



Raith

INNOVATION FROM A WORLD LEADER IN ELECTRON BEAM LITHOGRAPHY
AND SEMICONDUCTOR NAVIGATION SOLUTIONS

Exposure

Motivation

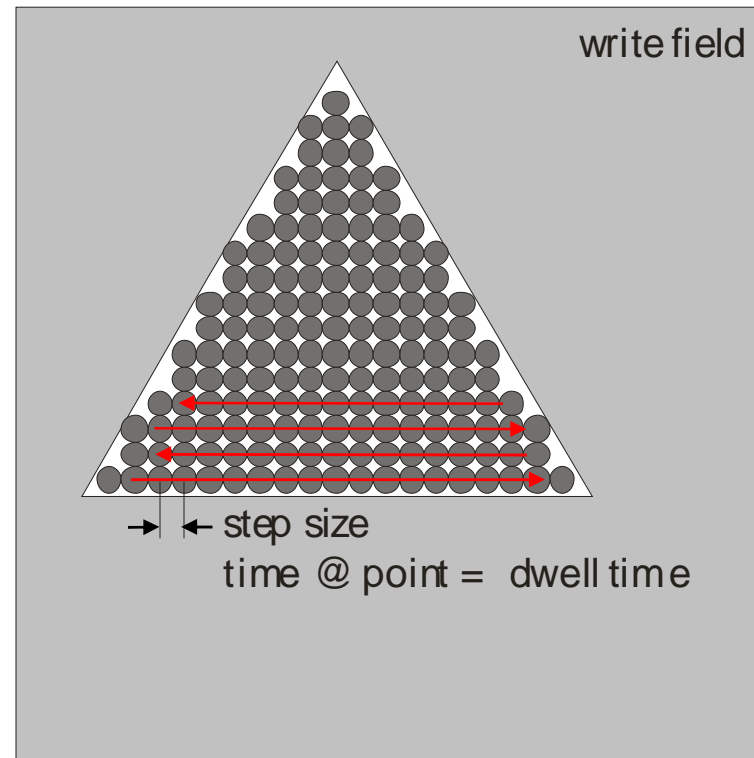
This talk will explain

- **definition of exposure parameters**
- **setting up an exposure**
- **details on exposure parameters**

Writing strategy

Raith uses

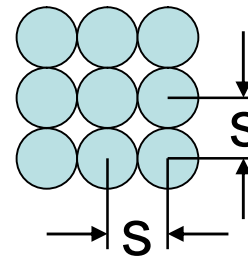
- Round beam with Gaussian-shaped profile
- moved along line = name vector scan



Dose Definition for Area Exposure

Rule: To clear an area, a certain **number of electrons** have to hit the sample within that **area**
= clearing area dose

number of electrons
 \propto beam current \times dwell time
 $= T_{\text{dwell}} \times I_{\text{beam}}$



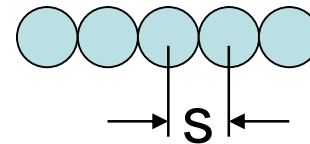
area
 \propto step size²
 $= s^2$

$$\text{AreaDose} = \frac{I_{\text{beam}} \cdot T_{\text{dwell}}}{s^2} \quad \text{Unit is } \mu\text{As/cm}^2$$

Dose Definition for Single Pixel Lines

Rule: To clear a line, a certain **number of electrons** have to hit the sample within a certain **length**
= clearing line dose

number of electrons
 \propto beam current \times dwell time
 $= T_{\text{dwell}} \times I_{\text{beam}}$



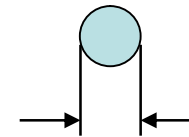
line
 \propto step size
 $= s$

$$\text{LineDose} = \frac{I_{\text{beam}} \cdot T_{\text{dwell}}}{s} \quad \text{Unit is pAs/cm}$$

Dose Definition for Dots

Rule: To clear a dot, a certain **number of electrons** have to hit the sample within a certain **point**
= clearing dot dose

number of electrons
 \propto beam current \times dwell time
 $= T_{\text{dwell}} \times I_{\text{beam}}$



$$\text{Dot Dose} = I_{\text{beam}} \cdot T_{\text{dwell}} \quad \text{Unit is pAs}$$

Quantities defined by ...

beam current

defined by column, i.e. filament, aperture, voltage, ...

dose

defined by process, i.e. resist, developer, temperature, voltage ...

dwel time and step size

exposure parameters defined by your needs, e.g. accuracy, GDSII, throughput, ...

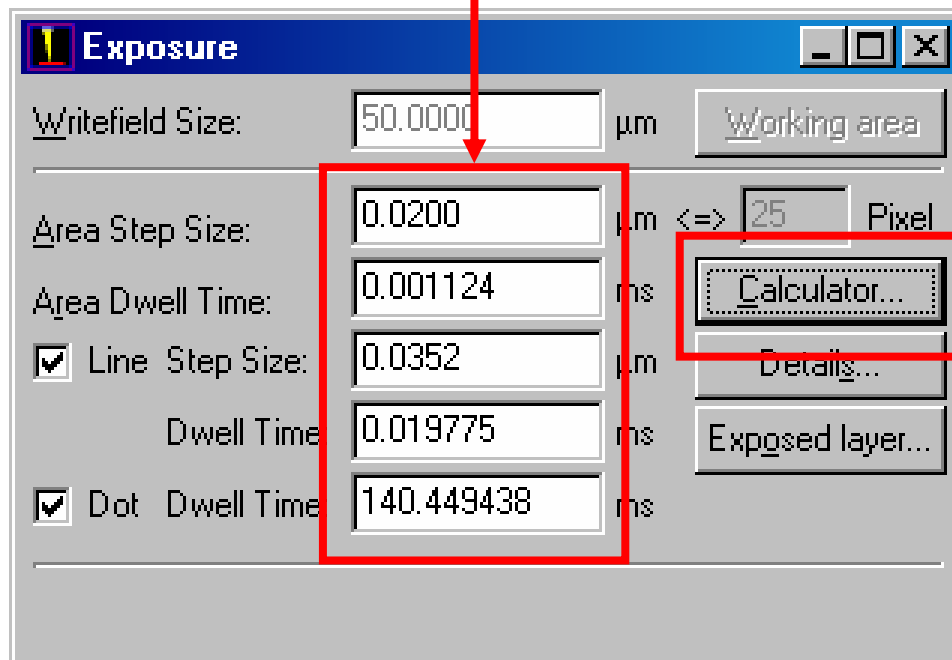
Quantities are used ...

<u>Paramter</u>	<u>Area</u>	<u>Line</u>	<u>Dot</u>
beam current	yes	yes	yes
dose	yes	yes	yes
dwell time	yes	yes	yes
step size	yes	yes	no
selectable	3	3	2
determined	1	1	1

under the condition to clear or equivalently fulfill the dose equation.

Exposure Window

Main window to set up
all exposure parameters



calculated
step size and
dwell time

Calculator using
clearing dose and
beam current

Calculator Window

Window to perform calculation

beam current and dose

start calculation

Exposure Parameter Calculation

Area | Line | Dot

Write Field Size: 50.0000 μm

Min. Step Size: 0.0008 μm

Beam Current: 0.356000 nA

Area Step Size: 0.0200 μm

Area Dwell Time: 0.001124 ms

Area Dose: 100.000000 μAs/cm²

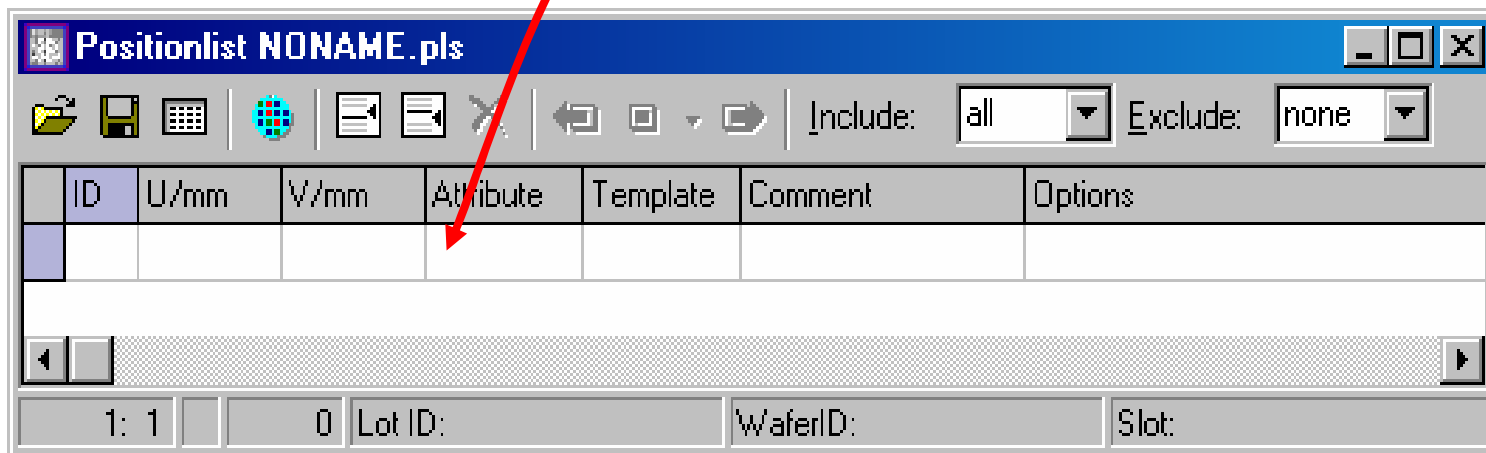
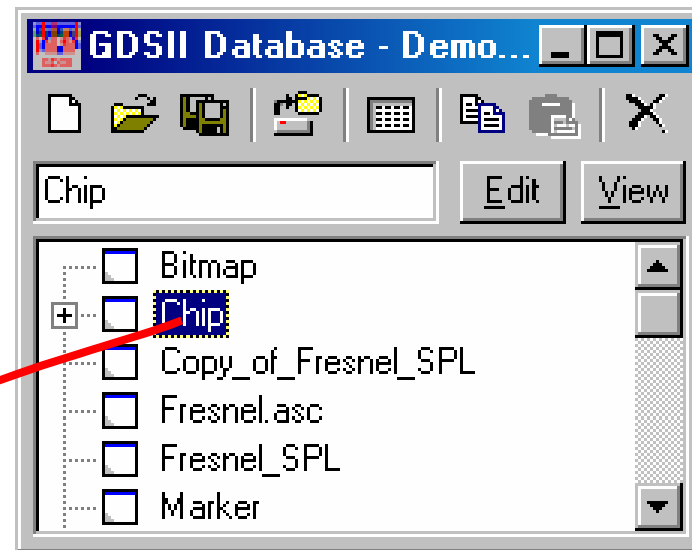
Beam Speed: 17.794 mm/s

Area Dose = (Beam Current * Area Dwell Time) / (Area Step Size)²

Cancel OK

Exposure Setup

Pull design into
positionlist by
„Drag and Drop“



PLS Exposure Properties 1

Right mouse click -
open properties

Exposure Properties

Database: C:\Raith150\USER\ANDY\GDSII\DEMO.CSF

Structure: Chip

Exposed Layer:

Working Area: U: -200.000 μ m to 500.000 μ m
V: -200.000 μ m to 500.000 μ m

Position: U: -5.000000 mm V: 0.000000 mm

Writefield Size: 50.000 μ m

Exposure Parameter >> Cancel OK

Positionlist NONAME.pls

Include: all Exclude: none

ID	U/mm	V/mm	Attribute	Template	Comment	Options
0	-5.000000	0.000000	XN	UV	Chip	

1: 1 * 1 Lot ID: WaferID: Slot:

PLS Exposure Properties 2

choose to expand dialog

calculated parameters as in exposure window

Writefield Size: 50.000 μm

Exposure Parameter <<

Cancel OK

Area Step Size:	0.0200 μm	<input checked="" type="checkbox"/> Default
Area Dwell Time:	0.001124 ms	<input checked="" type="checkbox"/> Default
Lines:	Enabled	<input checked="" type="checkbox"/> Default
Line Step Size:	0.0352 μm	<input checked="" type="checkbox"/> Default
Line Dwell Time:	0.019775 ms	<input checked="" type="checkbox"/> Default
Dots:	Enabled	<input checked="" type="checkbox"/> Default
Dot Dwell Time:	140.449438 ms	<input checked="" type="checkbox"/> Default
Dose Factor:	1.000	

Calculator...

Times

PLS Exposure Properties 3

Writefield Size: 50.000 μm

Exposure Parameter << Cancel OK

Area Step Size:	0.0200 μm	<input checked="" type="checkbox"/> Default
Area Dwell Time:	0.001124 ms	<input checked="" type="checkbox"/> Default
Lines:	Enabled	<input checked="" type="checkbox"/> Default
Line Step Size:	0.0352 μm	<input checked="" type="checkbox"/> Default
Line Dwell Time:	0.019775 ms	<input checked="" type="checkbox"/> Default
Dots:	Enabled	<input checked="" type="checkbox"/> Default
Dot Dwell Time:	140.449438 ms	<input checked="" type="checkbox"/> Default
Dose Factor:	1.000	

Calculator... Times

to use parameters from exposure window, place tick mark

PLS Exposure Properties 4

Writefield Size: 50.000 μm

Exposure Parameter << Cancel OK

Area Step Size:	0.0200 μm	<input checked="" type="checkbox"/> Default
Area Dwell Time:	0.001236 ms	<input type="checkbox"/> Default
Lines:	Enabled	<input checked="" type="checkbox"/> Default
Line Step Size:	0.0352 μm	<input checked="" type="checkbox"/> Default
Line Dwell Time:	0.021753 ms	<input type="checkbox"/> Default
Dots:	Enabled	<input checked="" type="checkbox"/> Default
Dot Dwell Time:	154.494382 ms	<input type="checkbox"/> Default
Dose Factor:	1.000	

Calculator... Times

to use individual parameters use calculator and remove tick marks

PLS Exposure Properties 5

Writefield Size: 50.000 μm

Exposure Parameter << Cancel OK

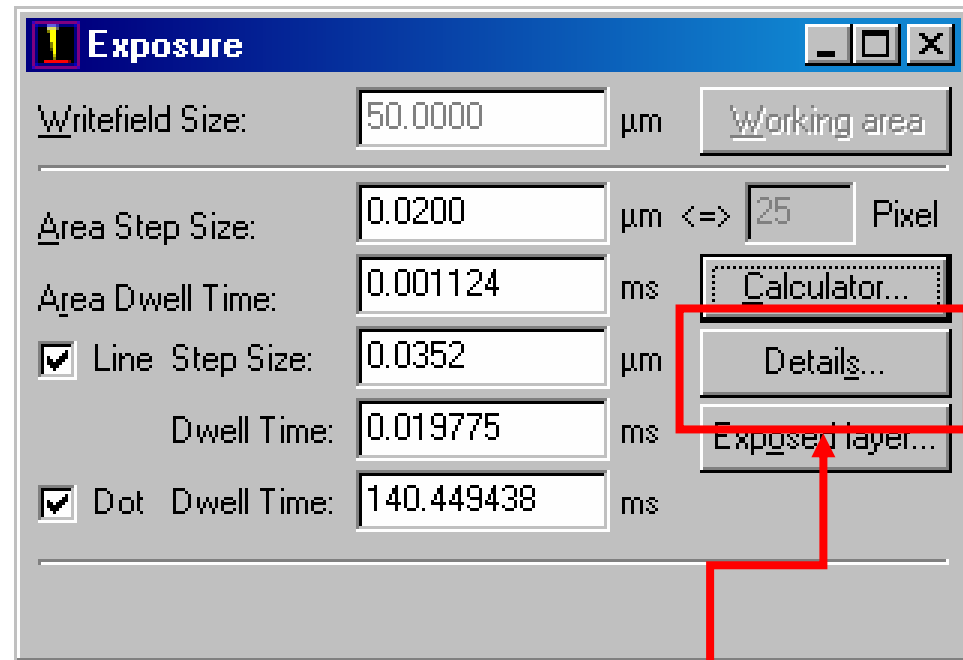
Area Step Size:	0.0200 μm	<input checked="" type="checkbox"/> Default
Area Dwell Time:	0.001236 ms	<input type="checkbox"/> Default
Lines:	Enabled	<input checked="" type="checkbox"/> Default
Line Step Size:	0.0352 μm	<input checked="" type="checkbox"/> Default
Line Dwell Time:	0.021753 ms	<input type="checkbox"/> Default
Dots:	Enabled	<input checked="" type="checkbox"/> Default
Dot Dwell Time:	154.494382 ms	<input type="checkbox"/> Default
Dose Factor:	1.000	

Calculator... Times

dwel time at each position can be re-scaled using dose factor

Additional Parameters 1 - Details

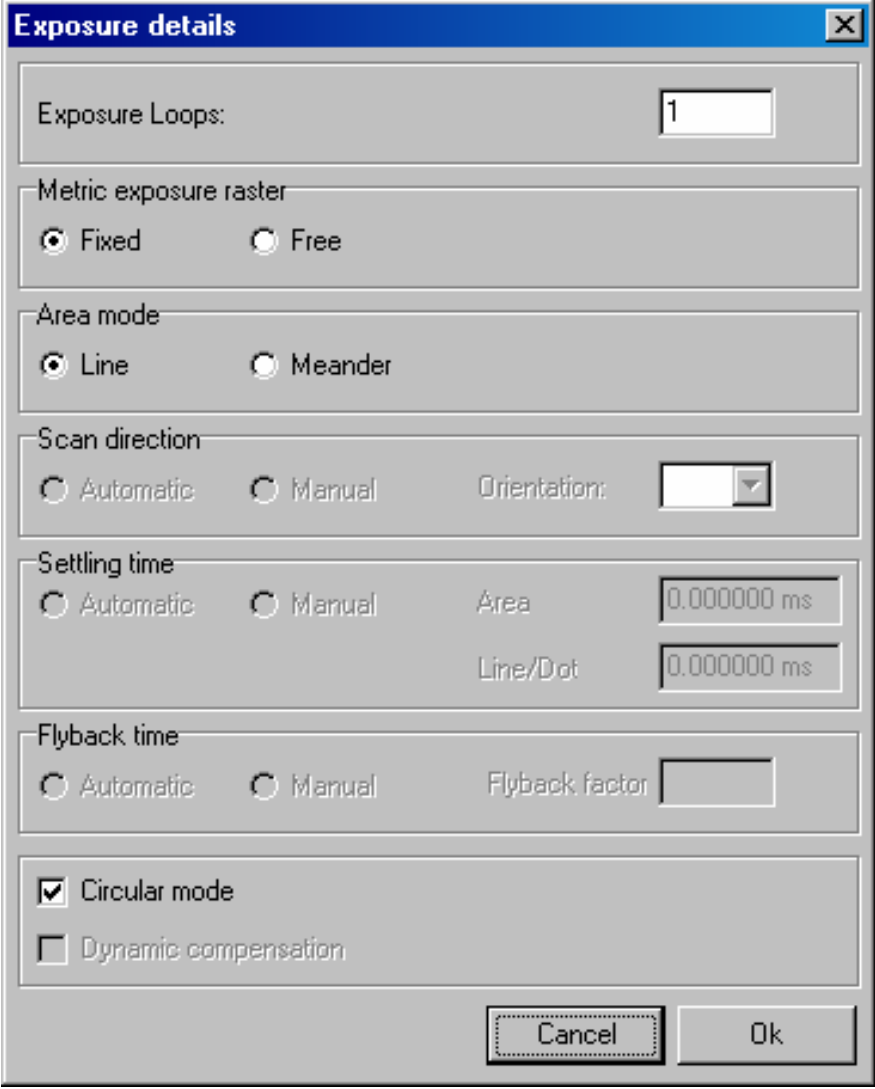
- Loops
- Line mode
- Meander mode
- Settling time
- Flyback time
- Circular mode



opens dialog to
set additional
parameters

Additional Parameters 2 - Details

- Loops
- Line mode
- Meander mode
- Settling time
- Flyback time
- Circular mode



The image shows a software dialog box titled "Exposure details". It contains several configuration options for exposure settings. The "Exposure Loops" field is set to 1. The "Metric exposure raster" section has "Fixed" selected. The "Area mode" section has "Line" selected. The "Scan direction" section has "Automatic" selected, and the "Orientation" is set to a default value. The "Settling time" section has "Automatic" selected, with "Area" and "Line/Dot" both set to 0.000000 ms. The "Flyback time" section has "Automatic" selected, and the "Flyback factor" is set to 1.0. The "Circular mode" checkbox is checked, and the "Dynamic compensation" checkbox is unchecked. The dialog box has "Cancel" and "Ok" buttons at the bottom right.

Exposure details

Exposure Loops: 1

Metric exposure raster

☒ Fixed ☐ Free

Area mode

☒ Line ☐ Meander

Scan direction

☒ Automatic ☐ Manual Orientation: [v]

Settling time

☒ Automatic ☐ Manual Area 0.000000 ms

Line/Dot 0.000000 ms

Flyback time

☒ Automatic ☐ Manual Flyback factor 1.0

☒ Circular mode

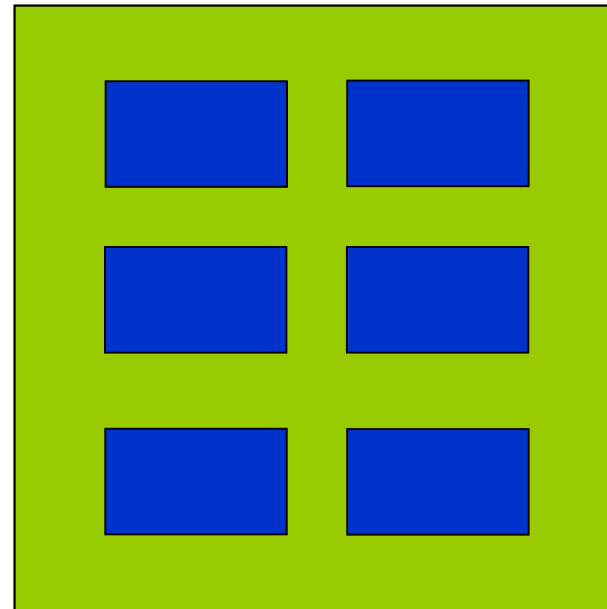
☐ Dynamic compensation

Cancel Ok

Loops

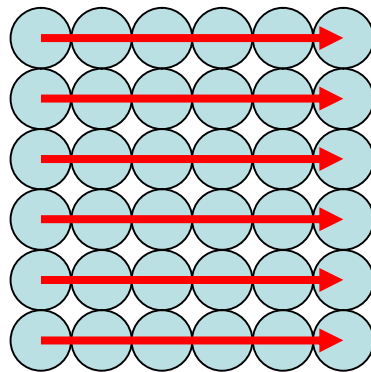
Each write field is repeated n times.

(0 means infinite number of loops)

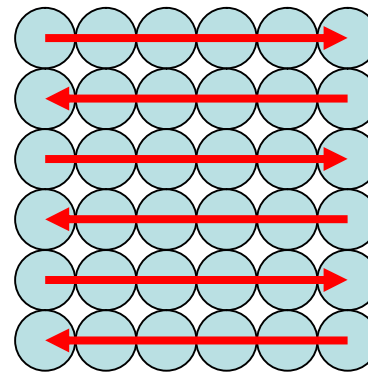


Line mode versus meander mode

Line mode = element is filled with each line from the **same** direction.



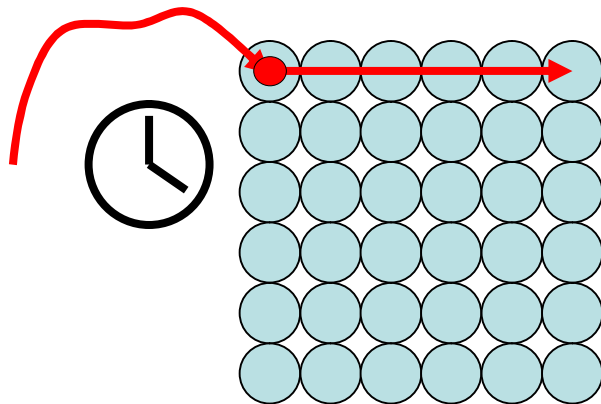
Meander mode = element is filled with each line from the **opposite** direction.



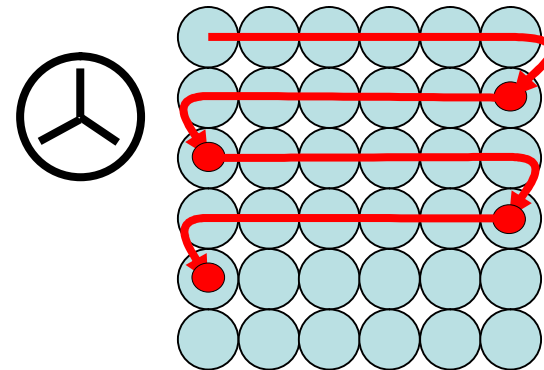
See talk “Exposure parameters” for hints which mode to use.

Settling and Flyback Time

Settling time = waiting period at beginning of each element



Flyback time = waiting period between lines.



Please note, in our software
 $\text{Flyback time} = \text{settling time} \times \text{flyback factor}$

Circular Mode

Circular mode =

- round elements are decomposed into dots
- dots are exposed in concentric rings
- vertices are not used

Version 3.0

- area step size, dwell time
- line settling time

Version 4.0

- only area parameters

