

Sysmex



**SYSMEX FPIA-2100 —  
BRINGING SHAPE TO THE WORLD OF PARTICLE  
CHARACTERIZATION**

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**MALVERN**  
I N S T R U M E N T S

## Particle shape? Particle size?...Perfectly simple!

Particle shape has long been recognised as an important variable that can influence the efficiency of a wide range of processes such as particle flow, active area, grinding efficiency. While it is known that particle geometry, as well as size distribution, affects the characteristics and behaviour of particulate materials, this parameter has always been difficult to characterize in a simple way.

Nevertheless, shape is becoming increasingly important when describing the properties of a particle. In the toner, pharmaceutical and powder coating industries for example, quantifying particle shape as well as size is already highly desirable. Areas such as ceramics, the manufacture of graphite and carbon for lithium batteries, metal powders, silica production, aggregate screening and polishing materials are assessing the impact of particle shape on product quality, but are hampered by the lack of a universal shape analysis technique.

Traditionally, particle shape measurements have involved onerous and subjective methods of analysis, requiring laborious sample preparation and manual microscopy. In order for particle shape measurement to become a reliable, repeatable and routine operation, there had to be a significant improvement in the methodologies available. The FPIA-2100, or Flow Particle Image Analyzer, delivers such an improvement, using imaging techniques, offering simultaneous and automated analysis of particle size, shape and count.

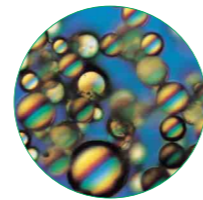
Comprehensive particle characterization data are generated in a very short period of time, typically less than 5 minutes and with minimal sample preparation. Extensive information about particle shape is acquired from a large number of particles and displays of size and shape distributions are supported by images of the particles to provide further visual understanding of the measurement data.



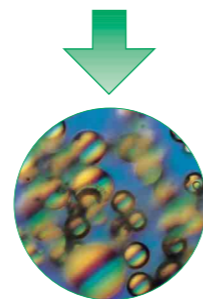
## The Challenge

### Current limitations

Microscopy has a limited depth of field hence either the large or small particles are in focus. This provides problems with data interpretation.



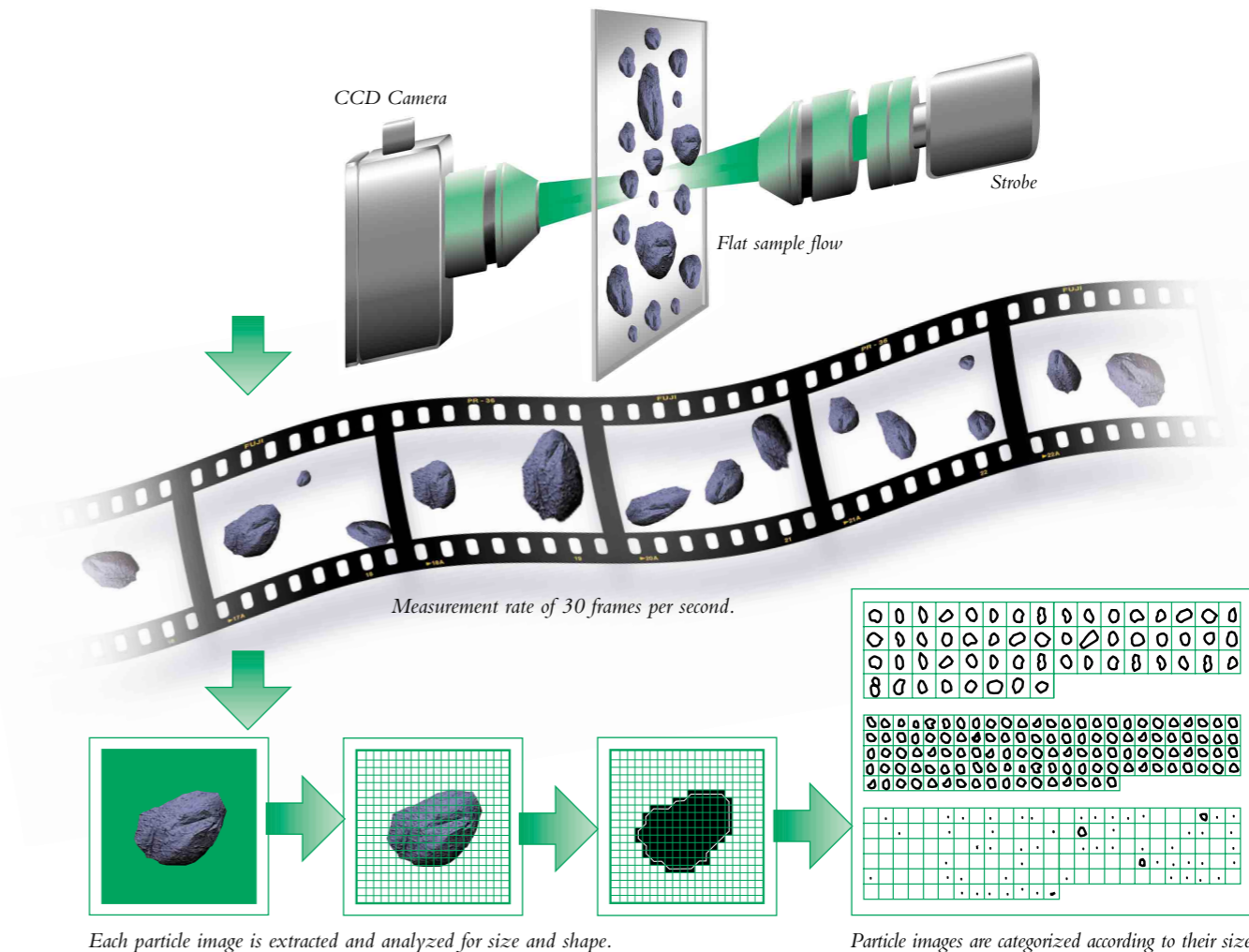
Large particles in Focus.



Small particles in Focus.

### The solution

The technique used by the FPIA-2100 ensures both large and small particles are in focus.



Each particle image is extracted and analyzed for size and shape.

Particle images are categorized according to their size.

### Principles of Operation

A sample is taken from a dilute suspension of particles. It is held in an agitated chamber to ensure it is maintained in suspension. This suspension is then passed through the cell, images of the particles are captured, using stroboscopic illumination and a CCD camera.

The system incorporates a patented high-speed image processor. Through a series of sophisticated digital imaging stages each particle is extracted and quantified.

A number of these images are saved, and classified according to their size, for reference.

### Flat Particle Flow

The Sheath flow cell is the heart of the FPIA-2100. Its design and technology are pivotal to the unique imaging capabilities of the instrument. Its purpose is to optimise the sample flow to produce an ideal

particle presentation for imaging. The sample is introduced in the Sheath flow cell through a jet nozzle. This sample flow is 'sandwiched' by the sheath liquid. This transforms the particle suspension into a flat flow by hydrodynamic effects.

This ensures that the largest area of the particle is presented to the CCD camera for image analysis.

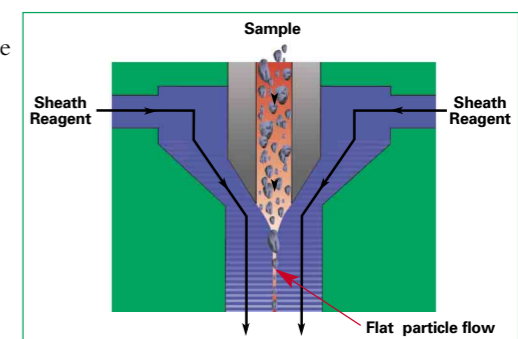
### Successful Image Analysis Every Time

Flat particle flow ensures that all particles in a sample lie in the same focusing plane. Consequently, image capture is always successful and every particle is clearly defined.

In addition, a large number of images can be acquired. For example, if there are seven particles

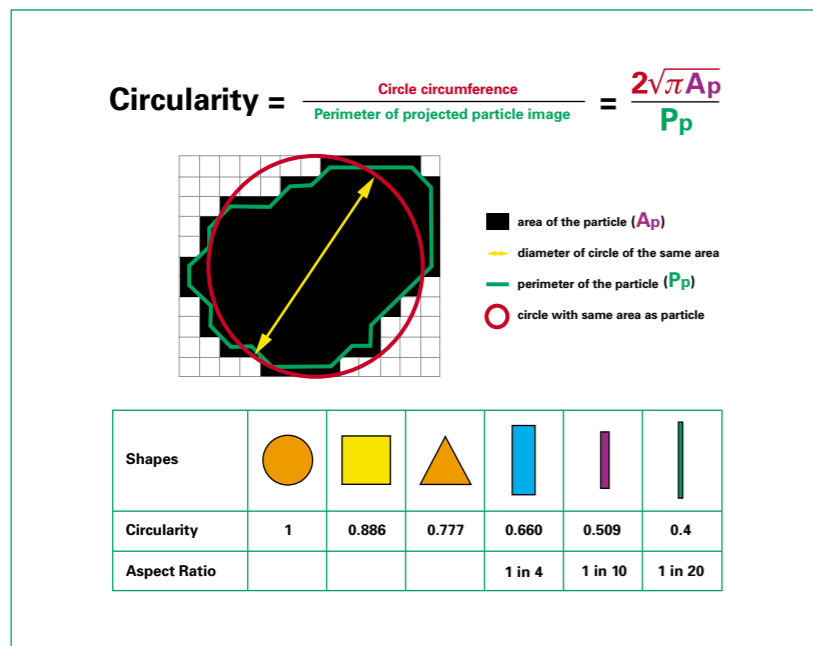
per image, a total of 25,000 particles are captured and analyzed, producing data with a high level of statistical validity.

All measurement and rinsing sequences are fully automated, making the process both simple and free from operator variability.



The Sheath Flow Cell.

## Comprehensive Data for Informed Decision Making



Quantifying particle shape—the calculation of Circularity.

### Shape Characterization

The primary shape index used in the FPIA-2100 is the Circularity. This is defined as the ratio between the circumference of a circle of equivalent area to the particle and the perimeter of the particle.

It is a simple and highly effective concept. The more spherical the particle, the closer its circularity is to 1. The more elongated the particle, the lower its circularity.

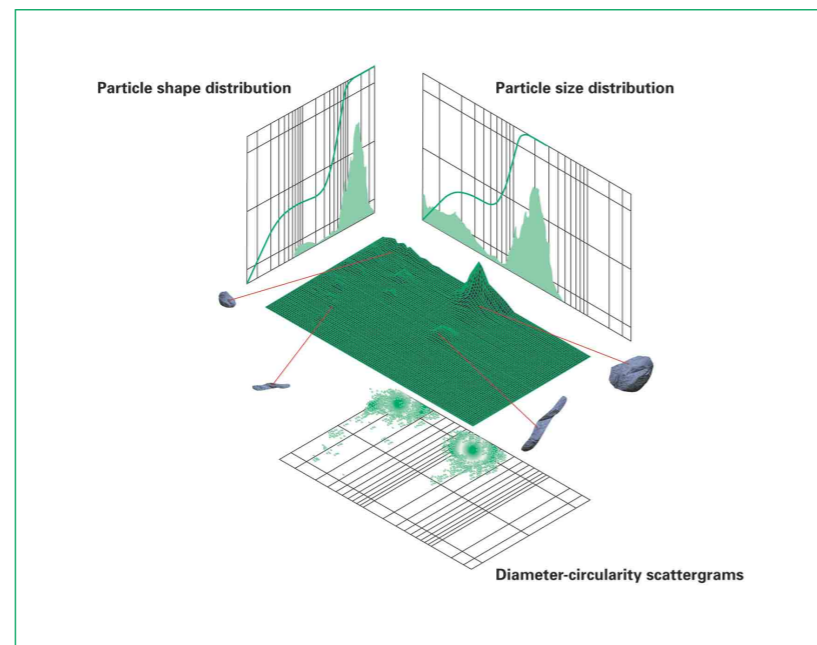
### Data Display

The complete set of data is summarised in two graphs, a particle size distribution and a circularity distribution, and a diameter-circularity scattergram. The 3D diagram illustrates how the link between size and shape is represented for easy data interpretation.

Also displayed as standard are particle counts (total and per size class) and user defined percentiles (for size and shape).

### Seeing is Believing

The ability to view the particle images means that all data can be visually verified. These images help to illustrate the derived graphs when sample preparation may be affecting the analysis.



3D representation linking size and shape data.

## Simple Intuitive Software

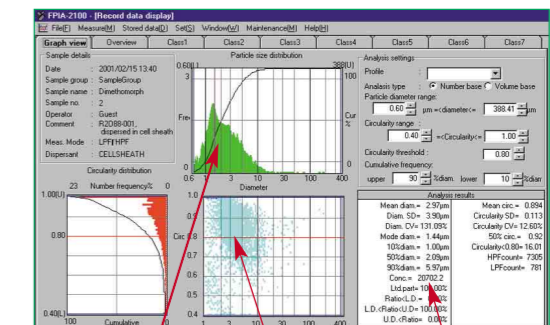
The FPIA-2100 software is simple and intuitive. All imaging parameters are factory set, hence no image analysis expertise is required to run any aspects of the software. The operator only needs to choose from a pre-set range of measurement conditions before starting the analysis. All results are then just a mouse-click away.

Multi-tasking ensures that even whilst a measurement is being made, the user can freely look at any data from previous measurements, print or reprocess data.

### Database view

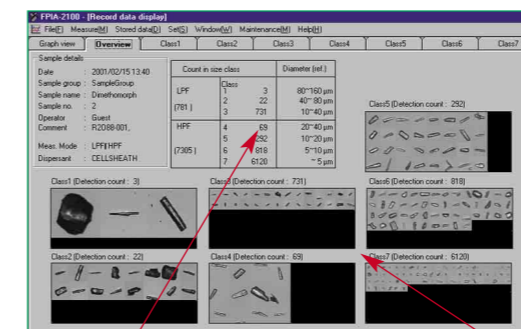
Measured samples are listed with comments and the measurement parameters. Selecting a record allows you to view full details of the analysis.

### Sample result: graphical overview



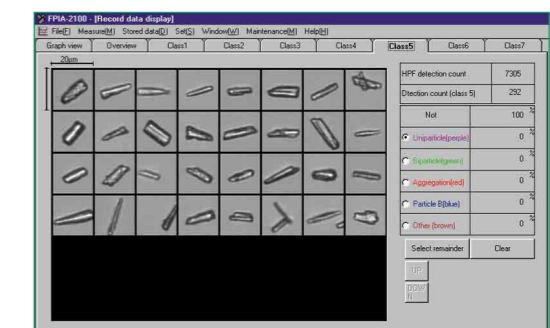
Particle Size Distribution.  
Diameter-Circularity Scattergram.  
Analysis Summary.

### Sample result: image overview



The total particle count is displayed for each size class.  
Images of the particles are grouped and displayed according to their size.

### Sample result: detailed image view



Each particle class can be viewed separately. There is a zoom feature and particles may be classified into five categories.

## Benefiting from Automated Shape Analysis

### Shape matters

Many properties of particulate materials are affected by their shape as well as their size.

#### ■ Flowability (Toners, Silica)

The rheology of a liquid or solid powder flow is directly affected by the shape of the particles within it, as well as by their size. Measuring and understanding the shape allows control of the flow properties.



#### ■ Compacting (Alumina, Silica)

Shape is one of the factors that determine the ability of a material to compact. Optimizing the strength of the resulting brick, for example, or the amount of material that can occupy a given volume is made possible by controlling particle shape, and size.



#### ■ Polishing and abrasive materials

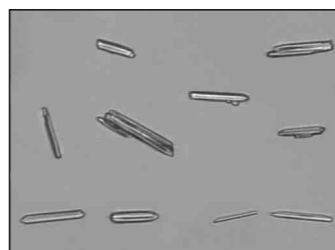
Characterization of particle size and shape of polishing or grinding materials offers improved quality control of particles used for polishing/cutting. A spherical particle will probably be less abrasive!



### Reproducible Analysis

#### ■ Needles

The problem of measuring irregular shapes is solved due to the design of the flow cell, which ensures consistent particle orientation so that image analysis is reliable, reproducible and representative of the whole sample.



Conventional analysis of needle shaped particles produces a wide variety of size and shape distributions. In a QC environment this is unacceptable. The FPIA-2100's unique flat sheath flow technology ensures the largest projected area of all particles are presented to the camera every time so that the result is reproducible and accurate.



#### ■ Aggregation

Aggregates show up clearly in the particle images and have a different circularity compared with that of the individual particles on the FPIA-2100, providing valuable information about the particulate state of any material.

### Typical applications

#### ■ Glass beads

With applications from reflective coatings to pharmaceuticals, glass beads are widely used. Quality control of the final product requires confirmation of the circularity of the material.

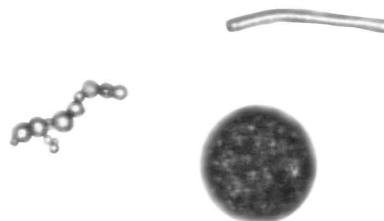
#### ■ Toners

Toner manufacturers have found that the size and shape of the toner particles influences the performance of the toner. In addition to there being an optimum size, an optimum shape influences the flow properties and charging capability. Toner manufacturers aim to produce toner particles that are as close to spheres as possible i.e. with circularity close to 1.0. Toners with a low circularity (~ 0.8) will result in poor flow properties and a wide variation in electrostatic charging from particle to particle this is seen as trailing phenomena in the resulting fixed image.



#### ■ Abrasive/cutting powders

Silicon Carbide powders are widely used to slice/cut silicon wafers in the semiconductor industry. Suppliers and users of these powders had noticed different cutting performance of powders with the same size distribution, one powder allowed faster, coarser cutting but with more surface scratching whilst another material caused slower, thinner cuts with less scratching. By using a combination of both size and shape information both supplier and consumer can optimize their process.



## SYSMEX FPIA-2100 TECHNICAL SPECIFICATIONS

Technical Specifications			
Measurement Technique	Automated Image Analysis—Flow Cytometry		
Patents Granted	US Patent No 5,721,433		
Light Source	White Light Stroboscope (30Hz)		
Detector	CCD Camera		
Measuring Mode	High Power Field (*20)	Low Power Field (*5)	High & Low Power Field
Particle Size Range	0.7* – 40µm	4.0 – 160µm	0.7 – 160µm
No of Size Classes	3	4	7
Max No of Images Stored	323	247	215
Measurement Time	4 mins	4 mins	5 mins
Sample Volume Required	5ml approx.	5ml approx.	5ml approx.
Measurement Volume	0.35µl	5.50µl	2.05µl
Particle Concentration	1000 – 50000 / µl	1000 – 3000 / µl	1000 – 10000 / µl
Sheath Reagents	Particle Sheath Reagent—aqueous based Methanol, ethanol, isopropyl alcohol and ethylene glycol solution (25%)		
Reagent Consumption	Approximately 100ml per sample		
Requirements			
Minimum Computer Requirements	Software operates on IBM compatible PC running Windows 2000 operating system. Minimum Hardware: Pentium 400MHz, 128Mb RAM, 5Gb hard disc, SVGA monitor, RS232, Video for CRT.		
Operating Environment	Temperature 15 – 30°C, Humidity 35 – 80%		
Power Requirements	100V to 240V with Standard IEC inlet socket		
Dimensions			
Main unit	811(w) x 599(h) x 490(d) weight 61.5kg		
Pneumatic unit	195(w) x 333(h) x 395(d) weight 15.5kg		

\* Detection Limit.

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## Malvern service and support

Malvern Instruments seeks innovation, not simply in product design and development, but in every area of business. We have invested to achieve ISO9001 with Tick It accreditation and we accept nothing short of excellence.

### Applications Expertise

Malvern Instruments trained specialists are available in more than 50 countries to assist with applications development and to advise on and analyze difficult samples. We have our own laboratory facilities and extensive applications expertise derived from our work and that of our users. Malvern Applications Laboratories in Europe, North and South America and Asia routinely run thousands of samples every year.

### Service Support

Comprehensive service support is provided across the entire range of Malvern Instruments products, in all areas. Telephone support is always available from the Malvern Help Desk and a variety of service packages can be tailored to meet the specific needs of individual customers. The development of after-sales remote diagnostics means that in many cases Malvern service specialists can access and control systems via standard telephone lines in order to minimize downtime and reduce costs.

## The Malvern Instruments Range

### Strategic Alliance

In 1998 Malvern Instruments Ltd and the Sysmex Corporation of Japan formed a strategic alliance that encompasses distribution agreements and allows for collaborations and co-operation in the field of particle characterization. Sysmex is the exclusive distributor in Japan for Malvern's laboratory based particle size analyzers and Malvern Instruments has exclusive distribution rights in North America, Europe and the Middle East for particle size analyzers from Sysmex' Scientific Instruments Division.

### Full Range

The FPIA-2100 forms part of Malvern Instruments' extensive range of particle characterization systems, which offers particle characterisation instruments for both use in the laboratory and on the process line. The range includes the Mastersizer for particle size analysis; Zetasizer instruments for dispersion stability applications; the HPPS for the size analysis of dispersions of microns sized particles and solutions of subnanometer molecules; the Ultrasizer for particle size measurement in concentrated systems; Spraytec for particle size measurement of aerosols and sprays; the PharmaVision 830 for size and shape measurements and Insitac for on-line particle size analysis.