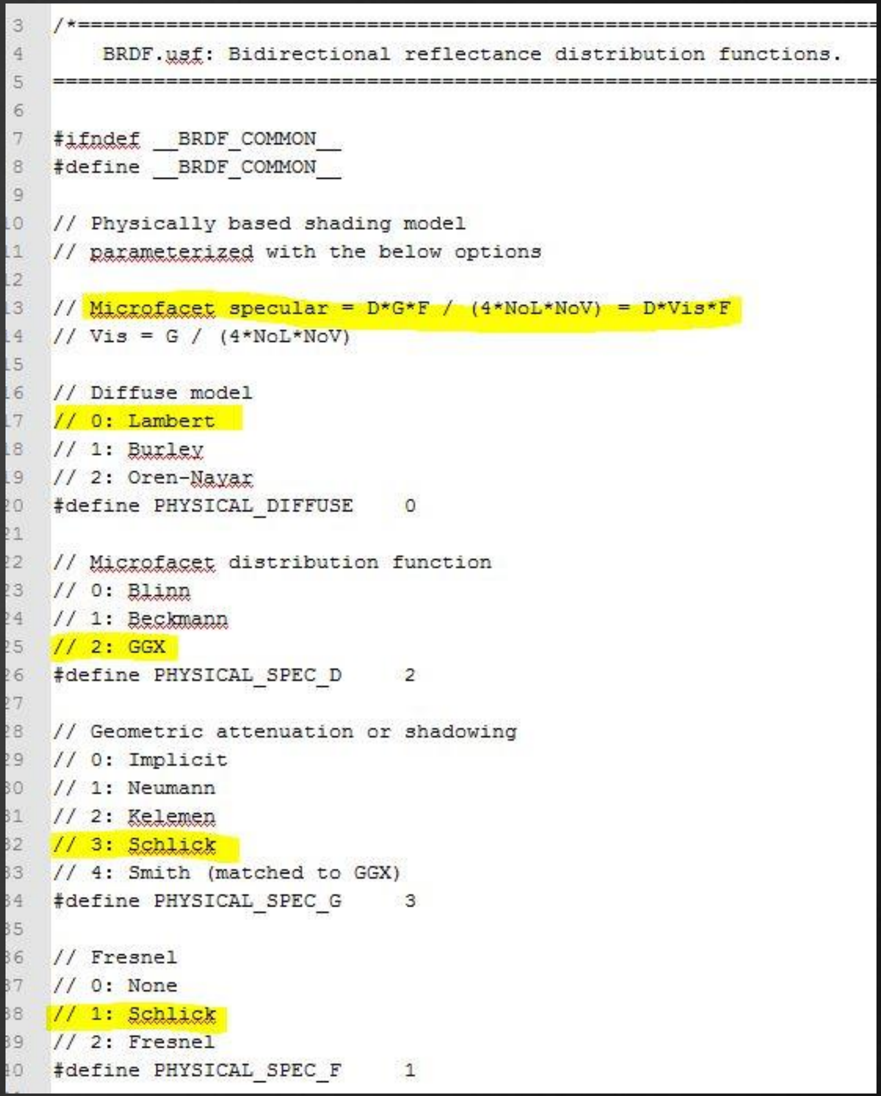


$$f(\mathrm{l},\mathrm{v}) = \frac{D(\mathrm{h})F(\mathrm{l},\mathrm{h})G(\mathrm{l},\mathrm{v},\mathrm{h})}{4(\mathrm{n}\cdot\mathrm{l})(\mathrm{n}\cdot\mathrm{v})}$$

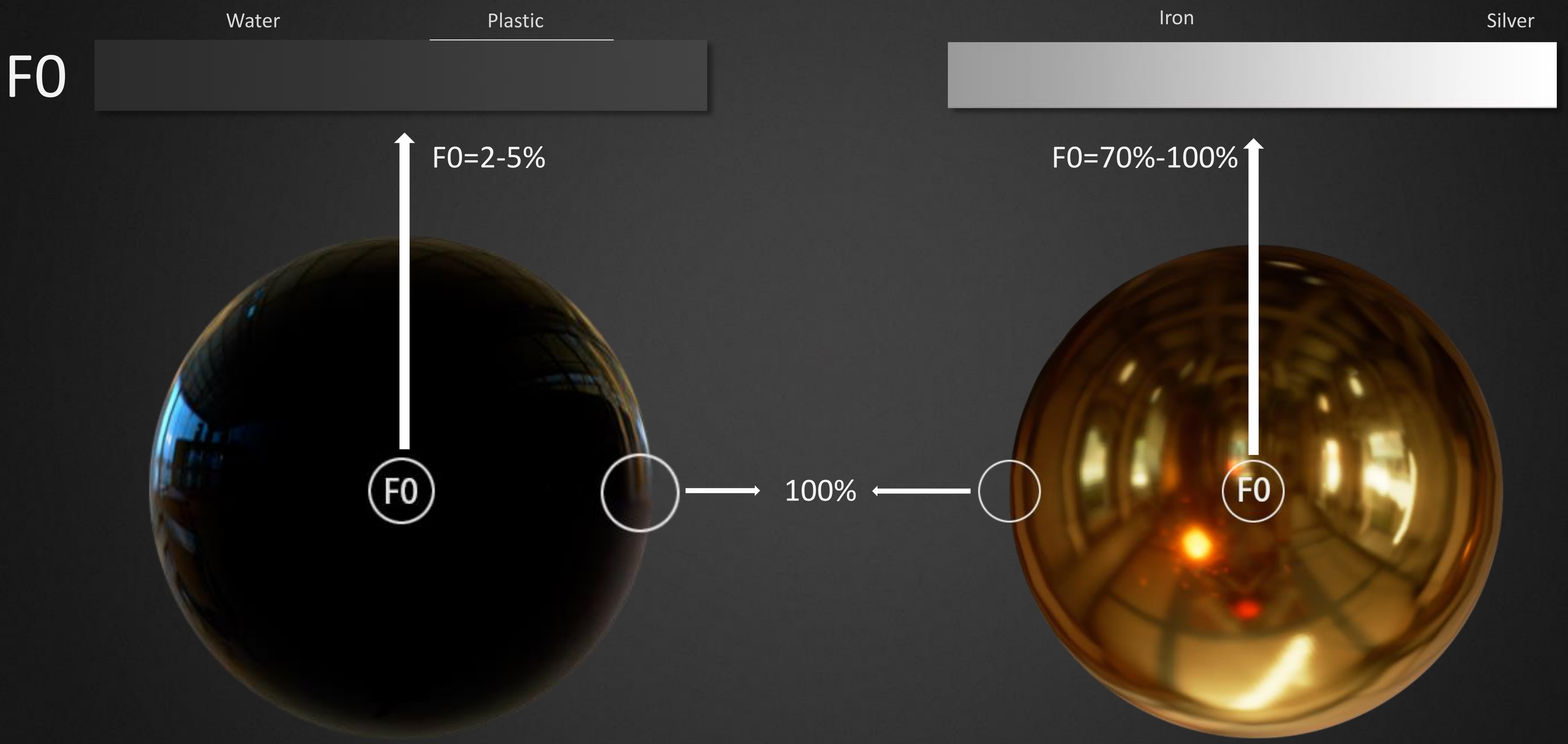
Geometric shadowing:Schlick

Environment BRDF





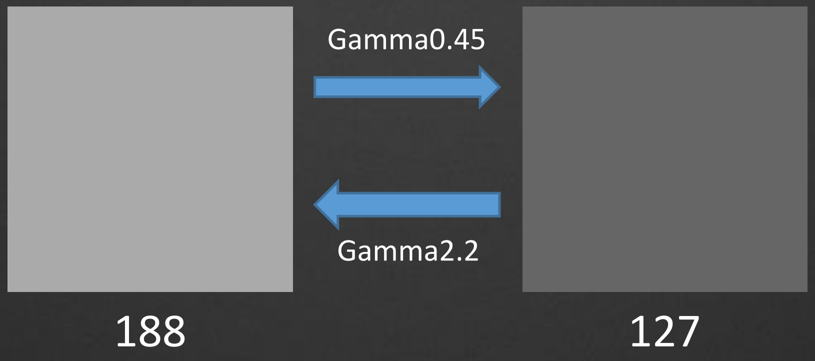
```
/*===================================================================
    BRDF.usf: Bidirectional reflectance distribution functions.
=====================================================================


#ifndef __BRDF_COMMON__
#define __BRDF_COMMON__

// Physically based shading model
// parameterized with the below options

// Microfacet specular = D*G*F / (4*NoL*NoV) = D*Vis*F
// Vis = G / (4*NoL*NoV)

// Diffuse model
// 0: Lambert
// 1: Burley
// 2: Oren-Nayar
#define PHYSICAL_DIFFUSE    0

// Microfacet distribution function
// 0: Blinn
// 1: Beckmann
// 2: GGX
#define PHYSICAL_SPEC_D     2

// Geometric attenuation or shadowing
// 0: Implicit
// 1: Neumann
// 2: Kelemen
// 3: Schlick
// 4: Smith (matched to GGX)
#define PHYSICAL_SPEC_G     3

// Fresnel
// 0: None
// 1: Schlick
// 2: Fresnel
#define PHYSICAL_SPEC_F     1
```



How to simulate in UE4

Linear space conversion behavior in UE4

- Convert sRGB map to linear space
- Conduct shader and lighting computing
- Convert rendered image to sRGB space



material Model

UE4 default parameters:

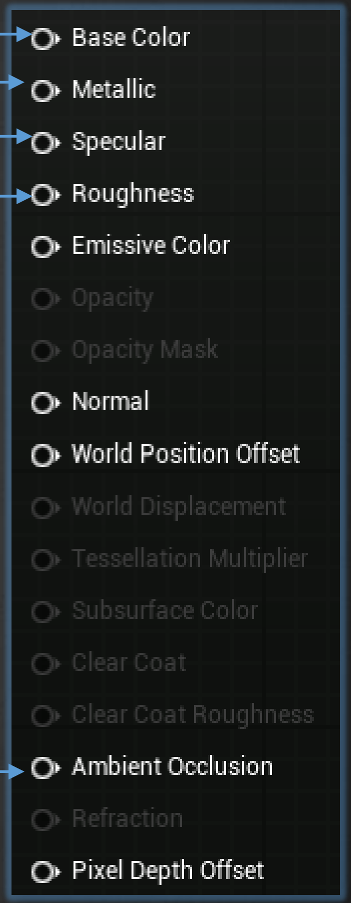
BaseColor=0

Metallic=0

Specular=0.5 (0-1)

Roughness=0.5（0-1）

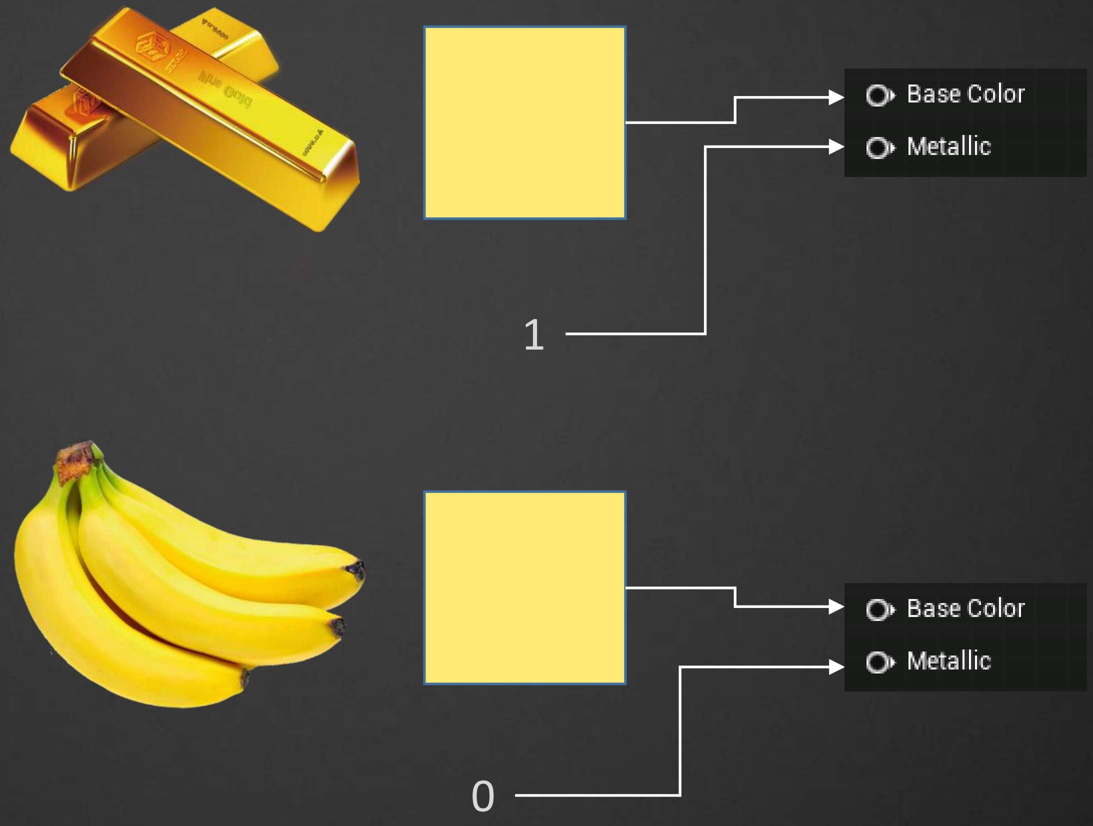
Ambient Occlusion=1



Base Color
Metallic

- **Metal**：
  Base Color: F0 value, reflectance value and color. Visually reflected as the intensity and color of Specular reflection

- **Non-metal:**
  Base Color: diffuse color. Visually reflected as the intensity and color of the inherent color



How to simulate in UE4

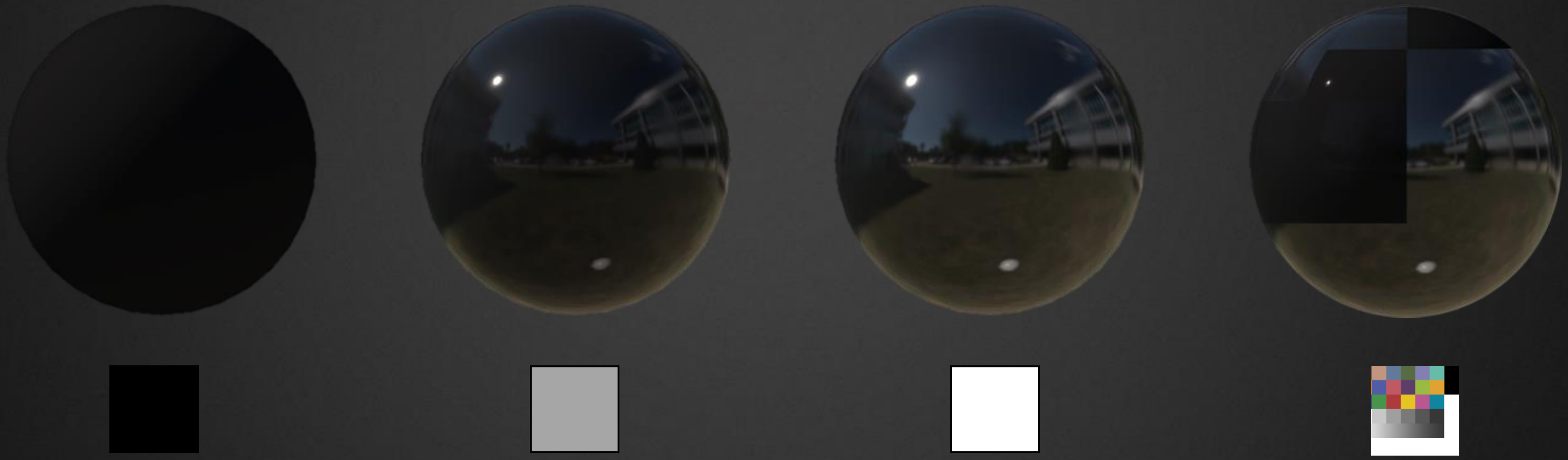
○ Specular

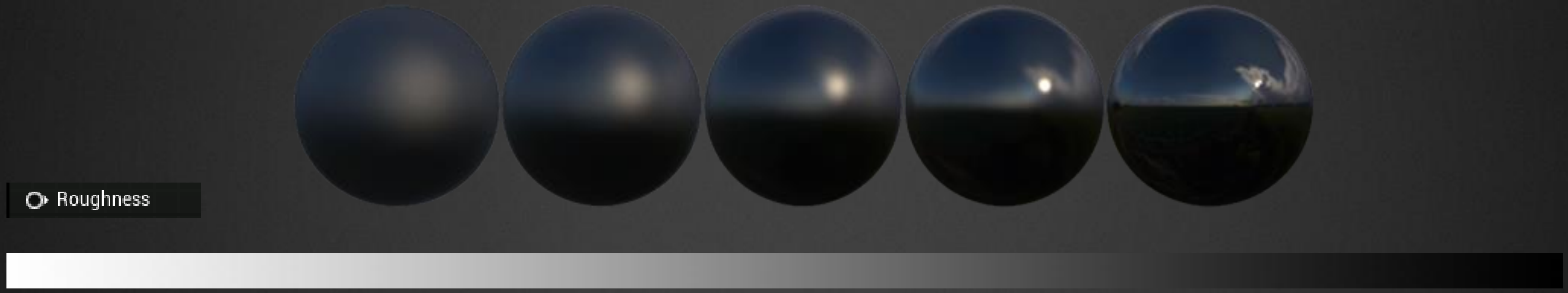
Note:

Any surface has specular. The visual experience of specular largely depends on the dispersion or focusing;

Use roughness to control the intensity of specular;

Specular channel can only be used to simulate occluded minor depression where could not generate specular for the eyes

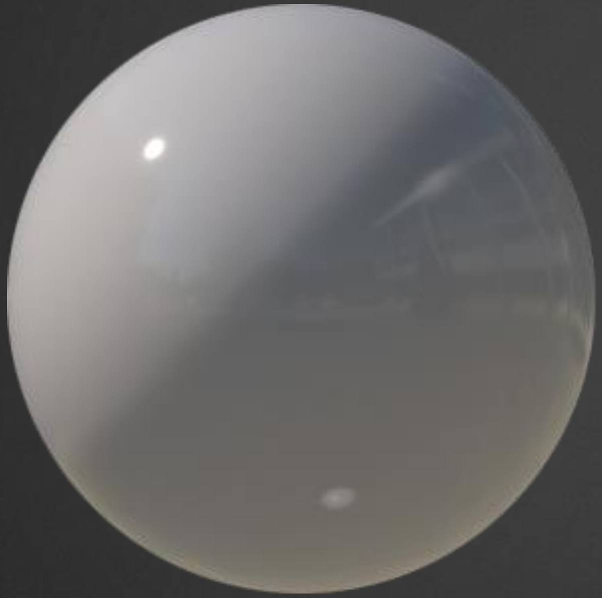


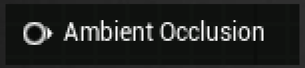


Constant specular, reducing roughness

UNREAL ENGINE

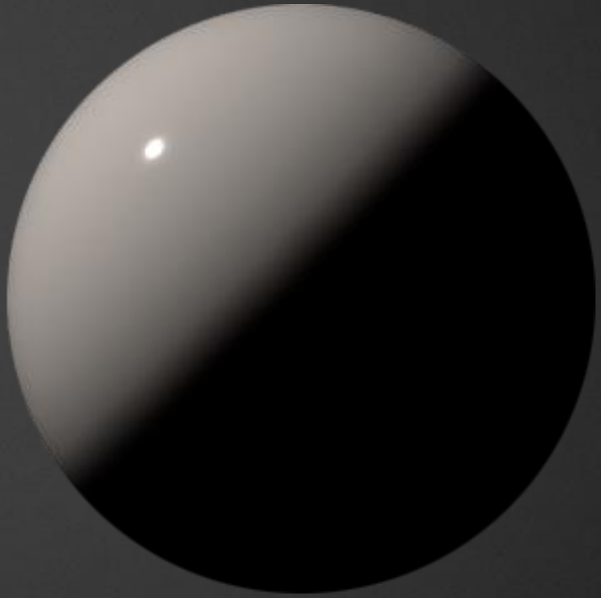
How to simulate in UE4





Ambient Occlusion

AO=1 or default



AO=0, non-direct light diffuse and reflection are fully shielded

How to simulate in UE4

How to perform

Observe/Design/Material

Method (Reuse? CG or Game? Need to change map? Inside or outside the editor?)

Select tools (DDO, Substance, Photoshop, Bipmap2Material, UE4)

Study and create basic materials

Distinguish different materials

Add details to basic materials

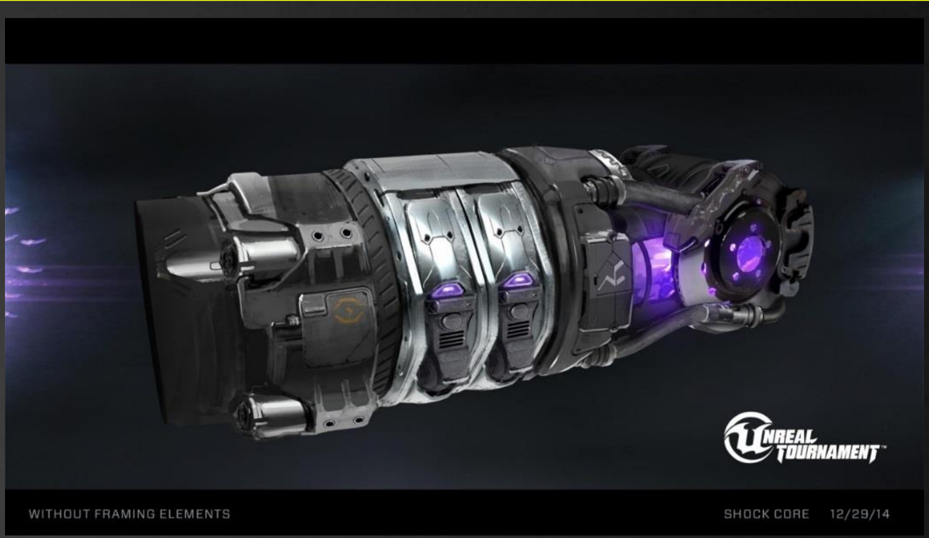
High quality normal map is the key

Lighting

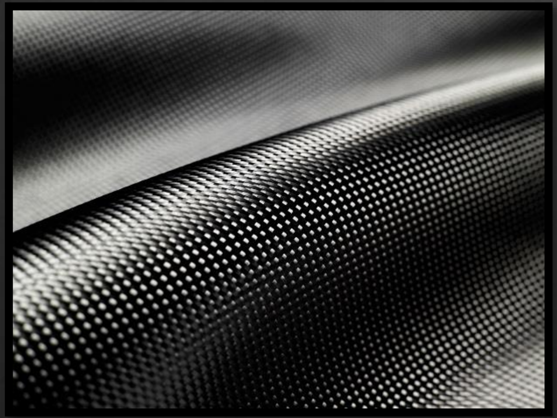
Observe/Design/Material

Polished steel

Polished steel



Carbon fiber



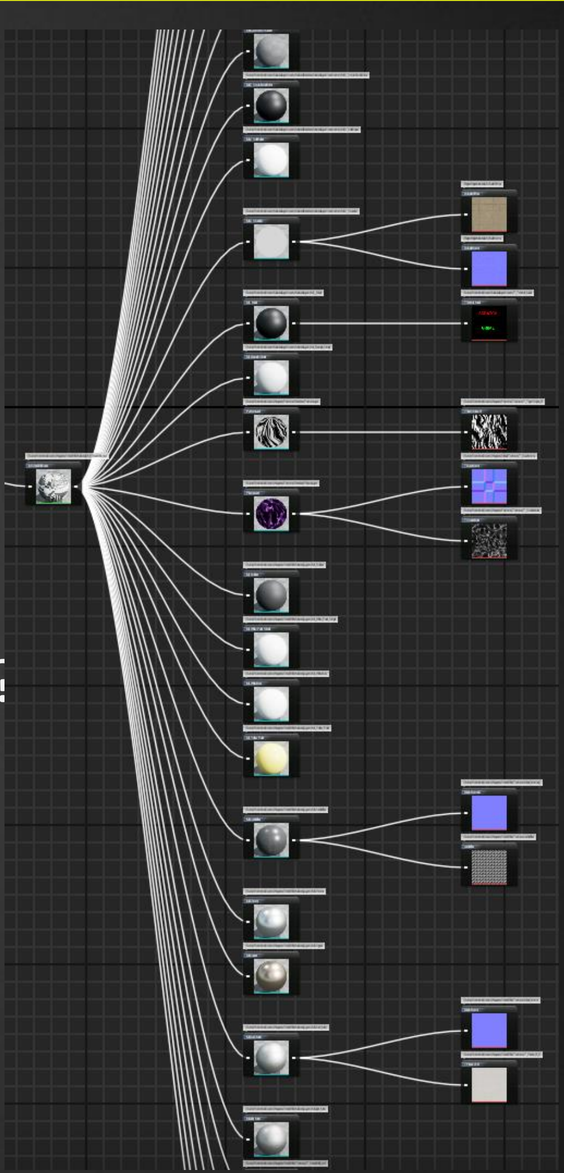
Painted Metal(Matte)

Bare Metal(semi-Reflectived)

Rubber

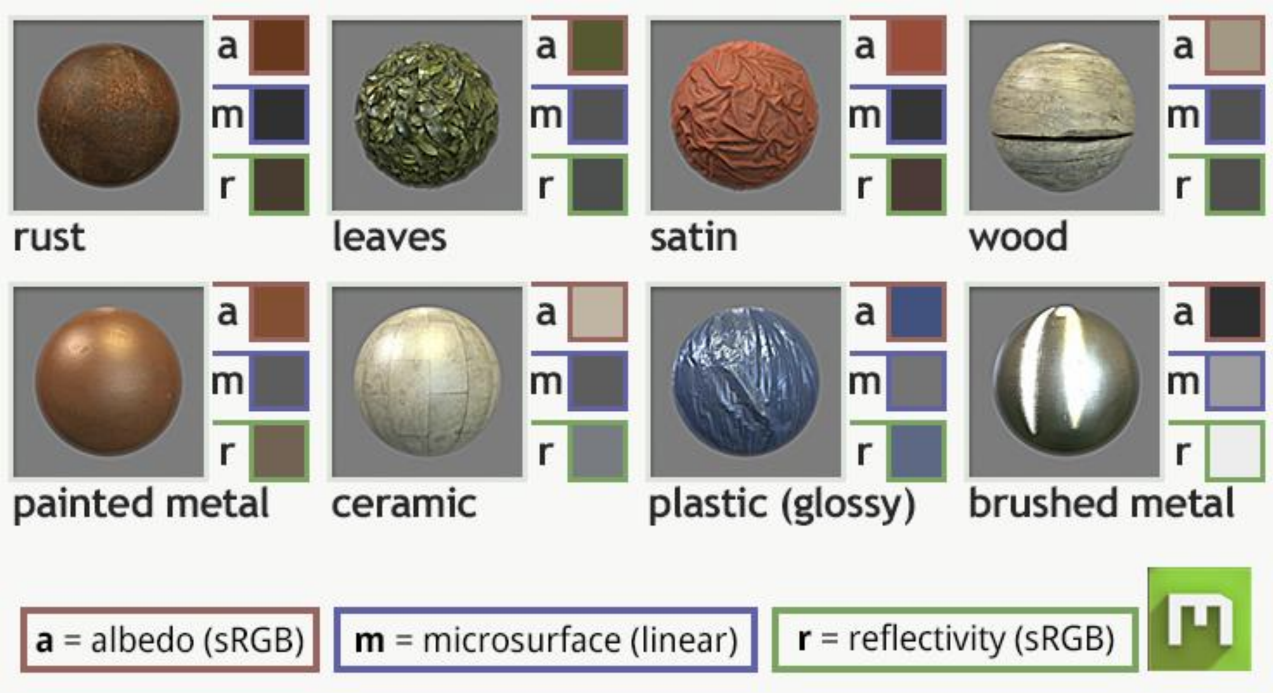
- Application requirements

Need to share the materials?
Is map accuracy required high?
Need to do management and rapid iteration of material?
Need custom or allow changing appearance?
Efficiency/Memory: How complicated the material can
Be? How many materials can maps support?

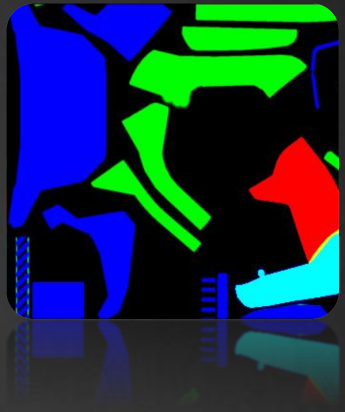


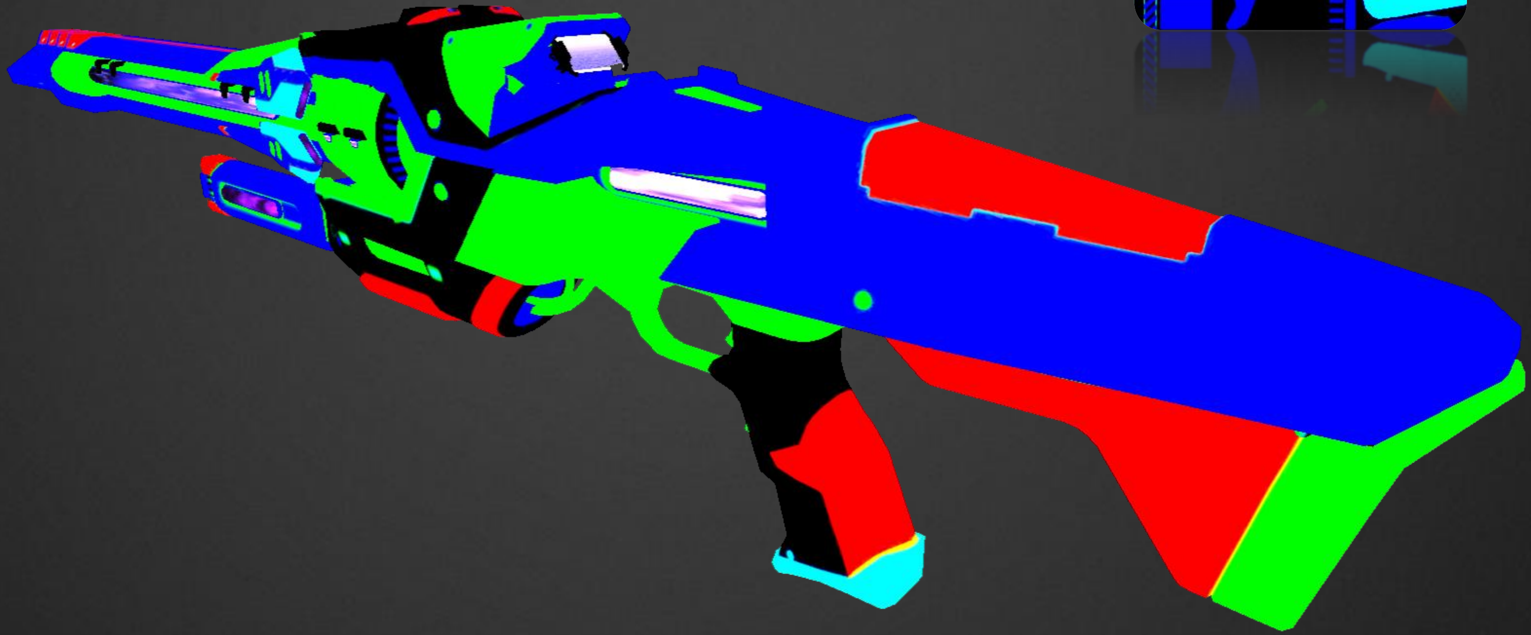
How to perform

- Study and create basic materials



- Distinguish different materials





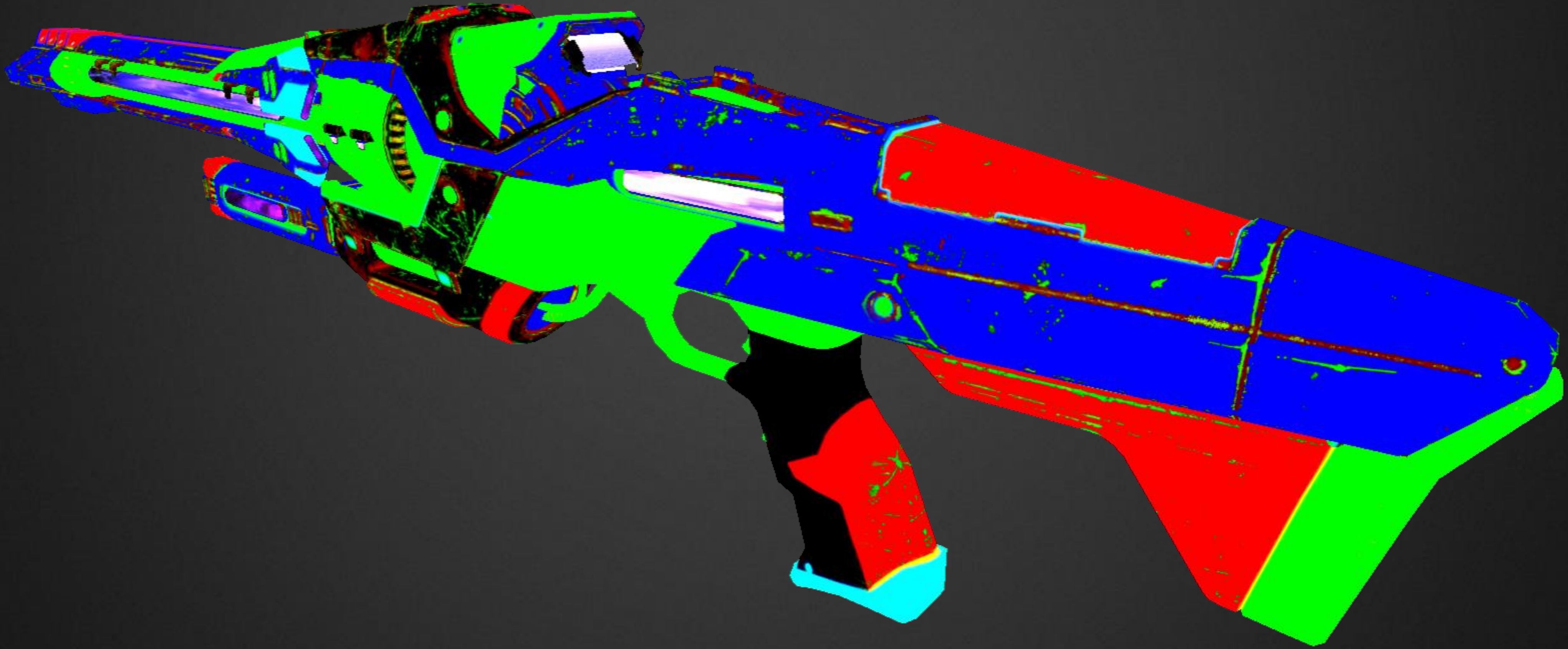
- Add details to basic materia

Scratch

Stain

Environmental elements

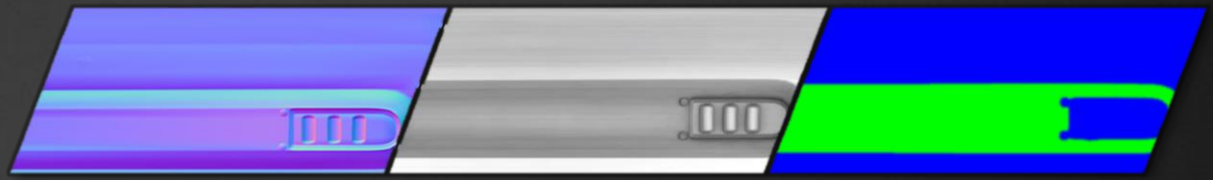
- Basic materials + details



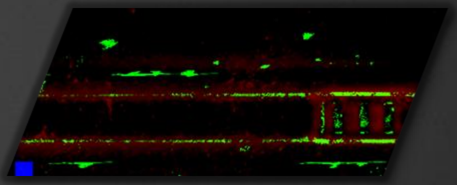
Select tools (UE4, Photoshop, DDO, Substance, Bipmap2Material… …)

high modulus + low modulus

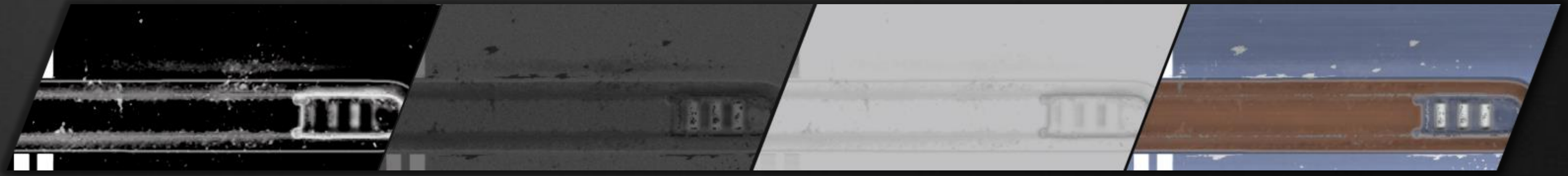
Basic Information: Normalmap， ID MASK， AO/Cavity



Added details (scratch, stain, environmental elements, etc.)

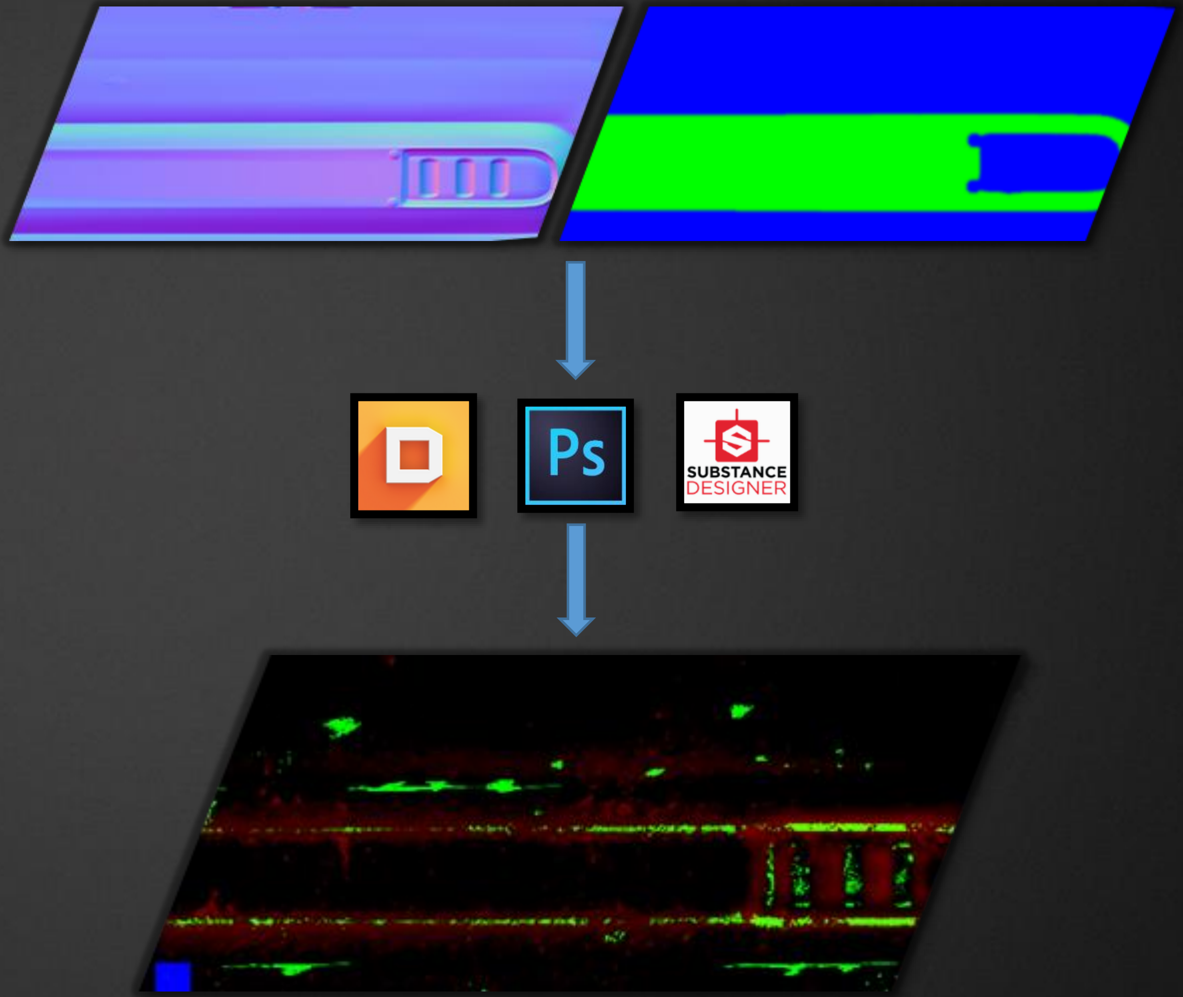


UE4 (import)

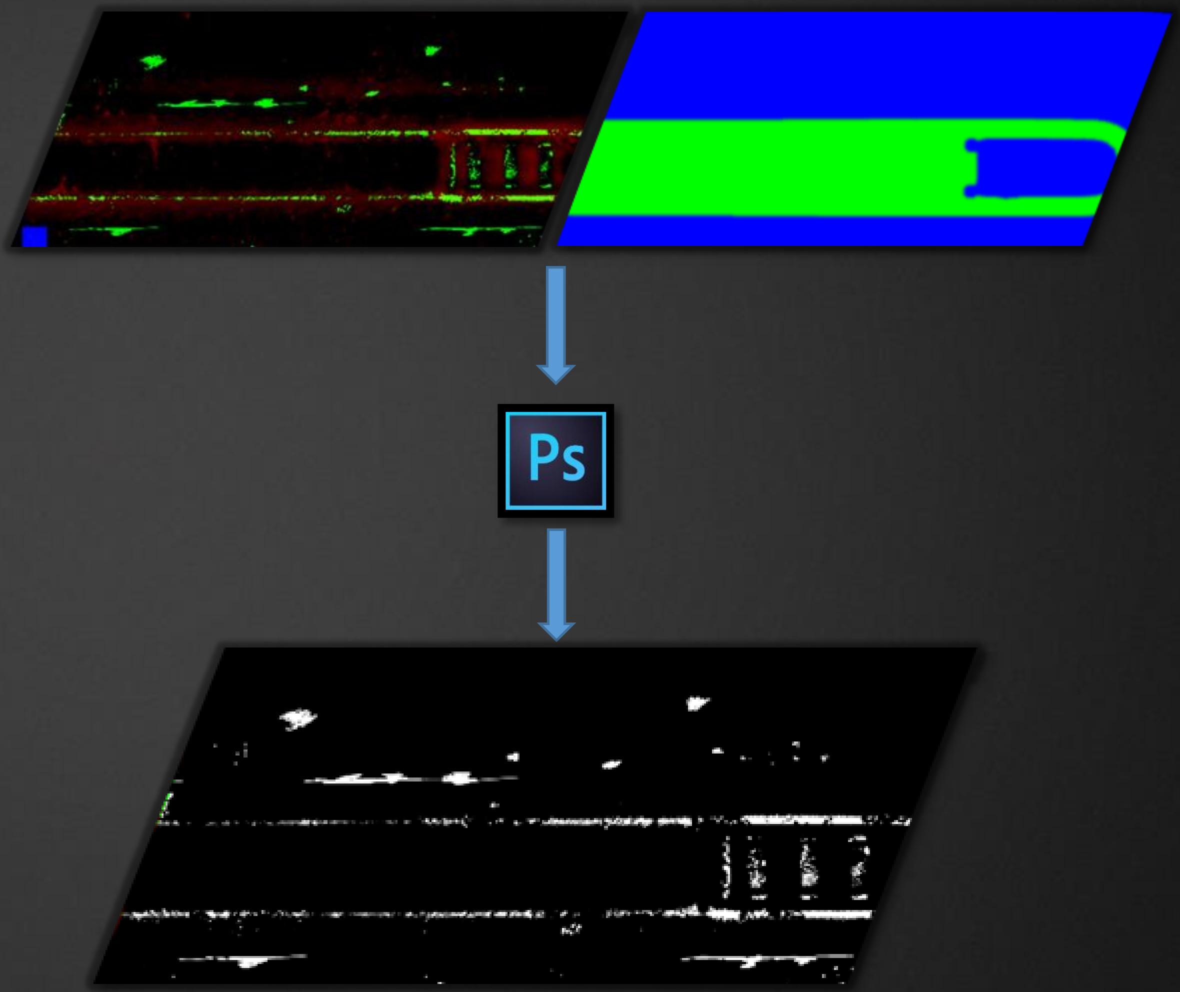


How to perform: traditional method

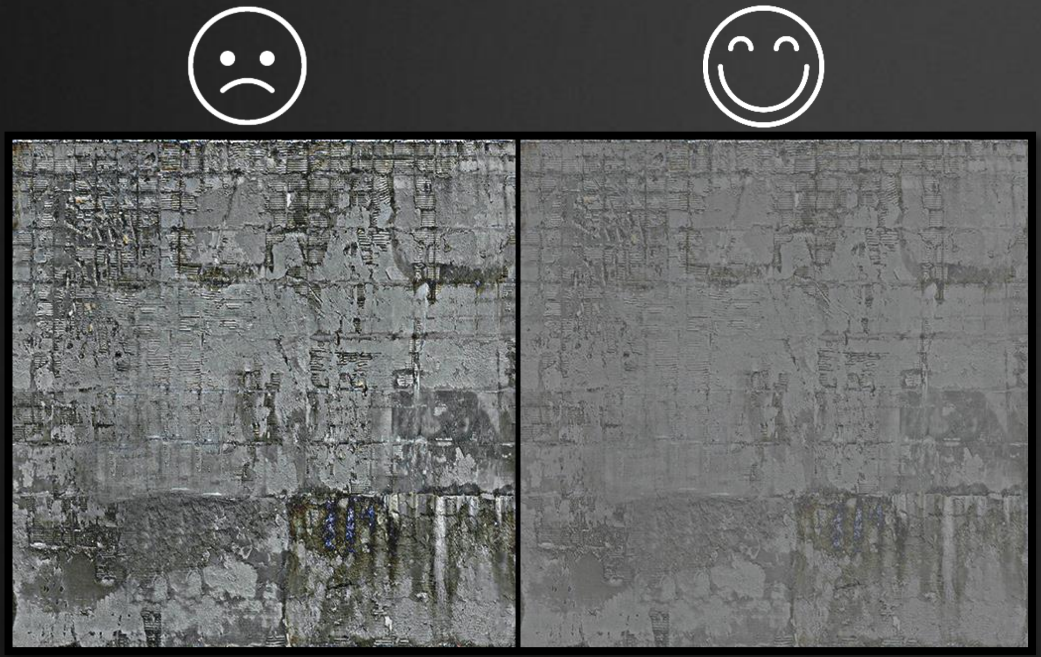
- Detailed MASK Map

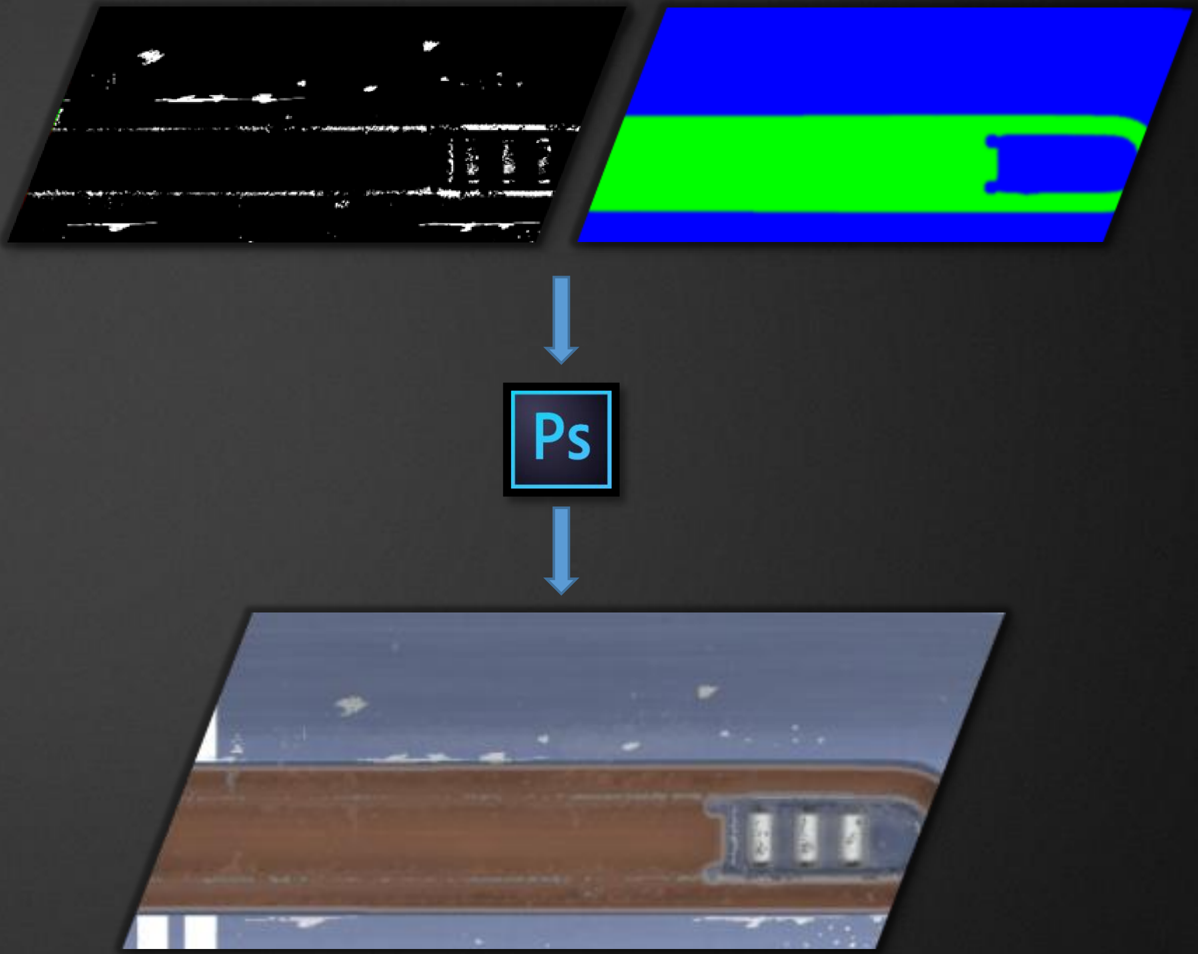


- Metallic



- BaseColor

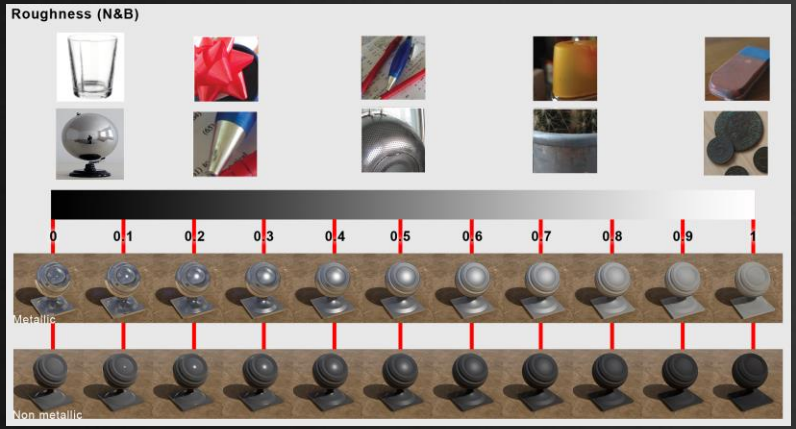


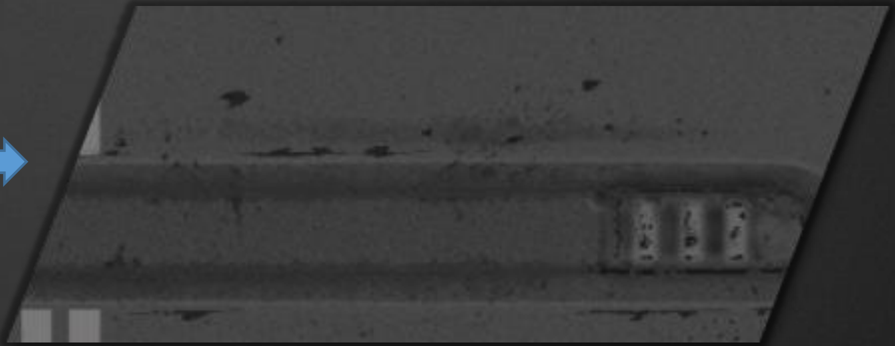


- Roughness

Ps

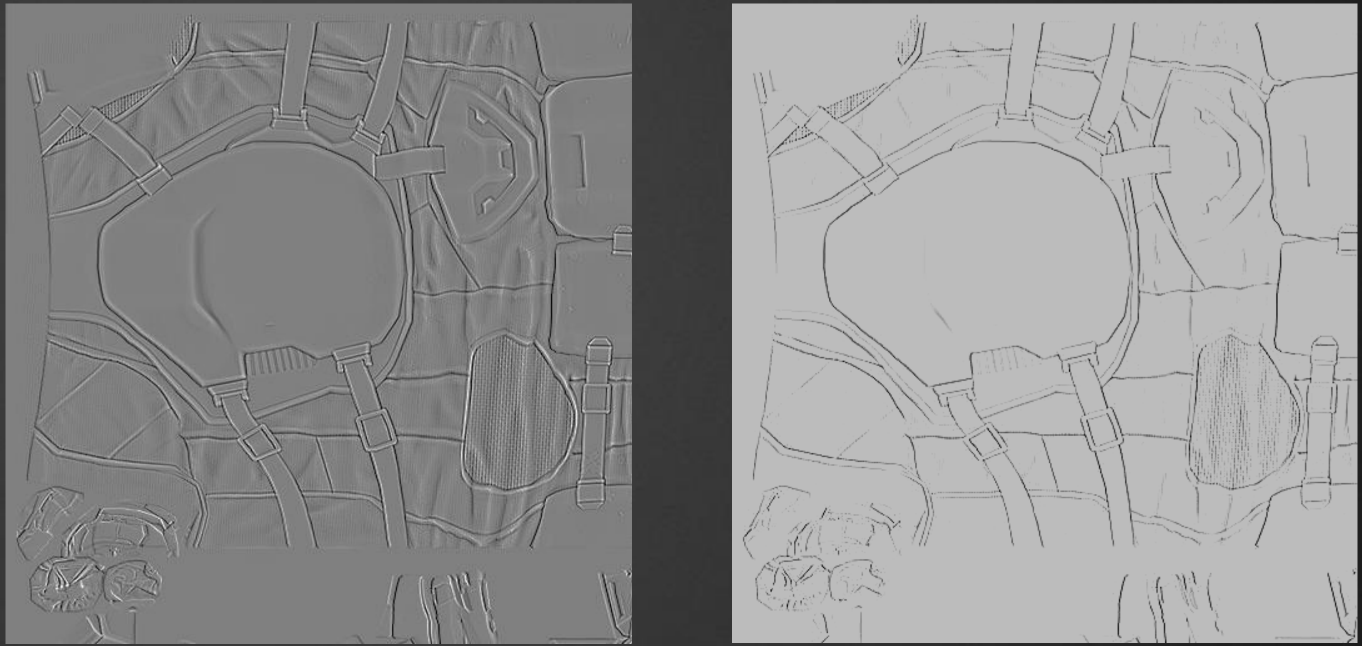
SUBSTANCE B2M





- Specular

Cavity/Curvature

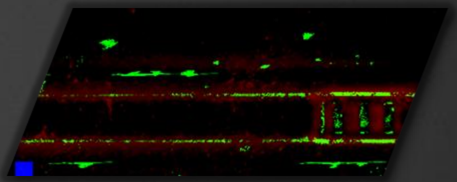


How to perform: multilayer materials

Basic Information: Normalmap， ID MASK，AO/Cavity

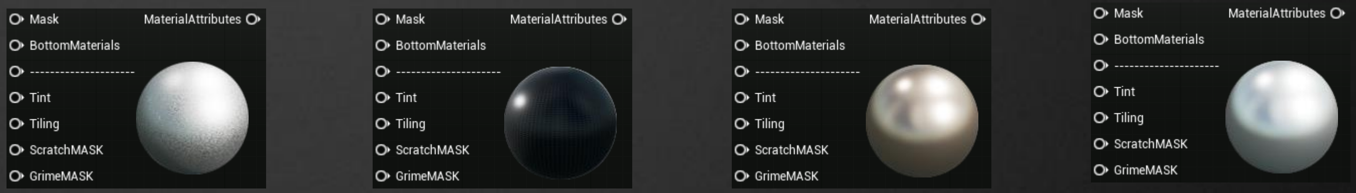
Normalmap
AO
ID Mask

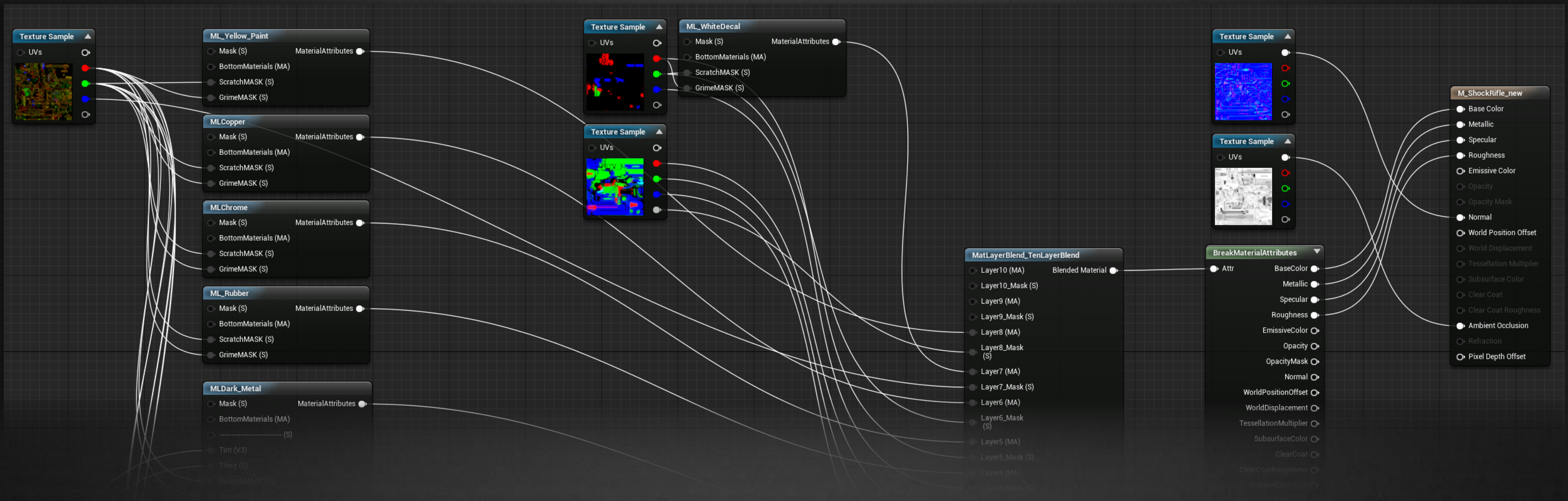
Added details (scratch, stain, environmental elements, etc.)

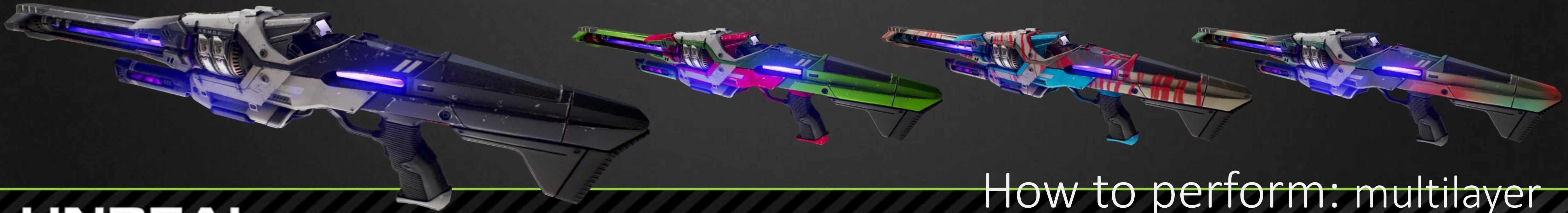


UE4

Create basic materials (Material Function)
Add details to basic materials (Material Function)
Create mother material: mixing basic materials
Add more changes: pattern, wetness/porosity
Create material instance and adjust instance parameters

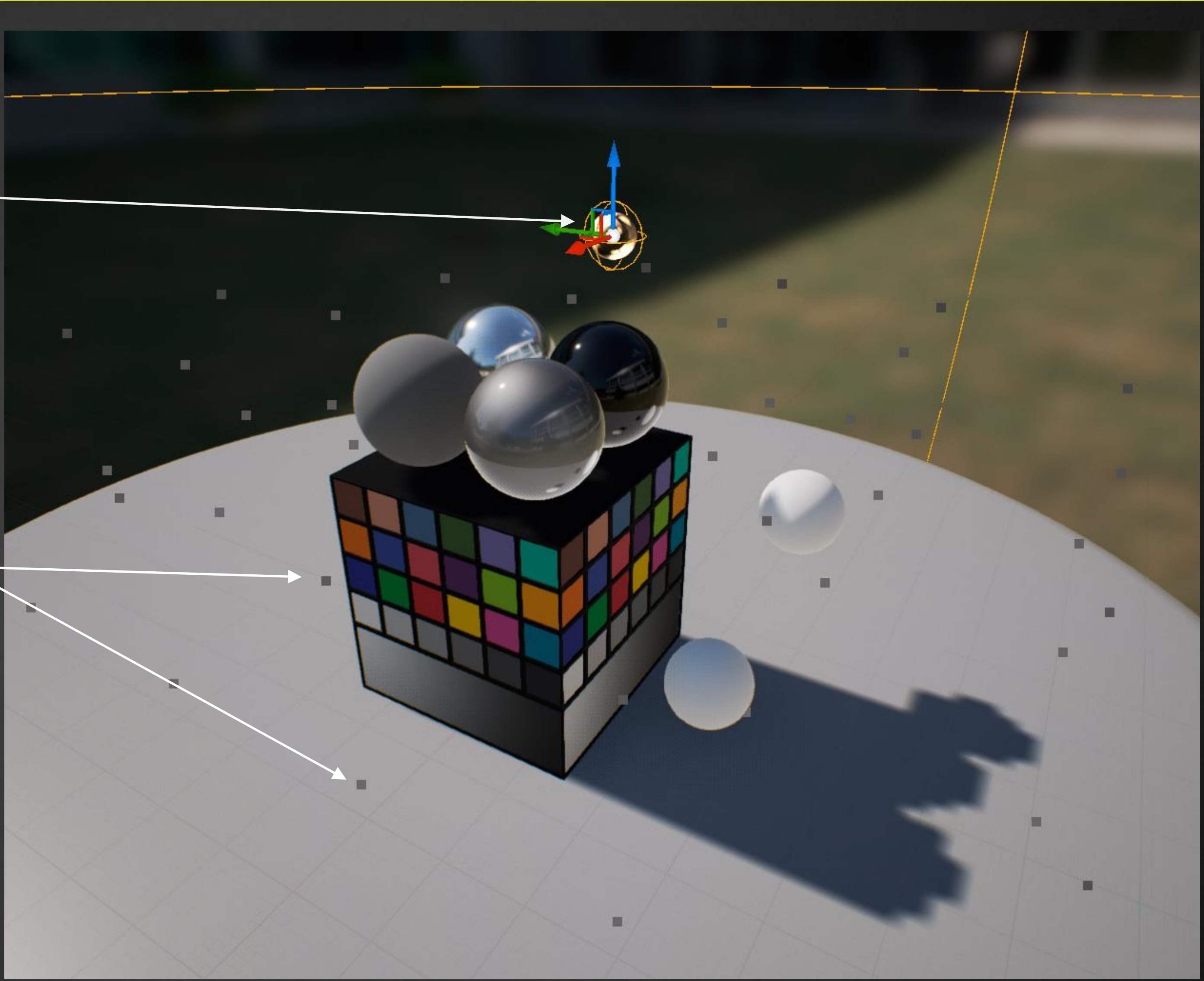






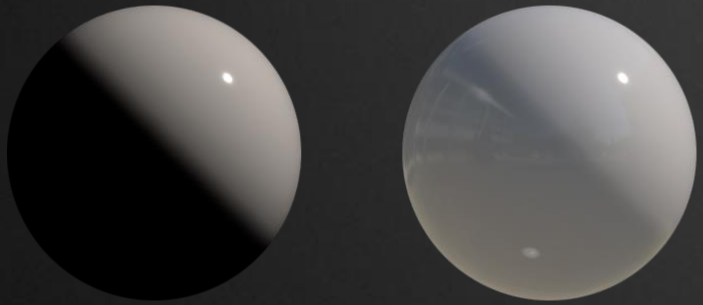
How to perform: multilayer materials

How to perform: lighting



Sphere reflection capture

Volume lighting samples



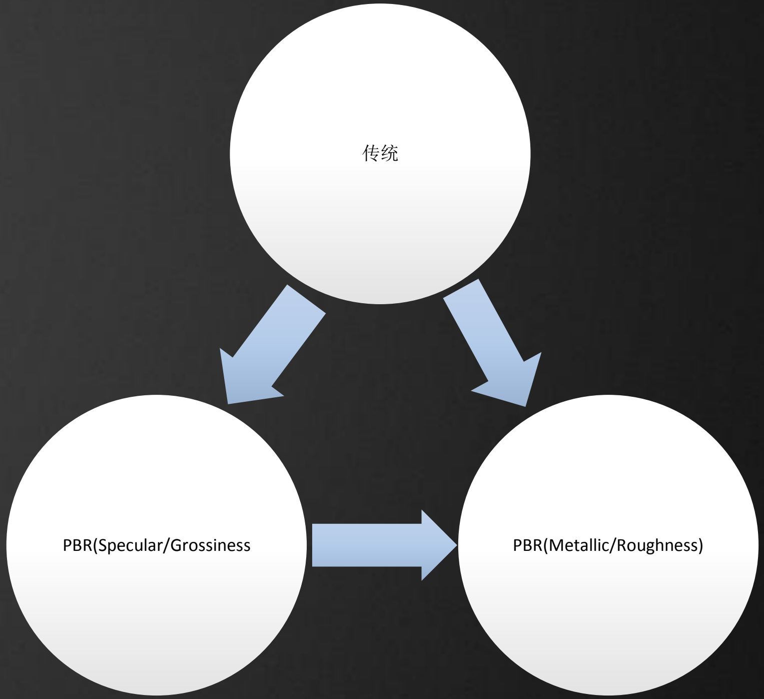
How to perform: lighting

Other processes resources converted to PBR processes resources

What changed?

From traditional technology to PBR (Metallic/Roughness)

From Speuclar/Grossiness to Metallic/Roughness (From other engines)



What changed?

Lighting: No need to draw lighting Information Base color: remove AO, shadow, specular, reflection, microfacet information, etc.

Material model: Input channels are different, where to put specular?

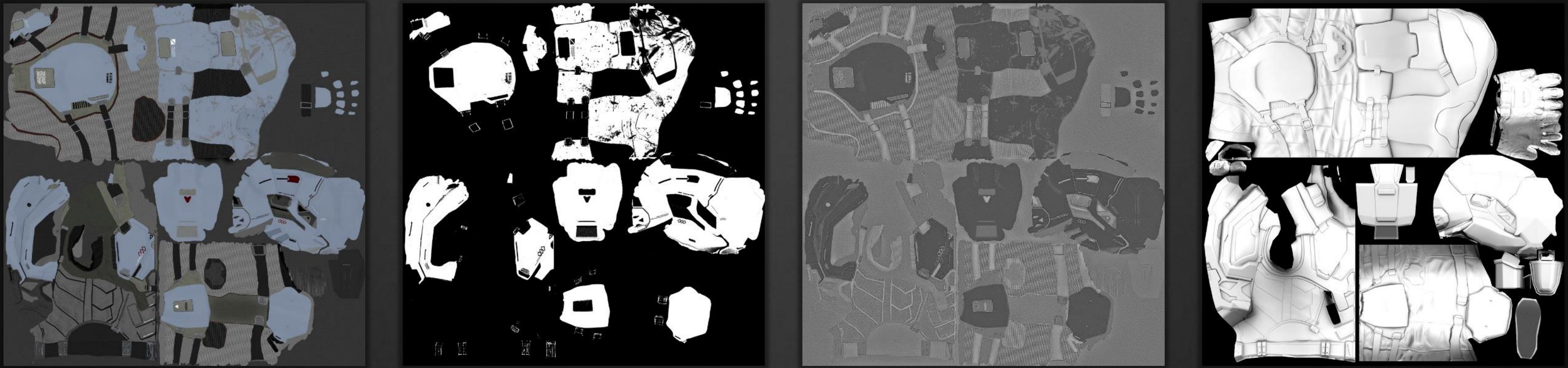
Brightness: Microfacet largely decides the texture – this is a new concept never appeared before.

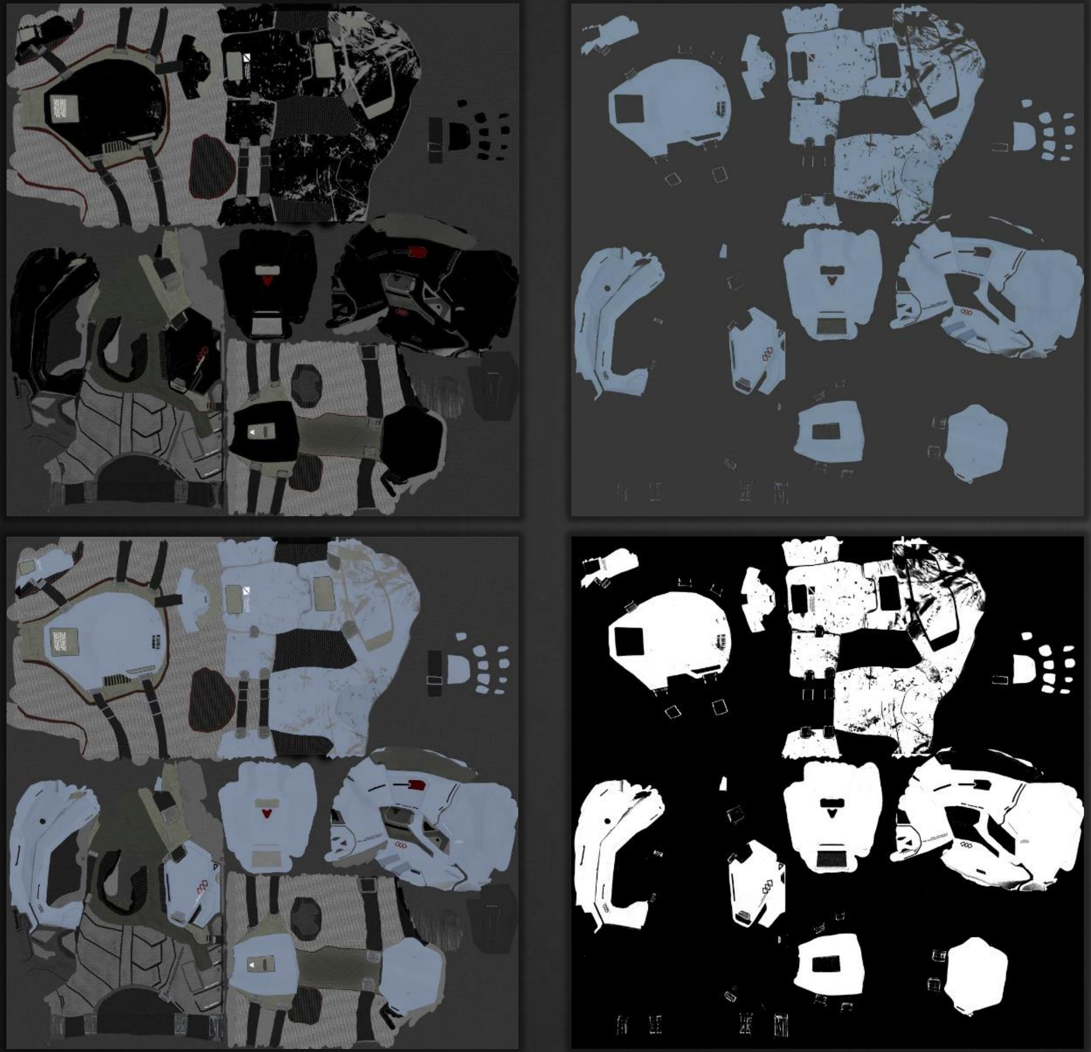
Linear Space: In sRGB, what is the best brightness range of Basecolor?

Other processes resources converted to PBR processes resources

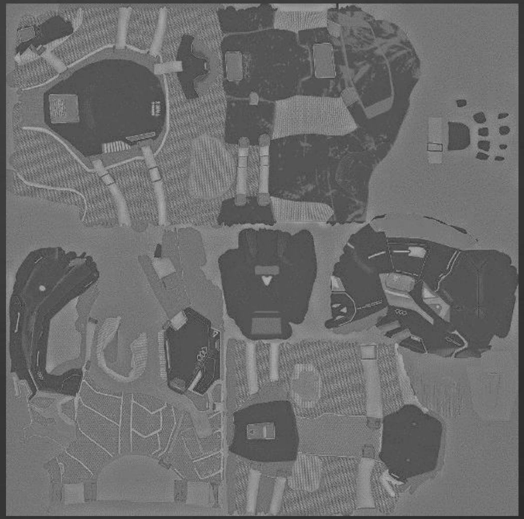
Other processes resources converted to PBR processes resources

From traditional technology to PBR (Metallic/Roughness)





From Speuclar/Grossiness to Metallic/Roughness



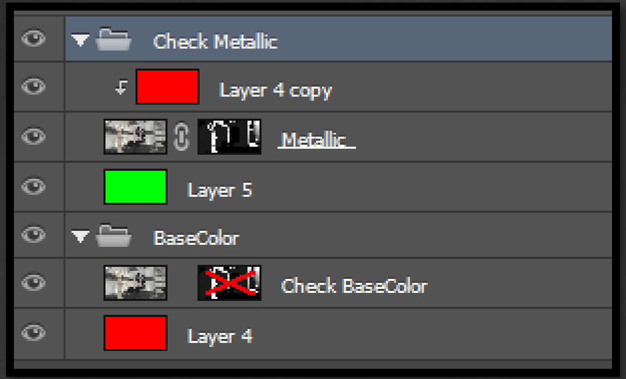
Other processes resources converted to PBR processes resources

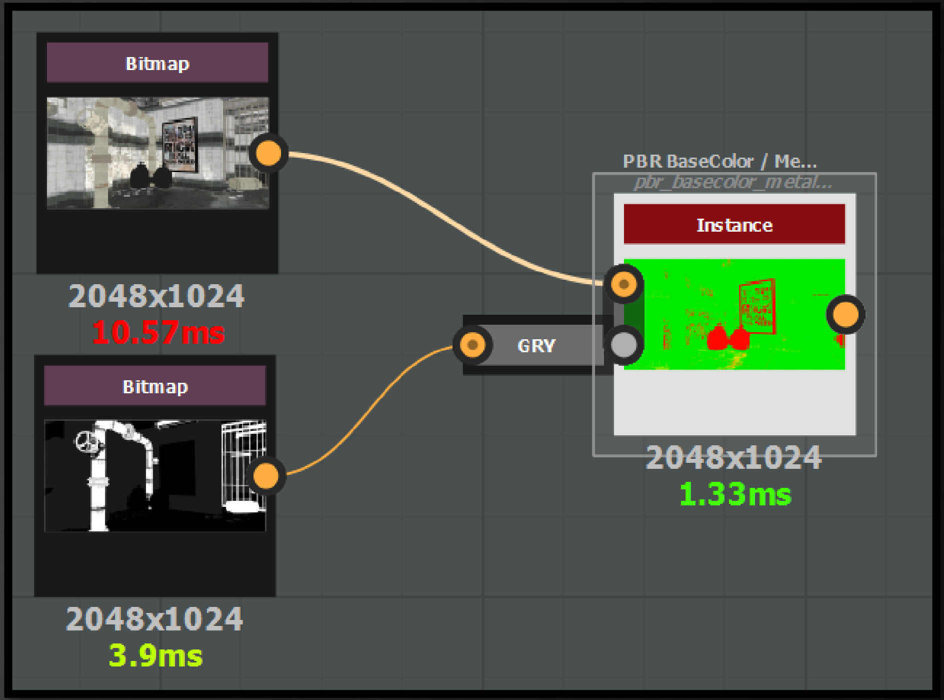
Common problems

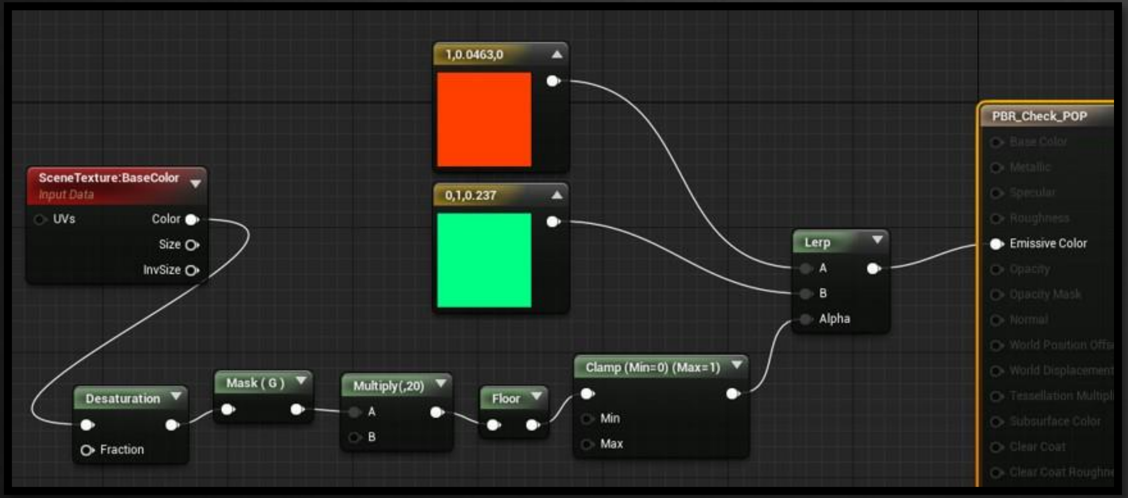
- Use specular to define more highlights
- Base color too dark/contrast too strong/don’t understand its special significance for metals
- Really need specular now? Sometime we really abuse it
- To make the material proper, please focus on Basecolor and Metallic; to make material more pretty, please spend more time on roughness
- Discussion on porosity?

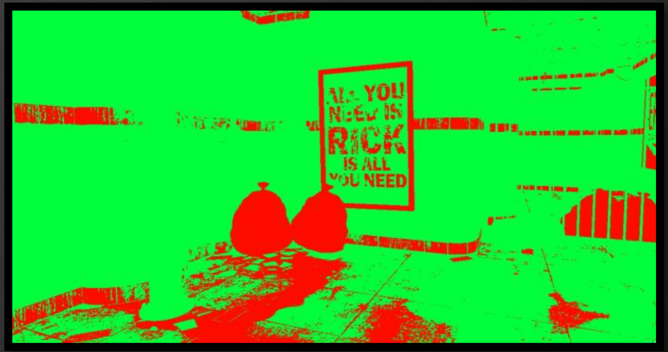
Inspection

- Check BaseColor
- Check Specular
- Check that if Metallic is matching with Specular









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Thank You

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