Motic®

MORE THAN MICROSCOPY

Additive Manufacturing (3D Printing) Inspection Applications and Light Microscopy Techniques

Introduction

The Additive Manufacturing (AM) industry has been exploding over the last several years with new materials and processes to produce more complex and reliable parts for critical applications. Due to this rapidly growing field with new developments and needs, it becomes extremely important to be able to understand the materials characteristics along with the process variations which can impact the final product.

From incoming inspection of raw materials to final inspection of the product, there are several points along the way for Light Microscopy to be a valuable tool in understanding how the process is working. Additionally, Light Microscopy is also extremely useful in the development of new processes or in failure analysis investigation.

We will look at several applications in Light Microscopy for use in Powder Bed Fusion which is one process widely used in metals. This method provides some challenges but also some distinct advantages. Motic Compound light microscopes and Stereo microscopes can provide the tools to improve the end AM product from start to finish.

Fundamentally, the AM process known as Powder Bed Fusion, discussed here, consists of several insertion points along the way from powder to the final product where microscopy can provide valuable insight.

Insertion Points

#1 Powder Material Analysis

For the metal powder bed fusion process, incoming powders of various metals and exotic alloys need to be inspected for size, shape, density and defects. Size distribution(s) needs to be checked to ensure proper operation of equipment.

The shape is considered to be best when spherical which leads to maximum powder bed density and flowability. Bed density is how well the particles fit tightly together. If all powder particles are of the same size there will be gaps between them.

Oftentimes two or three-size particles (bimodal or trimodal) are used to fill gaps when melting, to create flows to fill the smallest gaps for fully dense material.

- Light microscopy can provide powder size distribution and shape (sphericity / roundness) through use of image analysis. This is usually for powder sizes =/> 5micron (ISO/ASTM 52907) in brightfield transmitted light. Transmitted light is blocked by the particles and produces a shadow like image of high contrast for analysis. See below.

- Brightfield reflected light allows observation of powder particle's surfaces for inspection of powder defects such as surface voids, contaminants, etc.

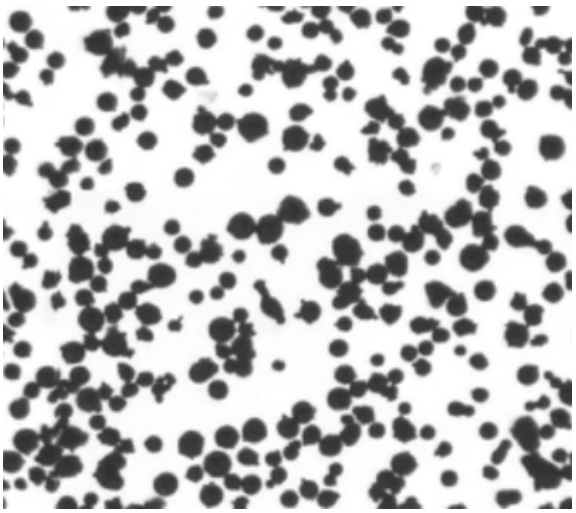


*Fig.1 Metallic powder imaged in **Brightfield transmitted** light microscopy*

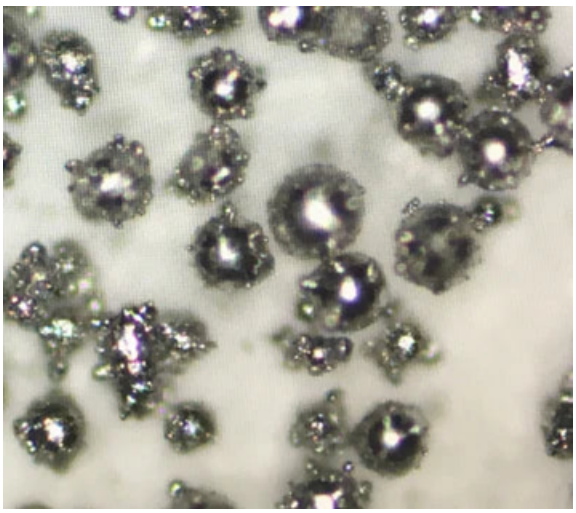


*Fig.2 Metallic powder imaged in **Brightfield reflected** light microscopy*

Insertion Points

#2 Process Analysis

Additive Manufacturing for metals is amazingly performing real-time metallurgy. Layer by layer is melted and solidified, something not seen in any other type of traditional machining.

Each part really is a one-of-a-kind outcome where problems can arise. To produce highly critical parts, one has to spend large amounts of time and money to insure proper and consistent processes for their product.

Even more complex metallurgy is available where the metal characteristics can be designed to function differently in different areas of the same part.

To ensure high levels of dependable parts production, a number of inspection methods are required, some of which may include destructive testing of a part per each build.

- Metallographic microscope techniques can be used to view and size grain structures and layering effects of cross sectioned polished parts using **reflected Brightfield** or **Crossed Polarized light**.
- Voids can be viewed and analyzed. Shapes or the voids/pores can tell the story of what process problems are causing them – examples are unmelted powder, oxides and moisture as examples.
- Contaminants can get into the process and cause a variety of problems. Understanding and tracing these unwanted particles to the source is of high importance, and light microscopy is used to visualize and aid identification.
- Delamination (layer separation), fatigue cracks and micro cracks can be seen in the reflected light microscopy of polished cross sections and can point to process issues and their solutions.

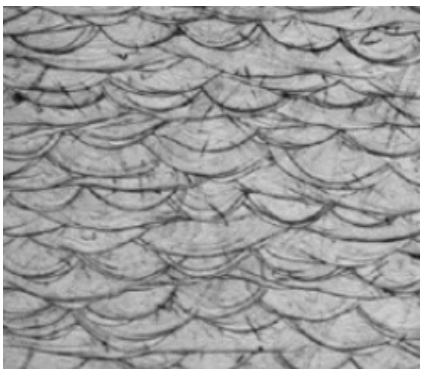


Fig.3 Brightfield reflected light image of longitudinal cross section laser tracks

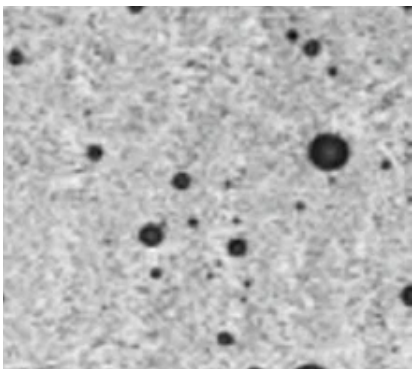


Fig.4 SLM (Selective Laser Melting) spherical voids in aluminum alloy caused by moisture.

*Fig.5 Contaminant (magenta color) in **reflected light polarization***

Insertion Points

#3 External Defect Analysis

Part during production, undergo a number of steps such as heat treatment, part removal, surface modification and cleaning which can cause defects.

- External critical areas can be inspected visually utilizing a stereomicroscope looking for damaged areas such as voids, pits, edge deformation for example.

#4 Surface Analysis

The surface of parts directly after production often have to some degree of surface roughness.
This may require further processes such as sand blasting, shot peening, electropolishing or a vibratory technique to produce a surface finish required for proper functionality.

- Using stereomicroscopy with various types of illumination we can visualize the effects of the surface finish method and also gauge how it compares to a known good surface. In addition, it can be used also to check for and damage that this surface finishing technique may be causing as an unwanted by product.

There are many other Additive Manufacturing methods and materials too numerous to mention. But they all have a common need for analysis and inspection by utilizing Light Microscopy.

SM7 Series

The First Motic Stereo Plan-Apochromat: Enjoy and Be Surprised.

Power in any Aspect

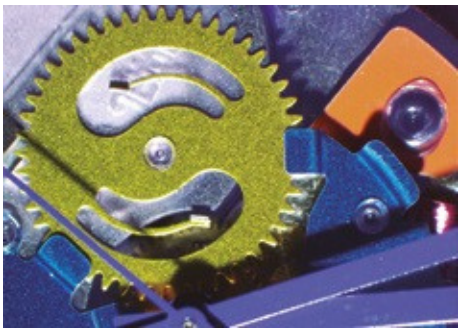
The SM7 features an optical performance with true colour reproduction, high resolution and low distortion. A stand with Incident/Transmitted LED light supplies variable illumination.

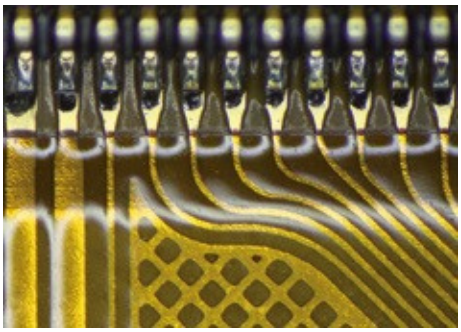
Stand Design

Ultra-flat stand bases for a relaxed positioning of hands and forearms facilitate lengthy preparation work. Pick your C. Elegans nema- todes from the petri dish, mount your gearwheel into the clockwork. The advanced ergonomic design maximizes efficient usage and minimizes fatigue.

Flexibility for Individual Demands

A variety of objectives and eyepieces allow tailoring a personal SM7. Upgrade your workplace with ergonomic stands and powerful optics, whether Apochromatic colour fidelity is in focus or improved resolution power.





SM7 Series

Motic SM7: High-Precision Galilean Optics

Galilean Optical System

The Galilean Optics of the SM7 show a 7:1 Zoom system, resulting in a standard magnification range of 8X-56X. A 10-Position Click-Stop helps to set precise magnifications in case repeatable measurements are required. The standard optical setup can be varied by exchanging objectives and/or eyepieces.

Superior Optics

For the best possible image results, a 1X Plan-Apochromatic objective with a Working Distance of 81mm is available. True-colour reproduction combined with improved Field Flatness and minimized image defects: both the world of living beings and technical samples are covered by our SM7 stereomicroscope.

Resolution Power for Tiny Details

Besides minimized chromatic and spherical aberrations, it is the resolution of the 1X Apochromatic objective which makes the SM7 especially interesting for technical applications. 36% more resolution power, an increase worth mentioning.

SM7 Series

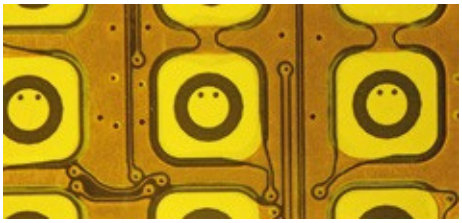
Powerful vizualisation for both eyes and camera

Eyepieces

The High eyepoint eyepieces 10X/22 suit spectacle wearers and offer a diopter adjustment range within +5/-8 dpt. Easy use of reticles is Motic's top model standard.

Observation Tubes

Our Trinocular head is supplied with a 100:0/20:80 2-position beam split, providing sufficient light to the camera port even under lowlight conditions. C-Mount cameras are adapted to the respective camera sensors. Besides the standard Binocular tube, a 60° inclination tube is available to meet special OEM demands.



SM7 Series

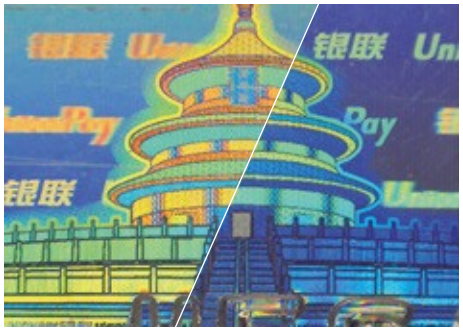
Illumination is the Second Key for the Safe of Information

Illumination

For years LEDs are replacing Halogen light sources in business and private life. A low energy consumption, a long lifetime and, especially for living samples, a low heat production are the main arguments.

Transmitted / Incident Light Stands

The SM7 Stand for transparent and opaque specimen incorporates 3W LEDs for both types of illumination, with separate controls for mixed samples. An optional 4-segment ring illuminator is meant for the standard stand. Herewith surface topographies can be visualized by activating different illumination angles. The SM7 features signifi- cantly flat stand bases for ergonomic positioning of hands and forearms. Long preparation work can be done without early fatigue. For ESD sensible work, Motic's ESD and surge protection system complies with both UL and CL standards and regulations. An essential feature for electronic and electric quality control environments.



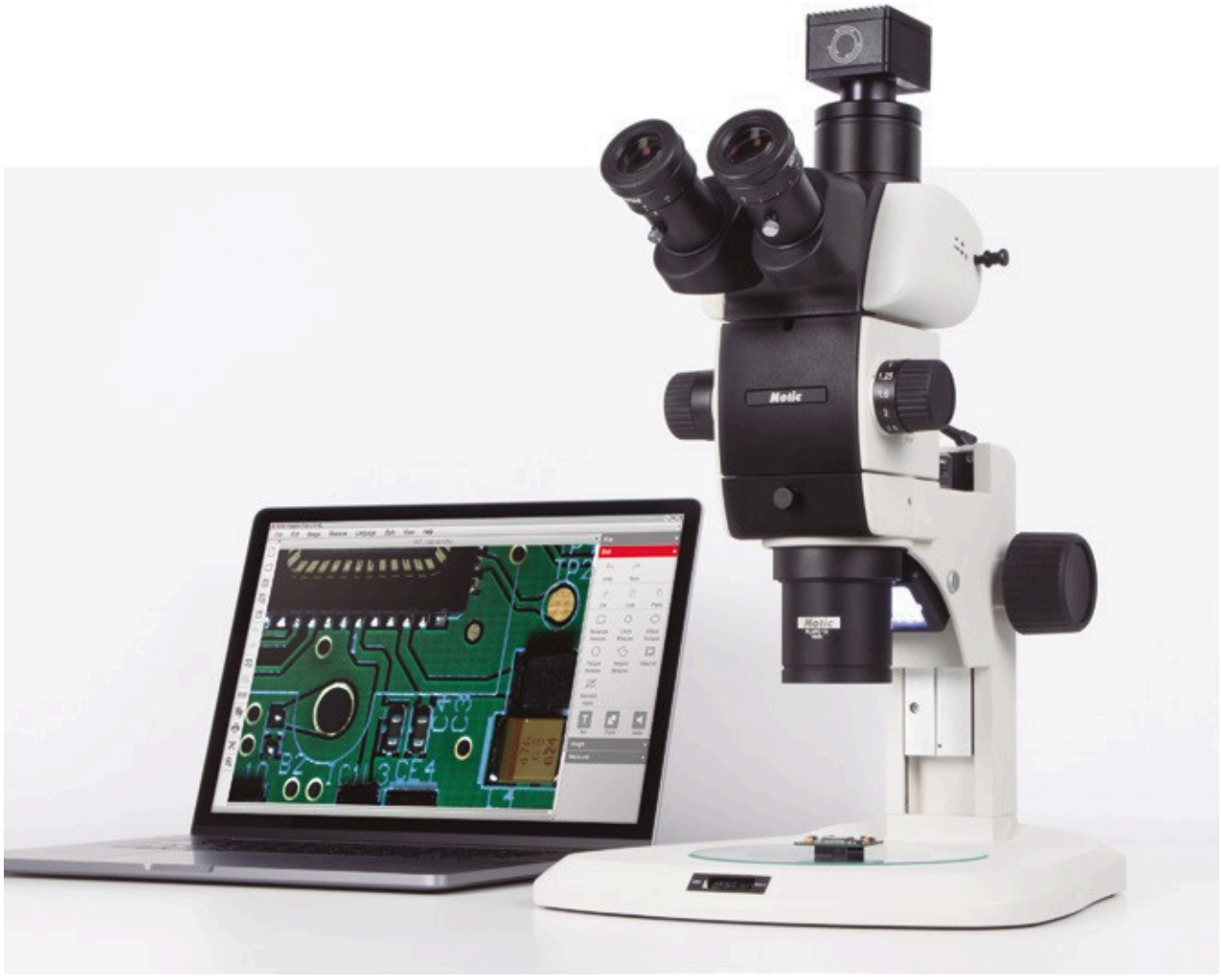
Moticam S-Line

Scientific-Grade Microscope Cameras

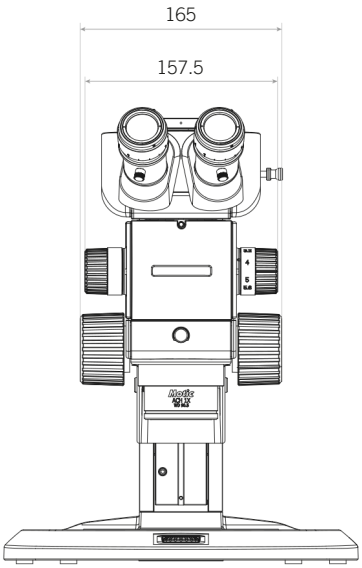
The new Moticam S-line marks a further step in Motic's digital microscopy. By utilizing the latest sCMOS sensors coupled with our own PCB design and on-board image management, each Moticam S series promises professional digital results at an affordable price. This MoticamS-line is designed and manufactured completely in-house under strict German quality guidelines. Whether for Clinical, Research or Industrial, this new generation of Moticams has got the answer for every demand. At Motic, we believe in making High-level Digital Microscopy affordable for everyone. You surely will enjoy this camera line.

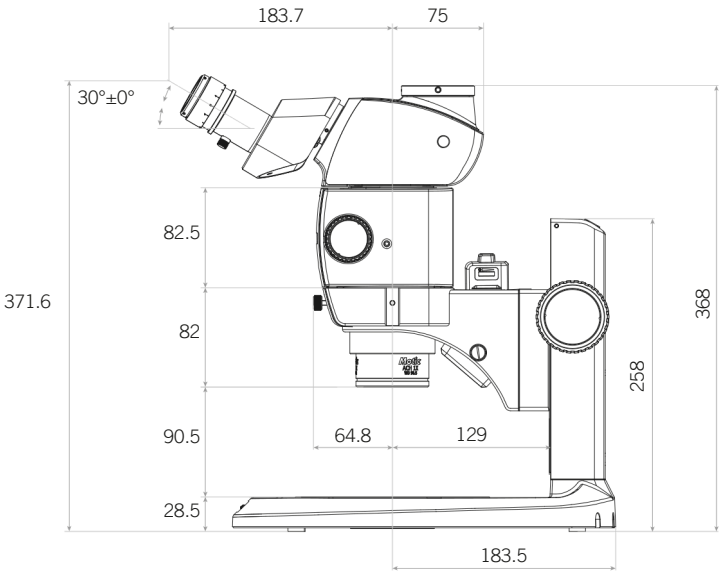
Key features

- FPS — Super-Fast Frame Rates
- USB3.1 — USB 3.1 Data Transfer
- True color reproduction
- sCMOS Sensor
- 20 MP — Up to 20MP Resolution
- Rolling and Global shutter models

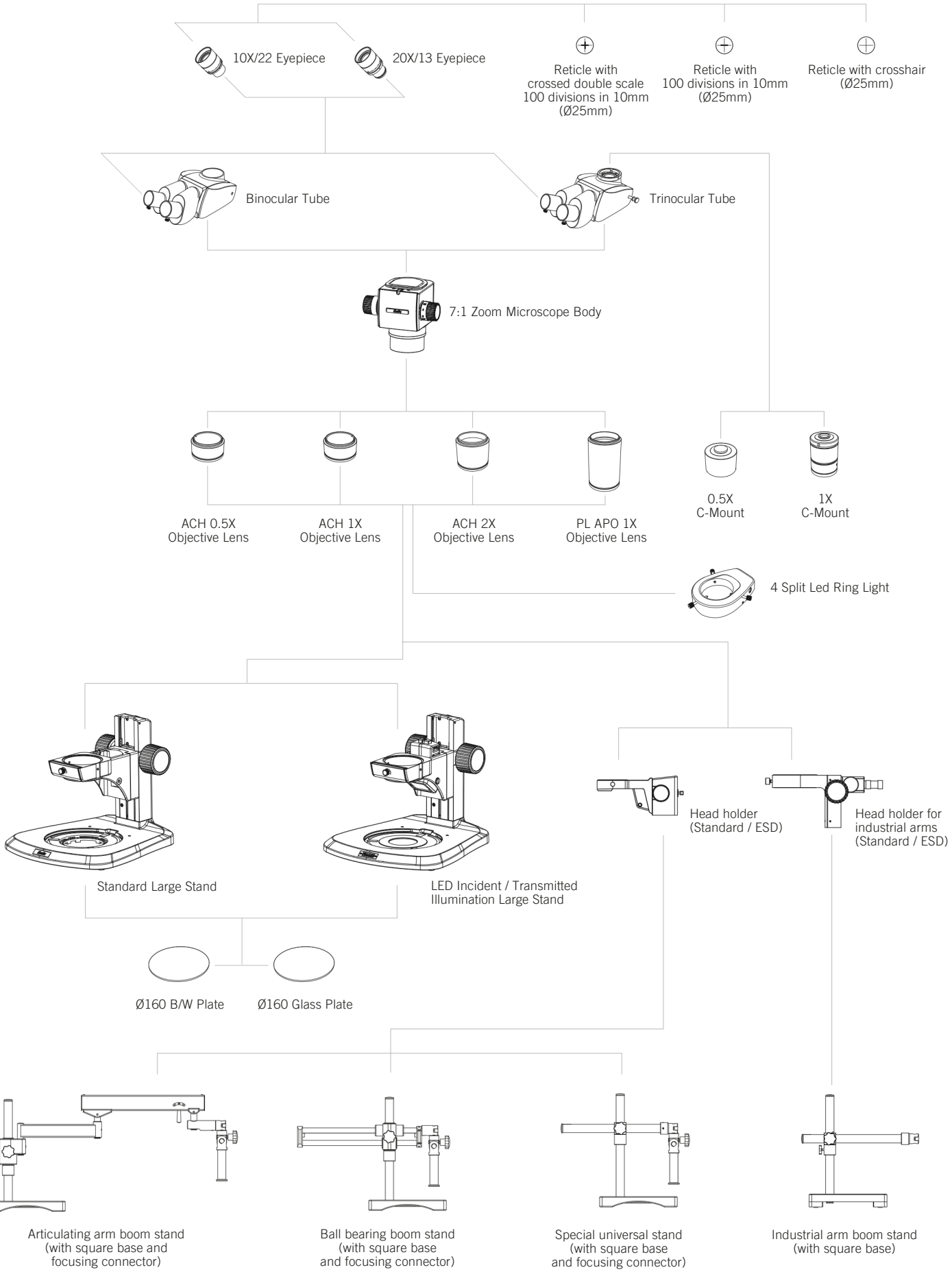


SM7 Series Dimensions





SM7 Series System Overview



SM7 Series Technical Specifications




●	Sku	1100201800061	1100201800021	1100201800071	1100201800031
●	Name	**SM7-P A1X**	**SM7TR-P A1X**	**SM7-P APO1X**	**SM7TR-P APO1X**
	Optical system	Galilean infinity optical design. Common Main Objective (CMO)			
●	Observation tube	Binocular head	Trinocular head	Binocular head	Trinocular head
	Inclination	30º inclined			
	Trinocular light split	-	100:0/20:80	-	100:0/20:80
	Interpupillary distance	55-75mm			
	Diopter adjustment	On both eyepieces, +5/-8 diopter			
	Eyepieces	Widefield WF10X/22mm with diopter adjustment			
	Objectives system	Zoom, ratio 7:1			
●	Objectives classification	Plan Achromat		Plan Apochromat	
	Objectives	0.8X~5.6X (10-step)			
●	Working distance	90mm		81mm	
	Stand type	Fixed-arm stand			
	Head holder	For Ø76mm head			
	Focus mechanism	Coarse focusing system with tension adjustment			
	Focusing stroke	120mm			
●	Incident illumination	-			
●	Transmitted illumination	-			
●	Transformer	-			
●	Power supply	-			
	Accessories included	Dust cover, Black/White plate Ø160mm			
	Dimensions LxWxH	367x290x372mm			
	Base	310x290mm			
	Column/Arm	254mm			
	Net weight	6.9 Kg	7 Kg	7 Kg	7.1 Kg
	CONTRAST TECHNIQUES				
	Brightfield	Brightfield			




1100201800081	1100201800041	1100201800091	1100201800051	Sku
SM7-TLED A1X	**SM7TR-TLED A1X**	**SM7-TLED APO1X**	**SM7TR-TLED APO1X**	Name
Galilean infinity optical design. Common Main Objective (CMO)				Optical system
Binocular head	Trinocular head	Binocular head	Trinocular head	Observation tube
30º inclined				Inclination
-	100:0/20:80	-	100:0/20:80	Trinocular light split
55-75mm				Interpupillary distance
On both eyepieces, +5/-8 diopter				Diopter adjustment
Widefield WF10X/22mm with diopter adjustment				Eyepieces
Zoom, ratio 7:1				Objectives system
Plan Achromat		Plan Apochromat		Objectives classification
0.8X~5.6X (10-step)				Objectives
90mm		81mm		Working distance
Fixed-arm stand with incident & transmitted illumination				Stand type
For Ø76mm head				Head holder
Coarse focusing system with tension adjustment				Focus mechanism
120mm				Focusing stroke
LED 3W with intensity control				Incident illumination
LED 3W with reflector and intensity control				Transmitted illumination
External				Transformer
110-240V (CE)				Power supply
Dust cover, Glass plate Ø160mm				Accessories included
367x290x372mm				Dimensions LxWxH
310x290mm				Base
254mm				Column/Arm
7.3 Kg	7.4 Kg	7.4 Kg	7.5 Kg	Net weight
				CONTRAST TECHNIQUES
Brightfield				Brightfield

Motic®

Canada | China | Germany | Spain | USA

See the SM7 in action

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B.C., V6V 2K9, Canada

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