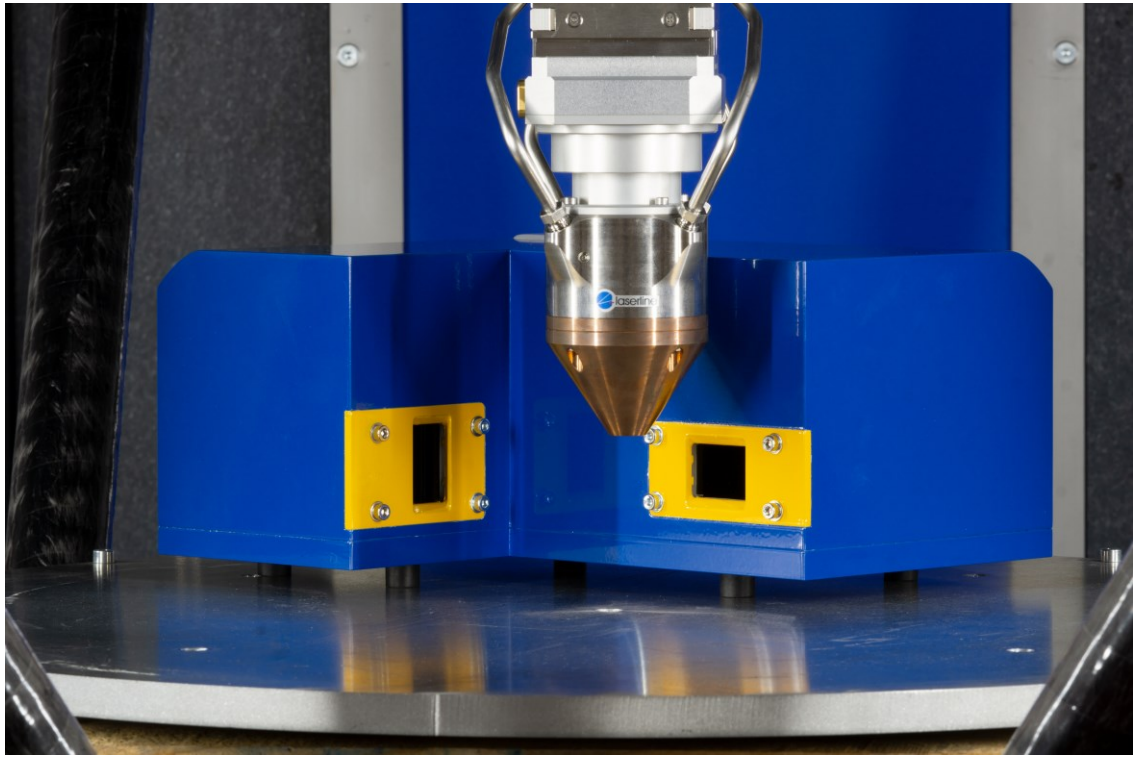
Reliable and efficient measurement of DED powder caustics

Why does PowderSpy exist?

Where we started: Non-reproduceable manufacturing results and endless (unproductive) hours of troubleshooting

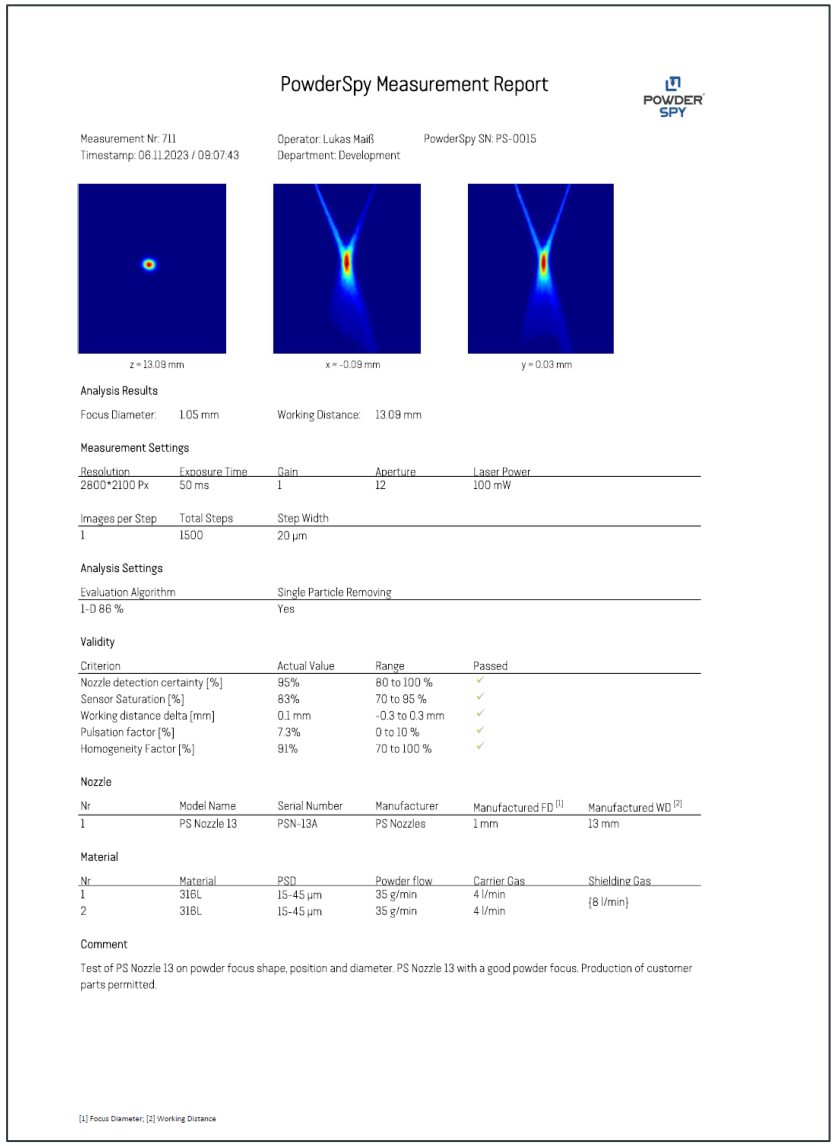
What we have done: Development of a sensor to ensure industry-grade DED manufacturing processes



What can you expect from PowderSpy?

Powerful tool for pre-process DED quality assurance and research purposes:

- Industry-grade housing and interfaces
- Standalone system with no need for machine integration
- Browser-based user interface running on embedded system
- Measurement report for nozzle condition
- Customizable evaluation algorithms
- Remote maintenance



PowderSpy Measurement Report

Measurement Nr: 711
Timestamp: 06.11.2023 / 09:07:43
Operator: Lukas Maiß
Department: Development
PowderSpy SN: PS-0015

z = 13.09 mm | x = -0.09 mm | y = 0.03 mm

Analysis Results

Focus Diameter: 1.05 mm
Working Distance: 13.09 mm

Measurement Settings

Resolution	Exposure Time	Gain	Aperture	Laser Power
2800*2100 Px	50 ms	1	12	100 mW

Images per Step	Total Steps	Step Width
1	1500	20 µm

Analysis Settings

Evaluation Algorithm	Single Particle Removing
1-0.86 %	Yes

Validity

Criterion	Actual Value	Range	Passed
Nozzle detection certainty [%]	95%	80 to 100 %	✓
Sensor Saturation [%]	83%	70 to 95 %	✓
Working distance delta [mm]	0.1 mm	-0.3 to 0.3 mm	✓
Pulsation factor [%]	7.3%	0 to 10 %	✓
Homogeneity Factor [%]	91%	70 to 100 %	✓

Nozzle

Nr	Model Name	Serial Number	Manufacturer	Manufactured FD [1]	Manufactured WD [2]
1	PS Nozzle 13	PSN-13A	PS Nozzles	1 mm	13 mm

Material

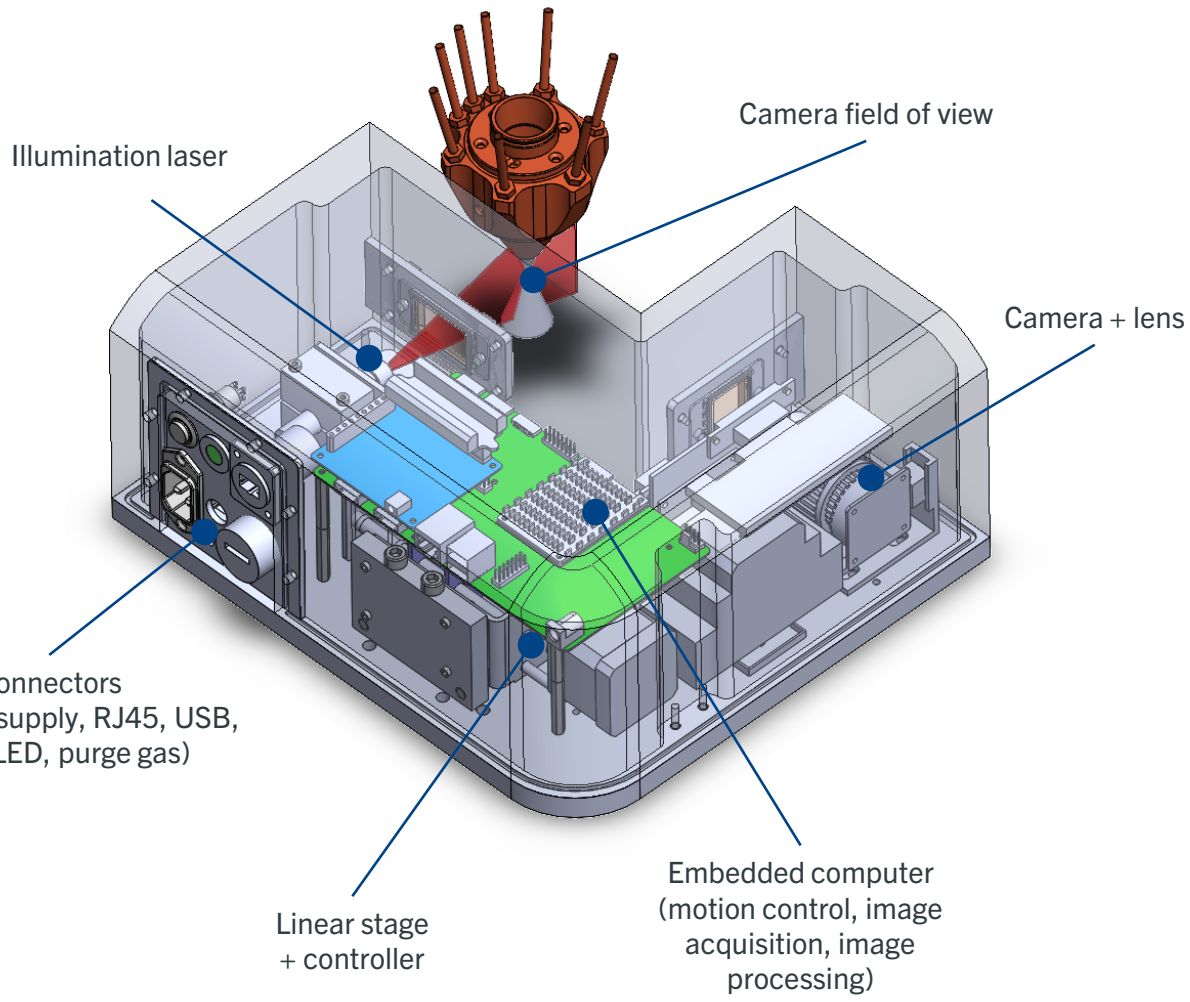
Nr	Material	PSD	Powder flow	Carrier Gas	Shielding Gas
1	316L	15-45 µm	35 g/min	4 l/min	{8 l/min}
2	316L	15-45 µm	35 g/min	4 l/min	

Comment

Test of PS Nozzle 13 on powder focus shape, position and diameter. PS Nozzle 13 with a good powder focus. Production of customer parts permitted.

[1] Focus Diameter; [2] Working Distance

Schematic and Specifications



Measurement values:

- Powder focus diameter
- Powder focus position (x, y and z)
- Particle distribution along X, Y and Z planes
- Powder mass flow stability
- Raw images and intensity information can be exported for further individual analysis
- Export of measurement report

Hardware specs:

- Spatial resolution at focus: up to 20 µm (x, y and z direction)
- Max. measurement frame: 30 x 30 x 50 mm
- 12 MP camera with 16 mm wide angle lens
- Status LED for indication of operating state
- Compact, fully-integrated housing
- Linear stage for fully automated measurement
- Purge gas connection to avoid powder contamination

Software specs:

- Intuitive browser-based UI for device control and data evaluation
- Parametric image processing algorithms
- Frequent OTA updates for latest firmware version
- Embedded architecture: Measurement, visualization and documentation runs on integrated hardware

Workflow

```
#classes related to the motor set-up
class DRV8825():
    def __init__(self, dir_pin, step_pin, enable_pin, mode_pins):
        self.dir_pin = dir_pin
        self.step_pin = step_pin
        self.enable_pin = enable_pin
        self.mode_pins = mode_pins

        GPIO.setmode(GPIO.BCM)
        GPIO.setwarnings(False)
        GPIO.setup(self.dir_pin, GPIO.OUT)
        GPIO.setup(self.step_pin, GPIO.OUT)
        GPIO.setup(self.enable_pin, GPIO.OUT)
        GPIO.setup(self.mode_pins, GPIO.OUT)

    def digital_write(self, pin, value):
        GPIO.output(pin, value)

    def Stop(self):
        self.digital_write(self.enable_pin, 0)

    def SetMicroStep(self, mode, stepformat):
        """
        (1) mode
            'hardward' :    Use the switch on the module to control the microstep
            'software' :    Use software to control microstep pin levels
                Need to put the All switch to 0
        (2) stepformat
            ('fullstep', 'halfstep', '1/4step', '1/8step', '1/16step', '1/32step')
        """
        microstep = {'fullstep': (0, 0, 0),
                     'halfstep': (1, 0, 0),
                     '1/4step': (0, 1, 0),
                     '1/8step': (1, 1, 0),
                     '1/16step': (0, 0, 1),
                     '1/32step': (1, 0, 1)}

        print ("Control mode:",mode)
        if (mode == ControlMode[1]):
            print ("set pins")
```

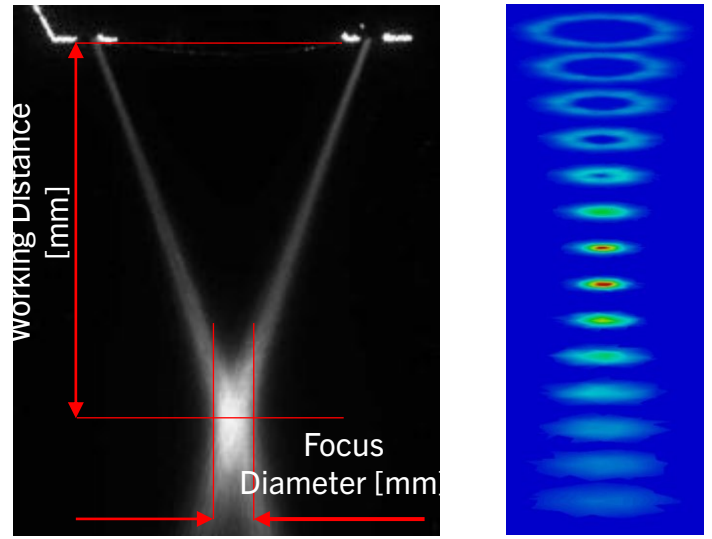


Image Stack Acquisition

- Industrial-grade hardware for image acquisition and illumination
- High dynamic range and resolution (20 µm line laser at 405 nm wavelength)
- Duration: 2 minutes for 30 mm stage movement

Image Processing

- Parametric code for image processing is running on embedded hardware
- Efficient algorithms, easy to modify according to individual requirements
- Multi-jet, ring-slit and rectangular nozzle types integrated

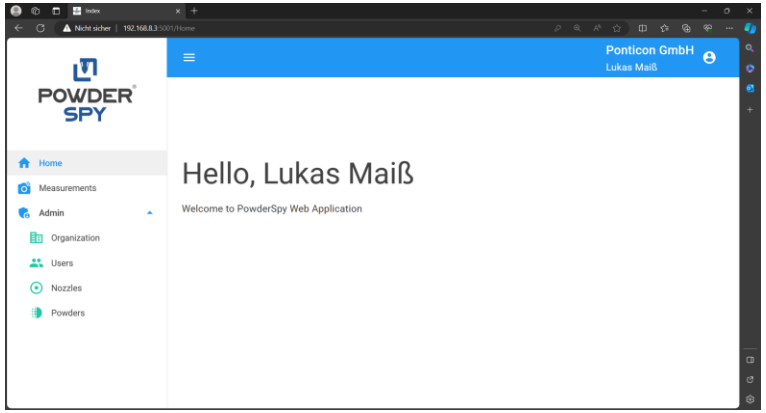
Results

- 3D-image of measured powder focus
- Automatic calculation of powder focus position (x, y, z) and working distance based on customizable rules
- Different visualization patterns (2D, 3D, stacked, interpolation, …)

Simple usage of PowderSpy

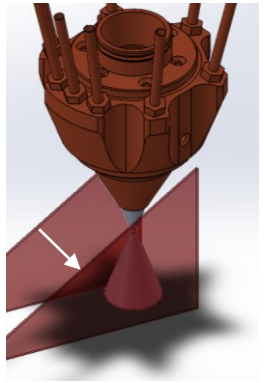
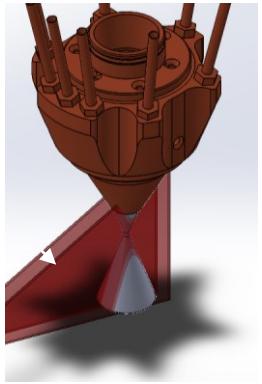
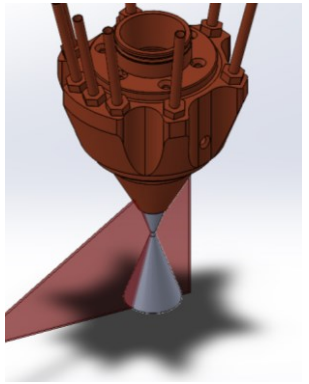
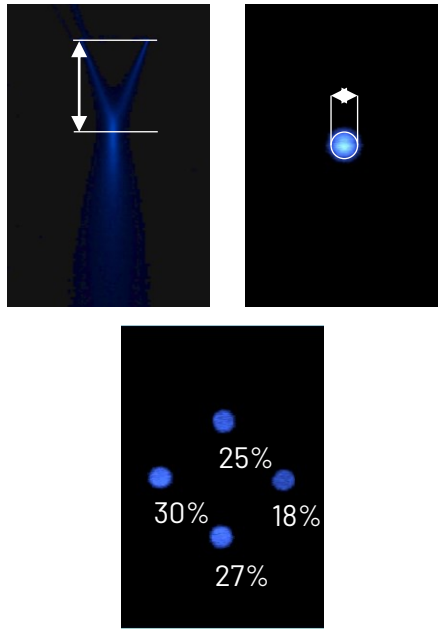
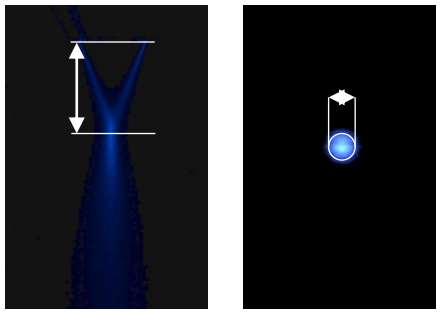
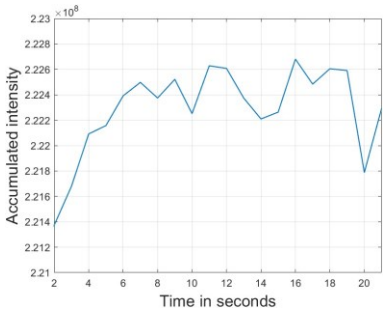
Easy nozzle positioning

Connectivity for remote maintenance

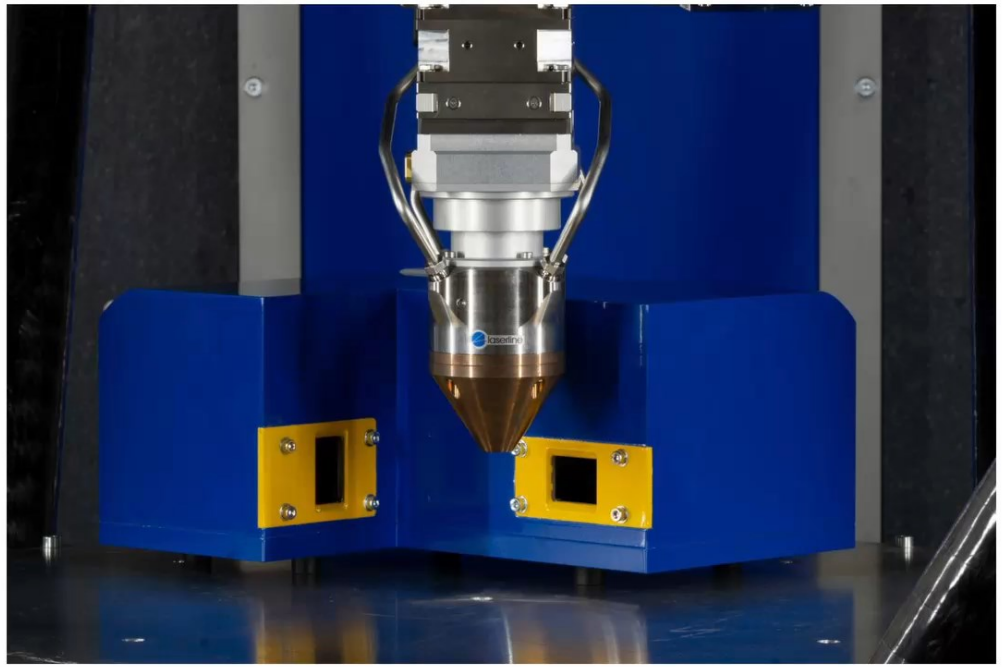


Browser-based user interface
(PC, Laptop, Tablet, Phone)

Measurement and Analysis

Measurement	 Full nozzle measurement	 Nozzle focus measurement	 Pulsation measurement
Analysis	Working distance, focus diameter, injector intensity distribution 	Working distance, focus diameter 	Pulsation 

Web Application



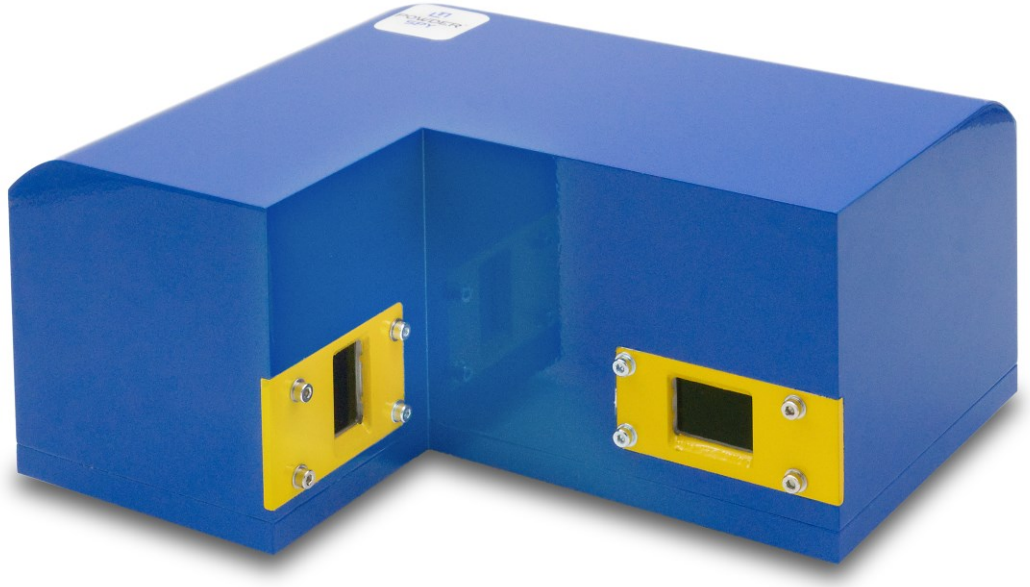
Measurement
Setup
Image Acquisition
Analysis

www.powderspy.de

[PowderSpy Web App demonstration video]

Sales, Commissioning and Service

- Standard system price: 23,800 €
- Delivery time: 3 months
- Direct software and hardware support
- Frequent OTA updates to the most recent software release (annual fee of 1,200 €)
- One-year warranty for all hardware components
- Support with installation and first measurements
- Customer-individual modifications available on request
- PowderSpy sensors available for testing purposes



Contact:
Lukas Maiß
Lukas.maiss@powderspy.de
+49 6136 917 450 20

Thank you
for your attention!