The OPfC® project file format

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1 The OPfC® project file format

1.1 General description

The OPfC® file format is equivalent to the standard .ini format. It consists of line-by-line key-value pairs, which are subdivided in sections due to structural reasons.
General rules:

- key and value are separated by an „=“
- blanks before or after the „=“ will be ignored
- section names are delimited by a preceding ”[“ and a following ”]“
- a section name must be unique within a file
- a key name must be unique within a section
- upper-/lowercase will be ignored
- comments don't need a special preceding sign, but have to be in extra lines

A short example extract of such a project file:

```
[file]
path=c:\programme\sio\filmdoctor
name=test.fdop
[data]
amount=7
sum=12
```

1.2 Rules for the OPfC® project file format

The OPfC® project file format has some additional specific rules:

- The file extension must be „**.fdop**“.
- Effective material properties of the sample must be provided in the section „[indenter]“.
- Either a value for the contact radius, the contact area or hardness must be provided in the

section „[indenter]“.
- The decimal separator is the dot (“.”).
- Basis for geometric values is the SI base unit meter (m).
- Basis for time values is the SI base unit second (s).
- Consequently, basis for all pressure and stress values is the unit Pascal (Pa) and basis for all force values is the unit Newton (N).

1.3 Sections of the OPfC® project file format

Following subchapters briefly describe the different sections of the OPfC® project file format.

1.3.1 Load-depth curve

Section name: curve

Content: Data of the measured load-depth-curve (normal load, corresponding depth, and optionally corresponding time)

If the data comes from a continuous stiffness measurement, the starting points of the sequential loading/unloading parts of the curve must be provided. Use the keys 'part_count' and 'start_position_POSNR'.

For a list of all keys see subchapter “measurement curve keys” in appendix.

1.3.2 Material

Section name: material

Content: Parameters of each constituent of the sample material (Young's modulus, Poisson's ratio, thickness and so forth)

For a list of all keys see subchapter “material parameter keys” of appendix.

1.3.3 Definition of the contact situation

Section name: indenter

Content: Description of the used indenter (indenter material and area function) and the results of the Oliver & Pharr analysis (effective mechanical properties of the sample, and either contact radius, contact area or hardness).

For a list of all keys see subchapter “load definition parameter” in appendix.

1.3.4 Definition of the calculation range

Section name: calculation

Content: This section is optional and only needed if you want to define a calculated region and density for the field calculation. The software packages will automatically use standard values if you don't define values in this section.

For a list of all keys see subchapter "calculation parameter" in appendix.

1.3.5 Definition of the maximum iteration steps

Section name: emodulfit

Content: In this section only one value can defined. It's named "maxsteps" and defines the maximum of iteration steps performed during the Young's modulus fit of the layer. The standard value is 15 and usually you don't need to change it.

1.3.6 Indentation maps

Section name: map

Content: In this section are the information about the map, in which this indent was performed, stored.

For a list of all keys see subchapter "indentation map" in appendix.

1.3.7 Creep fit options

Section name: indenter

Content: These values define which options for the OPfC creep analyzis are used.

For a list of all keys see subchapter "creep fit options" in appendix

1.4 Special features

1.4.1 Definition of the order of magnitude of units

To enhance the readability the exponent of a value is stored in a different key. The exponent will always be stored as the exponent of the base unit (m, m^2, N, Pa, s). For example: The key-value pairs

```
normal_force_value=1.5
normal_force_factor=-2
```

define a normal load of 15 mN.

You don't have to provide digits to the left of the decimal point. The following entries are valid and equivalent to each other:

```
normal_force_value=1.5
normal_force_factor=-2

normal_force_value=0.015
normal_force_factor=0

normal_force_value=1.5e-2
normal_force_factor=0
```

2 Appendix

2.1 A measurement curve keys

name	type	description	standard value
point_count	integer	number of measured points in a curve	0
loadfactor	integer	order of magnitude of load values	0 (stands for N)
depthfactor	integer	order of magnitude of depth values	-6 (stands for µm)
timefactor	integer	order of magnitude of time values	0 (stands for s)
load_NR	double	the force of point number NR	NR / (point_count-1)
depth_NR	double	the depth of point number NR	(NR /(point_count-1))^2
time_NR	double	the time of point number NR	NR / (point_count-1)
part_count	integer	number of loading/unloading parts	1
start_position_POSNR	integer	starting point number of part POSNR	0
use_part	integer	the used part of the curve {0, …, part_count}	0 (means use the complete curve)
x_pos	double	the x position of the indent	0
y_pos	double	the y position of the indent	0
z_pos	double	the z position of the indent	0
positionfactor	integer	order of magnitude of position values	-6 (stands for µm)
type	integer	define which measurement was performed	0 (means pure normal load indentation)

Table 1: description of the measurement curve keys

NR = {0, …, point_count-1}
POSNR = {1, …, part_count}

2.1.1 Measurement types

0 – standard indentation without additional load components
1 – mixed load indentation with additional lateral load during the normal load unloading part
2 – mixed load indentation with additional lateral load during the max normal load holding part

2.2 B material parameter keys

name	type	description	standard value
layer_NR_ny	double	Poisson's ratio of the layer NR	0,3
layer_NR_E_value	double	Young's Modulus of the layer NR	200
layer_NR_E_factor	integer	order of magnitude of E value	9 (stands for GPa)
layer_NR_height_value	double	height of the layer NR	1, NR goes from 1 to the amount of layers
layer_NR_height_factor	integer	order of magnitude of height	-6 (stands for µm)
layer_NR_inx_value	double	intrinsic stress in x direction	0
layer_NR_inx_factor	integer	order of magnitude of the inx value	9 (stands for GPa)
layer_NR_iny_value	double	intrinsic stress in y direction	0
layer_NR_iny_factor	integer	order of magnitude of the iny value	9 (stands for GPa)

layer_count	integer	number of layers	1
layer_fit	integer	layer to fit	1 (only used in OPfC Normal and OPfC Full)

Table 2: description of the material keys

NR = {0, …, number of layers}; NR>=1: coating layers; NR=0: substrate

2.3 C load definition parameters

name	type	description	standard value
indenter_ny	double	Poisson's ratio of the indenter	0,07
indenter_E_value	double	Young's Modulus of the indenter	1141
indenter_E_factor	integer	order of magnitude	9 (stands for GPa)
effective_ny	double	Poisson's ration of the effective sample	0,208
effective_E value	double	Young's Modulus of the effective sample	82, NR goes from 1 to the amount of parts
effective E value_NR	double	Young's Modulus of the effective sample for part NR	82,
effective_E_factor	integer	order of magnitude	9 (stands for GPa)
fit_points	integer	number of points to be fitted	10
fit_percents_high	integer	upper limit of the fit range (1-100)	98
fit_percents_low	integer	lower limit of the fit range (0-99)	40
radius_Area_Hardness_Index	integer	indicates whether contact radius (0), contact area (1) or hardness(2) should be used	0 (stands for contact radius)
contact_radius_value	double	contact radius	1
contact_radius_value_NR	double	contact radius of part NR	1, NR goes from 1 to the amount of parts
contact_radius_factor	integer	order of magnitude	-6 (stands for µm)
contact_area_value	double	the contact area	1
contact_area_value_NR	double	the contact area of part NR	1, NR goes from 1 to the amount of parts
contact_area_factor	integer	order of magnitude	-12 (stands for µm^2)
hardness_value	double	the hardness	5
hardness_value_NR	double	the hardness of part NR	5, NR goes from 1 to the amount of parts
hardness_factor	integer	order of magnitude	9 (stands for GPa)
reduced_e_value	double	reduced Young's Modulus	100
reduced_e_value_NR	double	reduced Young's Modulus of part NR	100, NR goes from 1 to the amount of parts
reduced_e_factor	integer	order of magnitude	9 (stands for GPa)
effective_reduced_index	integer	Indicates whether the effective (0) or reduced (1) Young's Modulus should be used.	0 (stands for effective Young's modulus)
area_func_exponent_X	double	part of the area function for h^X, where X can be [5, 4, 3, 2, 3/2, 1, 2/3, 0, 1/2 , 1/4 , 1/8 , 1/16 , 1/32, 1/64, 1/128]	0 for all except for X=2, if X=2 the value is 24,5
area_function_is_square_root	integer	indicates whether the area function is defined as square root (1) or not (0)	0

area_func_start	double	start value of the definition range for the area function	0
area_func_end	double	end value of the definition range for the area function	0
area_func_unit	integer	order of magnitude for the area function	-6 (stands for µm)

Table 3: description of the load defnition keys

2.4 D calculation parameter keys

name	type	description	standard value
use_defaults	integer	indicates if the software will use standard values (1) or the defined values in this section (0)	1
normal_force_value	double	normal force	1
lateral_force_x value	double	lateral force in x direction	0
lateral_force_y value	double	lateral force in y direction	0
rotating_force_value	double	rotation force	0
tilting_moment_value	double	tilting moment	0
tilting_angle	double	tilting angle	0
normal_force_factor	integer	order of magnitude	0 (stands for N)
lateral_force_x_factor	integer	order of magnitude	0 (stands for N)
lateral_force_y_factor	integer	order of magnitude	0 (stands for N)
rotating_force_factor	integer	order of magnitude	0 (stands for N)
tilting_moment_factor	integer	order of magnitude	0 (stands for N)
length_factor	integer	order of magnitude	-6 (stands for µm)
x_start	double	startvalue in x direction	Max(-2*a,-2*h)
x_end	double	endvalue in x direction	Max(2*a,2*h)
x_points	integer	number of calculated points in x direction	20
y_start	double	startvalue in y direction	0
y_end	double	endvalue in y direction	0
y_points	integer	number of calculated points in y direction	1
z_start	double	startvalue in z direction	0
z_end	double	endvalue in z direction	Max(2*a,2*h)
z_points	integer	number of calculated points in z direction	20

Table 4: description of the calculation parameter keys

2.5 E indentation map keys

Name	type	description	standard value
row_start	double	startvalue in row direction	0
row_step	double	distance between indents in row direction	0
row_count	integer	number of measurements in x direction	1
row_offset	double	the offset when moving to a new row	0
column_start	double	startvalue in y direction	0
column_step	double	distance between indents in column direction	0
column_count	integer	number of measurements in column direction	1

column_offset	double	the offset when moving to a new column	0
mapfactor	integer	order of magnitude of map values	-6 (stands for µm)
row_idx	integer	index of the measurement in row direction	1
column_idx	integer	index of the measurement in column direction	1

Table 5: description of the indentation map keys

index = {1, …, number of measurements}

2.6 F creep fit options

Name	type	description	standard value
op_fit_mode	integer	0 – standard opfc analyzis 1 – creep OPfC analyzis	0 (standard opfc analyzis)
creep_fit_mode	integer	fit mode 0 – unloading part 1 – hold time creep 2 – hold time retardation 3 – hold time retardation + relaxation 4 – hold time mix with parameter	1 (hold time creep)
creep_op_function	Integer	O&P fit method 0 – classic method 1 – time depending c 2 – time depending m (linear) 3 – time depending c and m 4 – time dep. m (exponential) 5 – time depending m (tan h) 6 – time depending m (quadratic) 7 – time dep. c and m (quadratic) 8 – time dep. c, h0 and m (quadratic) 9 – time dep. polynom for c, h0 and m	8 (time dep. C, h0 and m (quadratic))

Table 6: description of the creep fit option keys