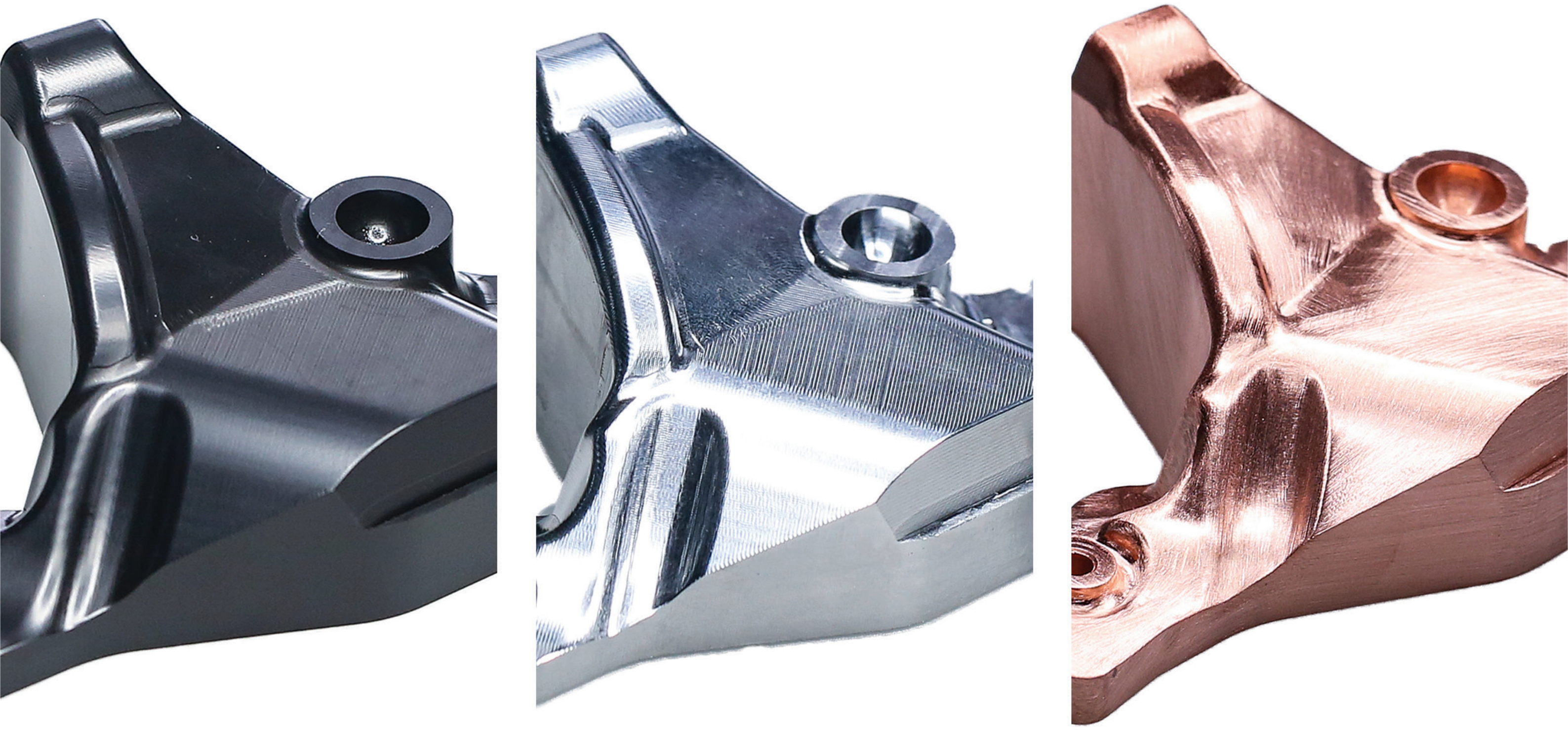
The Ultimate Guide to Understanding

Surface Texture for Product Developers



STAR RAPID

Contents

UNDERSTANDING SURFACE TEXTURE FOR PRODUCT DEVELOPERS

This guide for product developers is all about understanding surface textures. We hope it will enhance your product development journey so you get exactly the look and feel you want from your finished parts and prototypes.

In this guide you will learn how to describe the features of a surface, what the measurement values mean and how surface textures are produced using conventional manufacturing processes.

Product developers will also learn what type of texture is best suited for their application and how to make the best choice when designing for appearance.

Understanding Surfaces

Describing and measuring a surface can be tricky. There are four related terms that are sometimes used interchangeably and which often cause confusion. So let's first clarify the differences between surface texture, finish, pattern and roughness.

Surface Texture:

This is the most general term. Texture is derived from many components, all of them describing any change in geometry from a theoretically smooth, flat plane. All surfaces have a texture because perfectly smooth and flat is not possible.

Surface Finish:

Although often used to describe how a surface looks, this is really a coating or treatment applied after primary manufacturing. Finishes can alter both appearance and texture.

Surface Pattern:

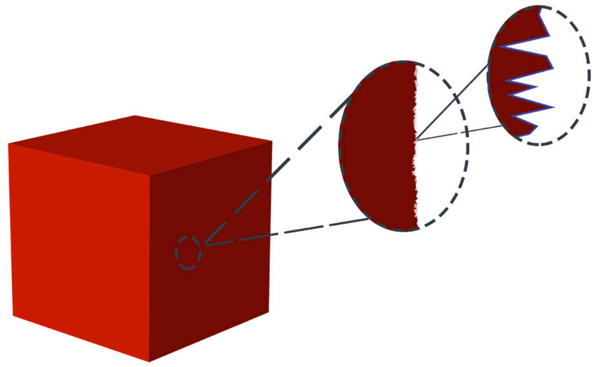
A pattern is a design that's molded, machined or otherwise impressed into the surface. Patterns are large-scale features, visible to the naked eye, and serve both functional and aesthetic purposes.

Surface Roughness:

High-frequency, small-scale measurements of a cross-sectional profile of the surface. Roughness values are taken as the average arithmetic deviation above and below a given reference line.

Terminology

These important engineering terms are used in manufacturing to accurately describe surface textures at different relative scales of measurement.



Ra

Ra is the arithmetic average of multiple surface profile readings after filtering. The purpose of filtering is to distinguish between roughness (higher frequency) and waviness (lower frequency). Product designers should specify their desired Ra value before the part is made. Note that Ra values are most commonly specified in microns, or µm.

Waviness

Waviness is a periodic, repeating distortion of the surface form over a longer sampling frequency than roughness. Waves are imparted to the surface by minor errors in the manufacturing process or the machinery, including vibrations in machine tool bearings or imperfections in guides and ways.

Lay

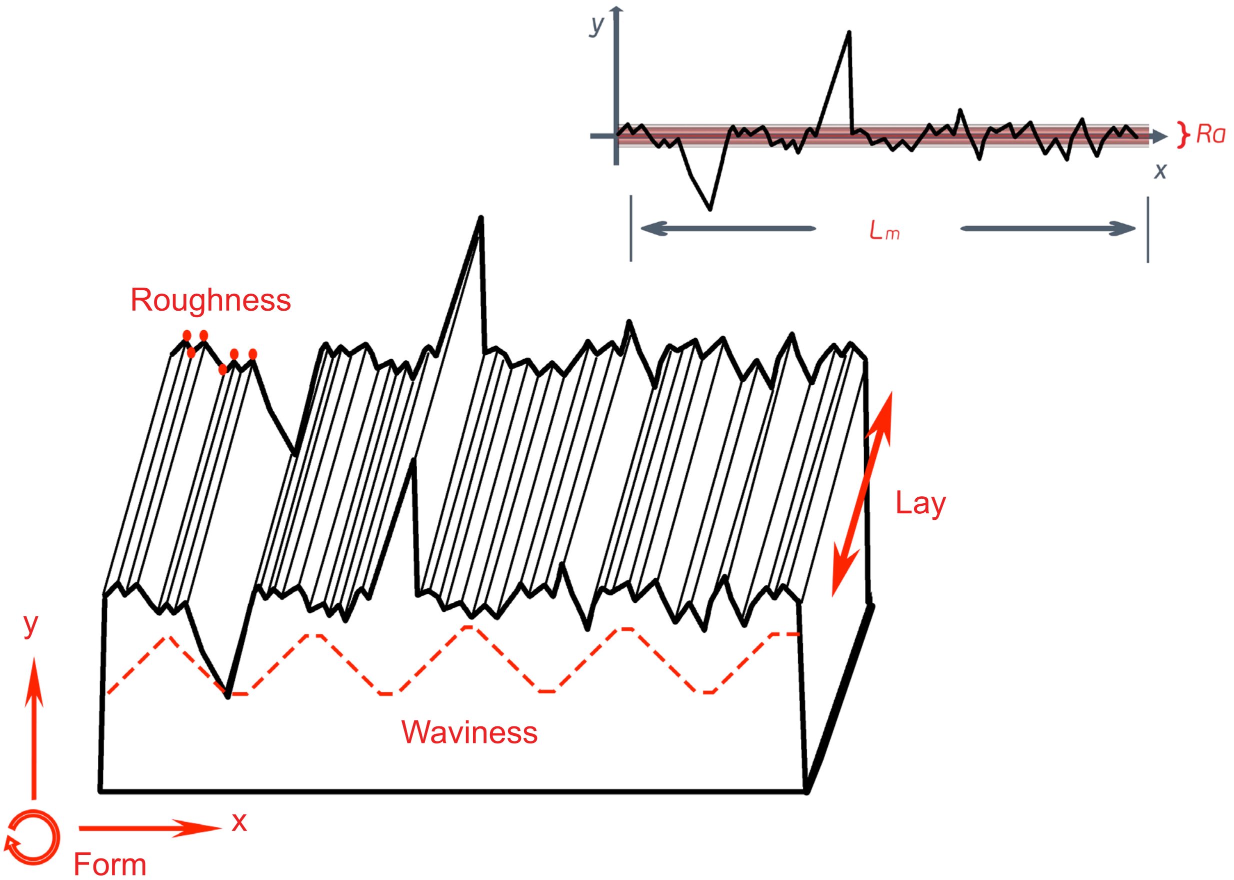
Lay refers to the dominant direction of a surface pattern, usually a repeating series of lines or grooves created by cutting tools and abrasives . Note that not all fabrication processes create a discernible lay but are random or “undirected”.

Form

Form is the large-scale 3D shape of the surface, distinct from how rough the surface may be. For example, a cylinder has a form that is flat on one axis but curved on another, while a sphere is curved in all directions.

Gloss

Gloss is the measure of how reflective the surface is, separate from its measured roughness.



Methods of Measurement

For manufacturers and product developers, surfaces are defined by roughness and gloss. Roughness can be measured by either contact or non-contact methods. A separate measurement for gloss is done to offer more complete information about total surface appearance.

Contact Method

The most common way to measure surface roughness is with a profilometer. This is an electronic meter with a very sensitive diamond stylus or probe tip that is slowly dragged across the surface. The tip of the probe should be perpendicular to the surface or geometric reference line, with the size and shape of the tip being appropriate for the features being measured.

To ensure accuracy, multiple readings must be taken from different directions, using a specified sample length. Most profilometers take the raw input data and automatically filter out high and low readings to provide a mean or average value.

When measuring it’s also necessary to discount atypical defects like scratches, dents, voids, cracks or other random imperfections that don’t represent the true surface profile.

Pros:

- Simple and portable
- Not affected by surface oils
- Not affected by surface reflectance or gloss

Cons:

- Part features may limit sampling length
- Stylus only covers a very limited area
- Is relatively slow for large parts
- Stylus can be damaged by very rough surfaces

Non-Contact Method

Optical comparators, interferometers, microscopes and other non-contact instruments use radiant energy to scan the surface but they do so in a larger 3D area and not on a 2D cross-section.

Pros:

- Very fast
- Covers a large surface area
- Cannot damage the part surface
- Unaffected by rough textures

Cons:

- May be affected by surface gloss
- Requires a larger, stationary machine
- Not able to resolve features smaller than some wavelengths of the radiant energy, especially visible light

Gloss Meter

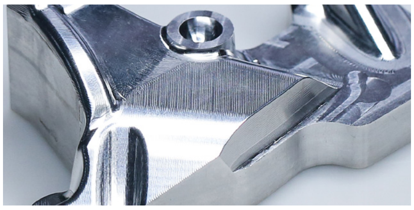
A gloss meter bounces a light source of known intensity from the surface of the target piece, and measures the reflected energy. These measurements are compared against the polished black glass reference standard of “100 gloss units” to yield a number that quantifies how reflective the surface is.

Material Considerations

A material's surface texture is affected by the raw material's density, hardness, grain size, molecular structure and many other factors.

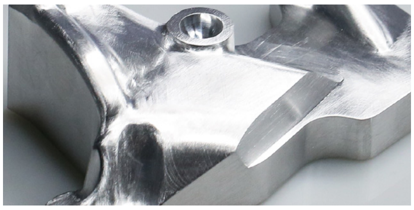
Here are some examples of textures that can be achieved in common materials using conventional manufacturing methods, for reference only.

Aluminum: Al6061-T6



As machined

Polished

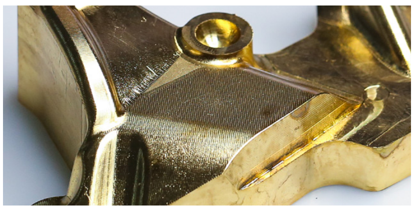


Sanded #320

Sand Blasted #120

Sanded #320
+Sand Blasted #120

Brass: H59



As machined

Polished


Sanded #320


Sand Blasted #120


Sanded #320
+Sand Blasted #120

ABS: Natural Color


As machined


Polished


Sanded #320


Sand Blasted #120


Sanded #320
+Sand Blasted #120

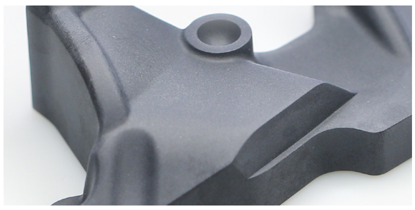
PMMA: Black Color


As machined


Polished


Sanded #320


Sand Blasted #120

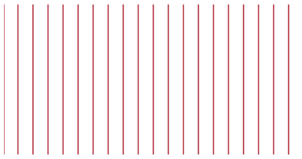

Sanded #320
+Sand Blasted #120

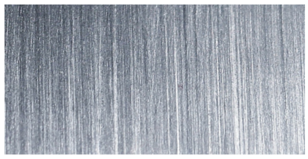
Patterns

Every process leaves a characteristic pattern or fingerprint on the resulting workpiece. Different patterns may require separate methods of measurement in order to capture the relevant surface information.

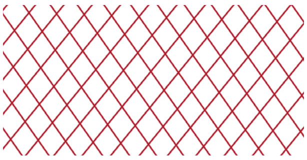
Here are the most common patterns:

Linear

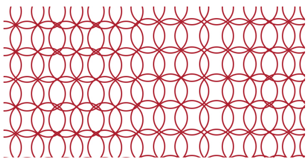


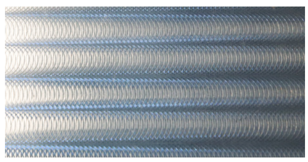


Cross-hatched

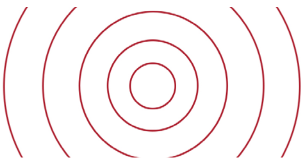


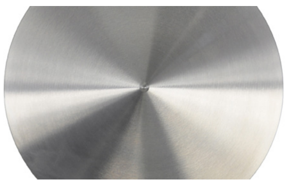
Multi





Concentric



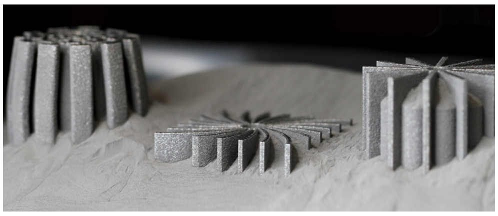


Manufacturing Methods

Product developers should be aware that there is a typical range of roughness values that can be expected from every conventional manufacturing method. The actual final surface roughness depends on many factors so this guide should be used for general reference only.

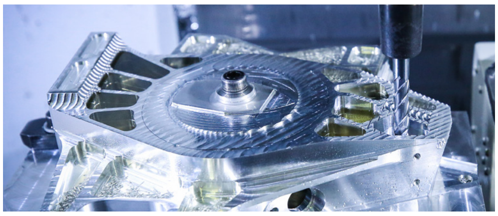
3D Metal Printing

Ra 4 -10 um



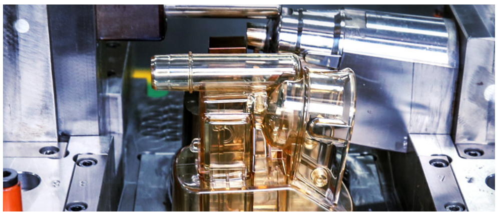
CNC Machining

Ra 3.2 - 6.3 um



Plastic Injection Molding

Ra: 3 - 15 um

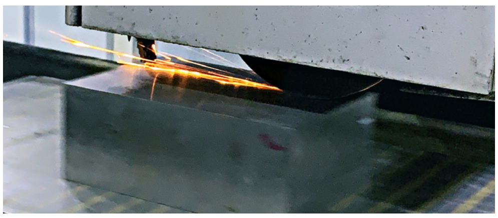


Pressure Die Casting

Ra 1.6 um

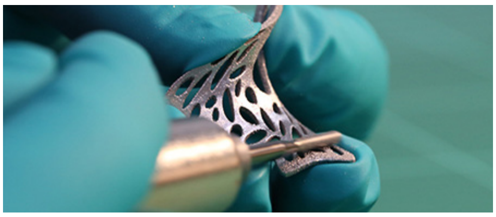
Surface Grinding

Ra 1.6 - 3.2 um



Polishing

Ra 0.4 - 0.8 um



			Star's General Surface Finishes Standard			
	Remarks to Customer	**Material Compatibility**	**Surface Roughness**	**Requirement**	**Specification**	**Comments**
As Machined	Visible tool marks on the machined part ** Note: Please select **Sanding (#320)** + **Bead Blasting (#120)** if tool marks are not acceptable.	All metals & plastics	**Ra 3.2 - 6.3 um** ** Note: Average Ra 3.2um but some areas can be as low as Ra 0.8um or < Ra 3.2um			
Bead Blasting (#120)	(I) Add a uniform matte or satin surface finish on a machined part (II) Macro tool marks will still be visible. ** Note: Please select **Sanding (#320)** + **Bead Blasting (#120)** if tool marks are not acceptable.	All metals & plastics	**Ra 3.2 um**	**Grit**	#120 (Glass Bead)	In Star, we offer **Glass Bead Blasting** &**Aluminum Oxide Grit Blasting** in a wide range of grit sizes (#80, #100, #120, #150, #180, #220). Unless otherwise specified, we will use **Glass Bead (#120)**.
				Surface Glossiness	Uniform matte or satin	
				Part Masking	Indicate masking requirements in technical drawing *(if requested by customer)*	
Sanding (#320)	(I) Manually remove visible tool marks (II) Inconsistent sanding marks will be visible ** Note: Please select **Sanding (#320)** + **Bead Blasting (#120)** if sanding marks are not acceptable.	All metals & plastics	**Ra 1.6 - 3.2 um**	**Grit**	# 320 (Aluminum Oxide Grit Paper)	In Star, we offer a wide range of grit sizes (#150, #240, #320, #400, #600, #800, #1000, #1500). Unless otherwise specified, we will use grit size of **#320**.
				Surface Glossiness	Matte or satin	
				Part Masking	Indicate masking requirements in technical drawing *(if requested by customer)*	
Sanding (#320) + Bead Blasting (#120)	(I) Uniform matte or satin surface finish on a machined part (II) Removed tool marks	All metals & plastics	**Ra 1.6 - 3.2 um**	**Grit**	Sanding: #320 (Aluminum Oxide Grit Paper) Bead Blasting: #120 (Glass Bead)	In Star, we offer sanding + bead blasting in a wide range of grit sizes. Unless otherwise specified, we will perform **Sanding** in grit size of **#320** and then **Bead Blasting** in grit size of **#120**
				Surface Glossiness	Uniform matte or satin	
				Part Masking	Indicate masking requirements in technical drawing *(if requested by customer)*	
Polishing		All metals & plastics	**Ra 0.4 - 0.8 um**	**Grit**	Sanding: #1000 (Aluminum Oxide Grit Paper)	Unless otherwise specified, we will perform **Sanding** up to grit size of **#1000** prior to polishing process
				Surface Glossiness	Gloss / High-gloss	
				Part Masking	Indicate masking requirements in technical drawing *(if requested by customer)*	
Vapour Polishing		PC only	**Ra 0.4 - Ra 0.8 um**	**Grit**	Sanding: #1000 (Aluminum Oxide Grit Paper)	Unless otherwise specified, we will perform **Sanding** up to grit size of **#1000** prior to vapour polishing process
				Surface Glossiness	Gloss / High-gloss	
				Part Masking	Indicate masking requirements in technical drawing *(if requested by customer)*	
Graining (Brushing)	Unidirectional satin finish.	Metals only	**Ra 0.8 - 1.2 um**	**Grit**	# 150 (Aluminum Oxide Grit Paper)	In Star, we offer a wide range of grit sizes (#150, #240, #320) for graining (brushing). Unless otherwise specified, we will use grit size of **#150**.
				Direction	Indicate direction in technical drawing	
				Part Masking	Indicate masking requirements in technical drawing *(if requested by customer)*	

For more information on the use of comparators and other tools to measure surfaces, please see this helpful link.

Functions

Surface texture has a large effect on the function of a part. Let's take a closer look at the practical applications of different surface textures and treatments.

Friction

Rougher textures create more friction on moving parts like bearings, gears and shafts. Friction generates heat, and abrades more quickly. But high-friction textures also improve grip and traction for surfaces that need to be non-slip.

Very smooth, low-friction surfaces can be easier to scratch. Similar materials, rubbing together, can seize up or "gall" as they share electrons across the surface layer.

Adhesion

A certain amount of surface roughness promotes the adhesion of paints, dyes, adhesives and primers.

Passivation

Passivation means treating the surface so that it is less electrically reactive with the environment and therefore more corrosion-resistant. Some common examples include galvanizing and anodizing.

Hardening

Some surface treatments can affect the hardness of a part. These include work hardening and case hardening.

Reflection and Absorption

Surfaces differ in their ability to reflect and absorb both visible and invisible light energy. This is a function not only of the degree of surface polishing but also the unique molecular structure of the base material.

Design Considerations

Your choice of surface texture affects the cost of your parts, the time it takes to make them, how durable they are and their fitness for their intended purpose.

Generally speaking, more refined textures take longer to make and will cost more. Some can be designed into an injection mold tool and so thousands of exact copies can be made, but that tool must also be carefully made in advance.

It is always best to explain your intended use for the finished part and the environment in which it will be used. Then your manufacturing partner can work with you to optimize the solution that fits your schedule, budget and application.

Thank You

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