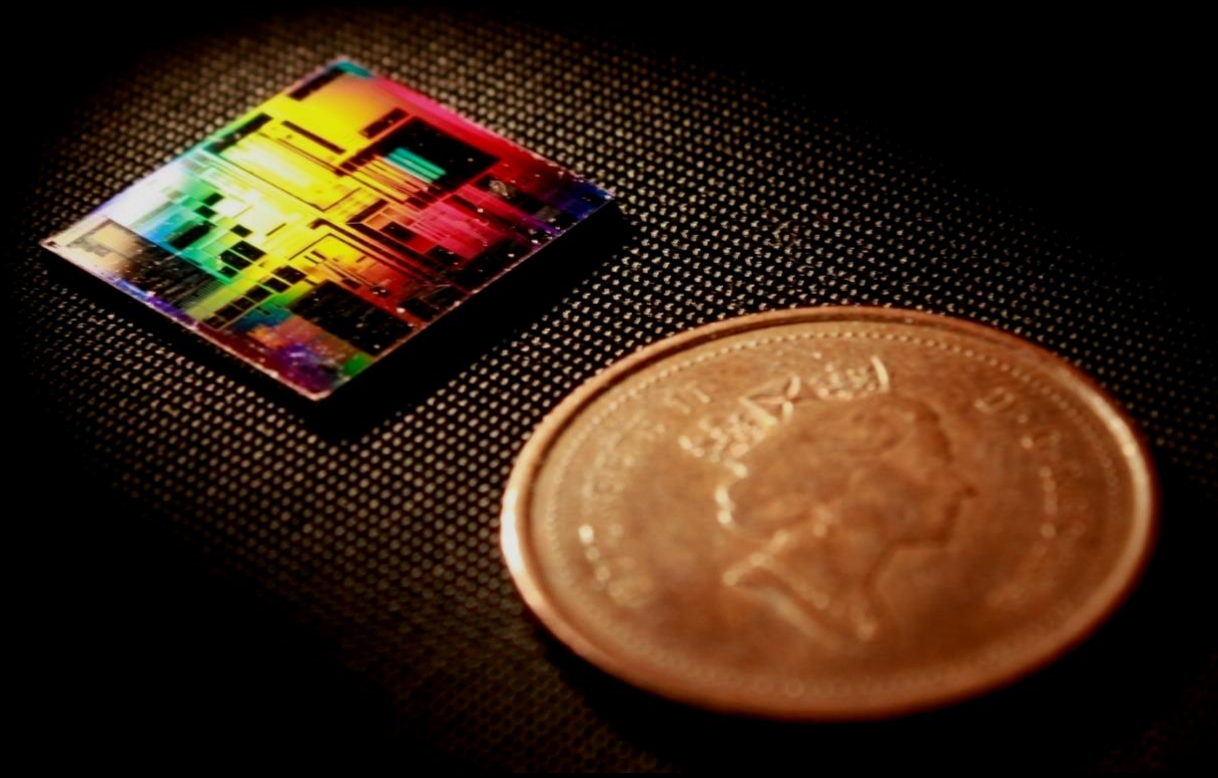
Klayout: Parameterized Cells Scripting

2020 SiEPIC Passive Silicon Photonics Workshop, Vancouver, Canada



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a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

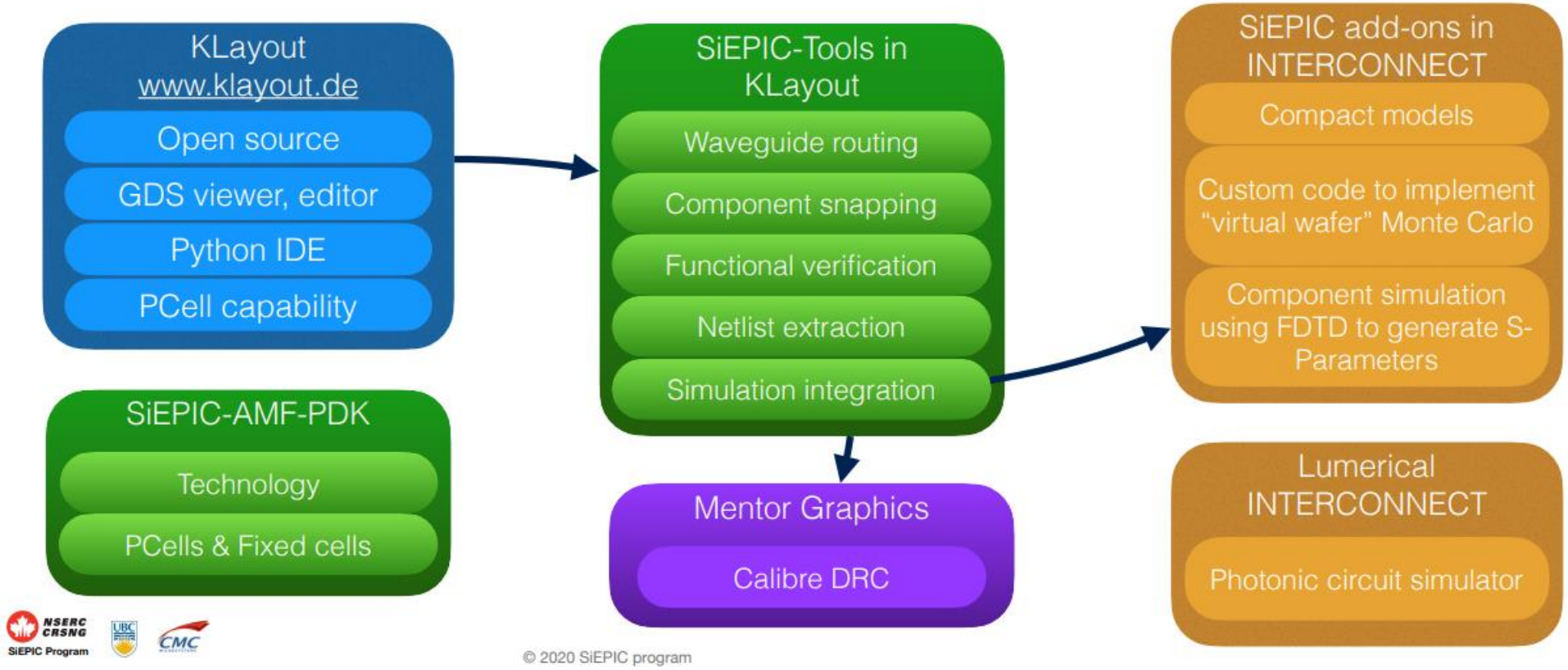
MiNa Microsystems and Nanotechnology Group
Photonics Research Group

ece Electrical and Computer Engineering

Outline

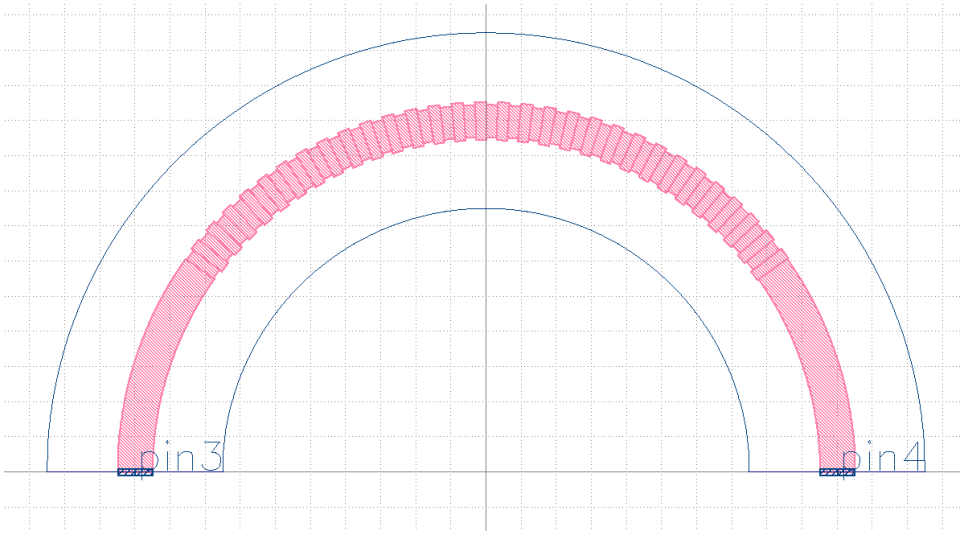
- SiEPIC EPDA Flow
- What is a parameterized cell?
- How to setup and start creating scripts
- Define components library
- Make your first parameterized cell

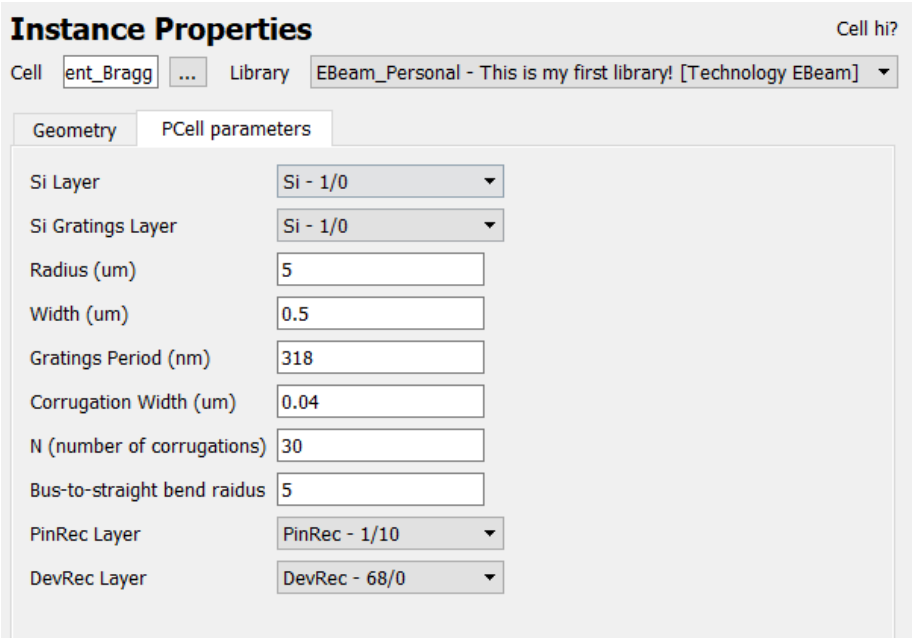
SiEPIC EPDA


KLayout
www.klayout.de
Open source
GDS viewer, editor
Python IDE
PCell capability
SiEPIC-AMF-PDK
Technology
PCells & Fixed cells
SiEPIC-Tools in KLayout
Waveguide routing
Component snapping
Functional verification
Netlist extraction
Simulation integration
Mentor Graphics
Calibre DRC
SiEPIC add-ons in INTERCONNECT
Compact models
Custom code to implement "virtual wafer" Monte Carlo
Component simulation using FDTD to generate S-Parameters
Lumerical INTERCONNECT
Photonic circuit simulator
NSERC CRSNG
SiEPIC Program
UBC
CMC
© 2020 SiEPIC program

Pcell?

- **A method to generate the layout of a parameterized device, contains:**
  - **Physical device parameters**
  - **Ports definitions**
  - **Device region definition**
  - **Compact models (?)**

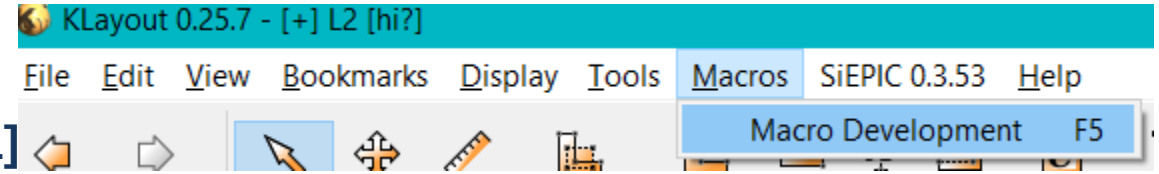




Setup

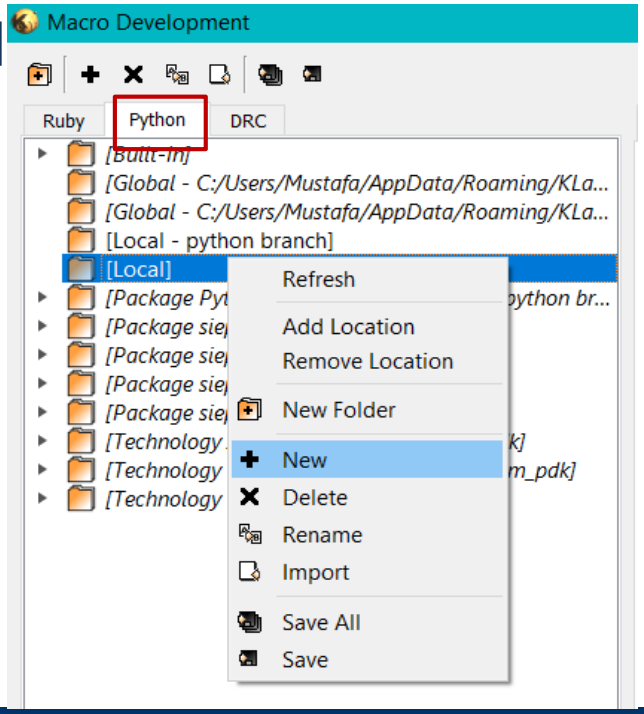
- **Open Macro Development**

[1]

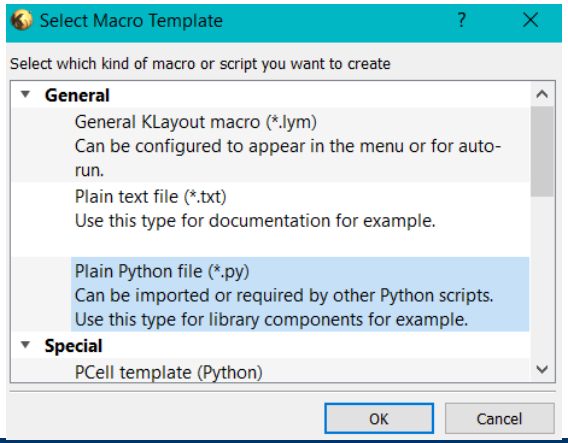


- **Create a new Python script in your local directory**
- **Copy content of my_first_script.py**

[2]



[3]

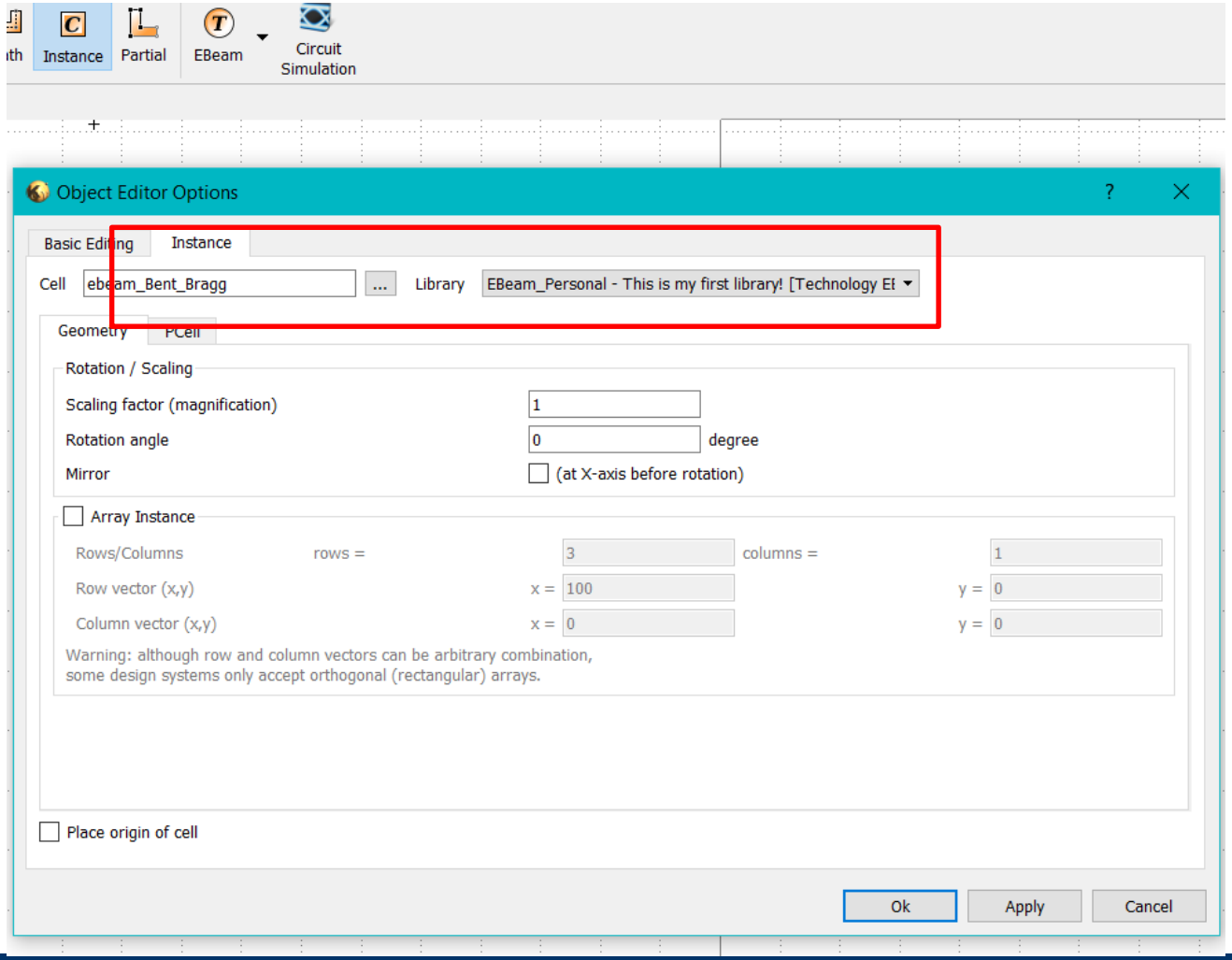


Define components library

- **Call it SiEPIC_Demo**
- **Built on a technology**
  - **‘EBeam’**
- **Register all PCells in the script**
  - **‘Ebeam_Bent_Bragg’**

```
157 class SiEPIC_Demo(Library):
158   """
159   The library where we will put the PCells and GDS into
160   """
161
162   def __init__(self):
163
164     tech_name = 'EBeam_Personal'
165     library = tech_name
166
167     print("Initializing '%s' Library." % library)
168
169     # Set the description
170 # windows only allows for a fixed width, short description
171     self.description = ""
172 # OSX does a resizing:
173     self.description = "This is my first library!"
174
175     # Create the PCell declarations
176     self.layout().register_pcell("ebeam_Bent_Bragg", ebeam_Bent_Bragg())
177
178     # Register the library with the technology name
179     # If a library with that name already existed, it will be replaced then.
180     self.register(library)
181
182     self.technology='EBeam'
183
184 # Instantiate and register the library
185 SiEPIC_Demo()
```

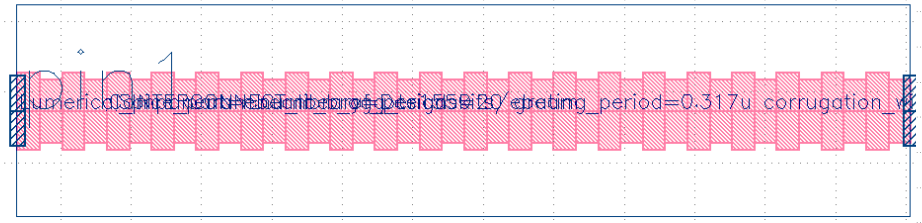
Define components library

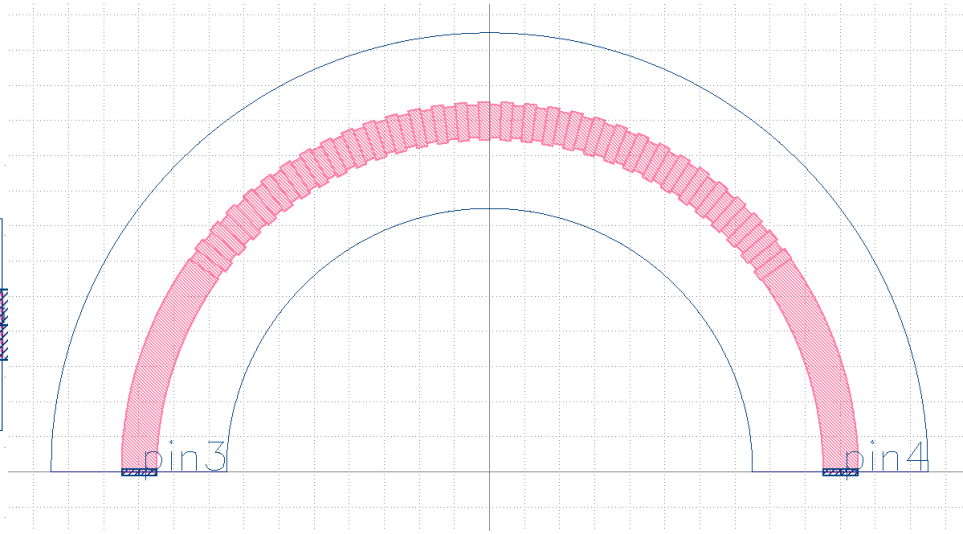


Pcell: Objective

- **We want to turn Bragg gratings from straight to bent over an Arc**

- **Parameters:**
  - **Radius**
  - **Waveguide width**
  - **Bragg period**
  - **Bragg corrugation width**
  - **Number of Bragg periods**
  - **Layers**





Pcell: Format

- `__init__`: **initialize technology and GUI Pcell parameters**
- `Display_text_impl`: **Description of the Pcell, appears when selected**
- `produce`: **Actual implementation of the Pcell (polygon drawing definition) and ports definition, and device recognition**

```
16  class ebeam_Bent_Bragg(PCellDeclarationHelper):
17
18    def __init__(self):
19      # initialize the super class and technology
20      super(ebeam_Bent_Bragg, self).__init__()
21      TECHNOLOGY = get_technology_by_name('EBeam')
22
23      # declare the PCell parameters
24      self.param("silayer", self.TypeLayer, "Si Layer", default = TECHNOLOGY['Waveguide'])
25      self.param("width", self.TypeDouble, "Width (um)", default = 0.5)
26
27    def display_text_impl(self):
28      # Provide a descriptive text for the cell
29      return "Description"
30
31    def produce(self, layout, layers, parameters, cell):
32
33
34      # Draw the PCell polygons
35
36      # Create the device pins, as short paths:
37
38      # Create the device recognition layer -- make it 1 * wg_width away from the waveguides.
```

Pcell: Objective

- **We want to turn Bragg gratings from straight to bent over an Arc**

- **Parameters:**
  - **Radius**
  - **Waveguide width**
  - **Bragg period**
  - **Bragg corrugation width**
  - **Number of Bragg periods**
  - **Layers**

Pcell: Script Parameters GUI and tech

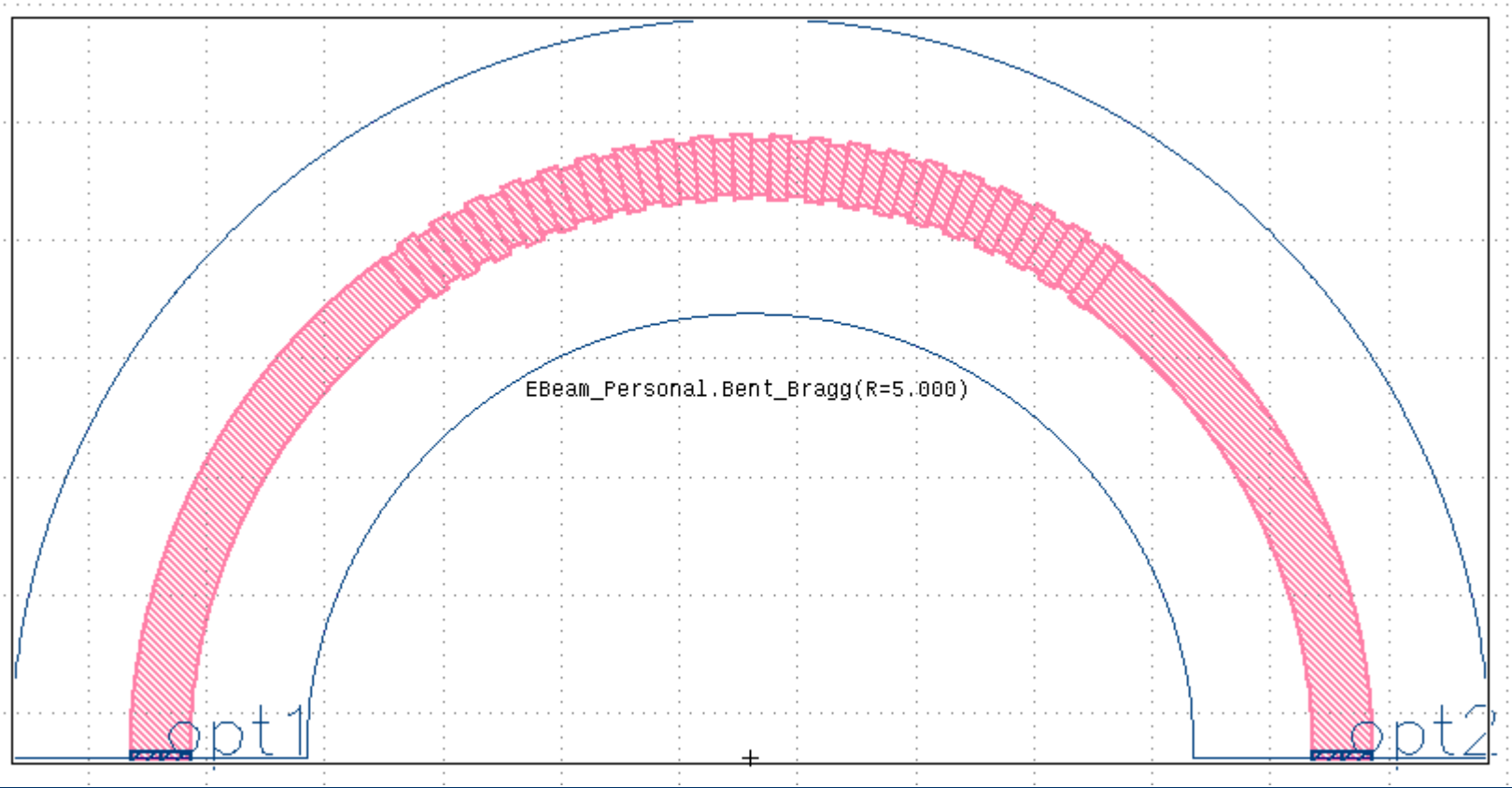
- **Method: __init__**

```
def __init__(self):

  # Important: initialize the super class
  super(ebeam_Bent_Bragg, self).__init__()
  TECHNOLOGY = get_technology_by_name('EBeam')

  # declare the parameters
  self.param("silayer", self.TypeLayer, "Si Layer", default = TECHNOLOGY['Waveguide'])
  self.param("silayer_gratings", self.TypeLayer, "Si Gratings Layer", default = TECHNOLOGY['31_Si_p6nm'])
  self.param("radius", self.TypeDouble, "Radius (um)", default = 25)
  self.param("width", self.TypeDouble, "Width (um)", default = 0.5)

  self.param("period", self.TypeDouble, "Gratings Period (nm)", default = 318)
  self.param("deltaW", self.TypeDouble, "Corrugation Width (um)", default = 0.04)

  self.param("gamma", self.TypeDouble, "N (number of corrugations)", default = 135)

  self.param("pinrec", self.TypeLayer, "PinRec Layer", default = TECHNOLOGY['PinRec'])
  self.param("devrec", self.TypeLayer, "DevRec Layer", default = TECHNOLOGY['DevRec'])
```

Pcell: Description

- **Method: display_text_impl**

```
def display_text_impl(self):
  # Provide a descriptive text for the cell
  return "Bent_Bragg(R=" + ('%.3f' % self.radius) + ")"
```



Pcell: Produce: fetch layout parameters

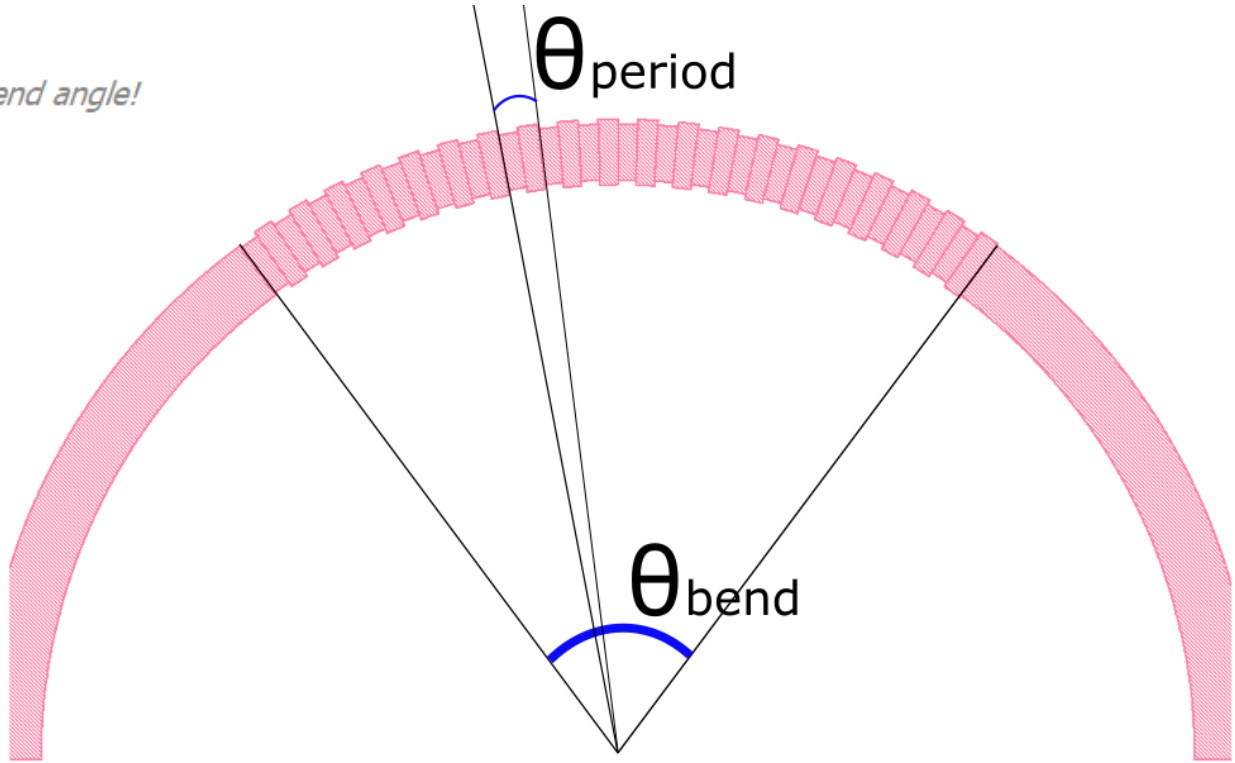
- **Method: Produce**

```
def produce(self, layout, layers, parameters, cell):

 #coerce parameters (make consistent)

 self._layers = layers
 self.cell = cell
 self._param_values = parameters
 self.layout = layout


 # cell: layout cell to place the layout
 # LayerSiN: which layer to use
 # r: radius
 # w: waveguide width
 # length units in dbu

 from math import pi, cos, sin
 from SiEPIC.utils import arc_wg, arc_wg_xy
 from SiEPIC._globals import PIN_LENGTH

 # fetch the parameters
 dbu = self.layout.dbu
 ly = self.layout

 LayerSi = self.silayer
 LayerSiN_gratings = self.silayer_gratings_layer
 LayerSiN = self.silayer_layer
 LayerPinRecN = ly.layer(self.pinrec)
 LayerDevRecN = ly.layer(self.devrec)
 from SiEPIC.extend import to_itype
 w = to_itype(self.width,dbu)
 r = to_itype(self.radius,dbu)
 period = self.period
 deltaW = to_itype(self.deltaW,dbu)
 N = int(self.gamma)
```

Pcell: Produce: Draw layout!

- **Method: Produce**

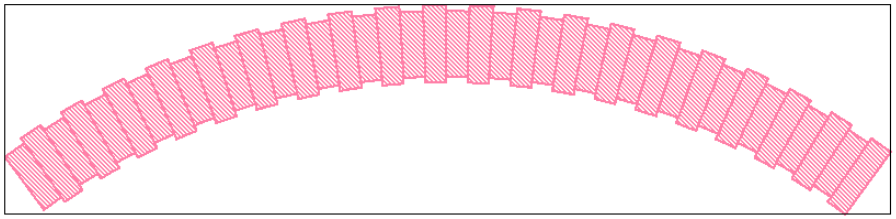
```
# Center of everything
x = 0
y = 0

# Angle of  Bragg corrugated portion, also bend angle!
periodAngle = (180/pi) * (period/2) /r

# Bend angle
bendAngle = (180/pi) * (N*period/2) /r
```



Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw corrugations (wide)**
- **Use an arc function (arg_wg_xy)**
  - **skip every other period**

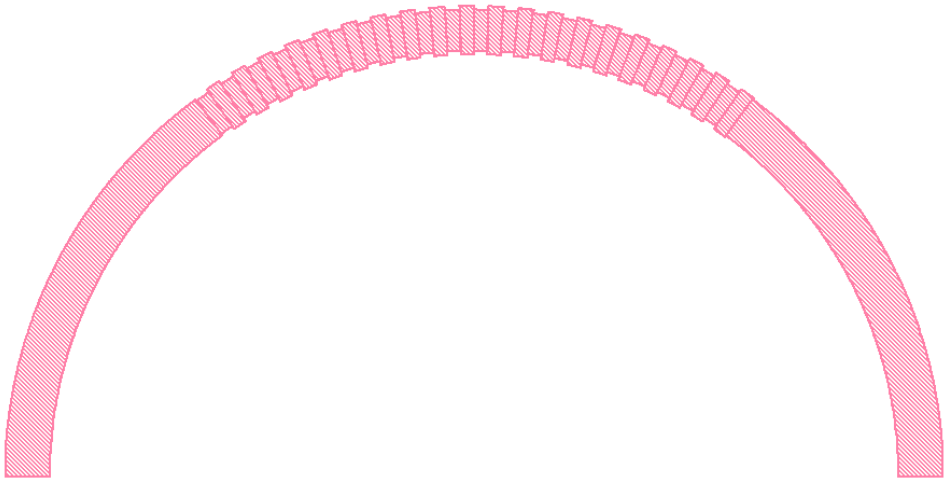
- **Draw corrugations (narrow)**
- **Use an arc function (arg_wg_xy)**
  - **skip every other period**



```
# Bragg wide
ii = periodAngle*2
while ii < N+periodAngle*1.5:
  self.cell.shapes(LayerSiN_gratings).insert(arc_wg_xy(x,y, r, w+deltaW, 90+bendAngle-ii, 90+bendAngle-ii-periodAngle))
  ii = ii+periodAngle
  ii = ii+periodAngle


 # Bragg narrow
ii = periodAngle
while ii < N:
  self.cell.shapes(LayerSiN_gratings).insert(arc_wg_xy(x,y, r, w-deltaW, 90+bendAngle-ii, 90+bendAngle-ii-periodAngle))
  ii = ii+periodAngle
  ii = ii+periodAngle
```

Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw bend sections (uncorrugated)**
- **Use an arc function (arg_wg_xy)**



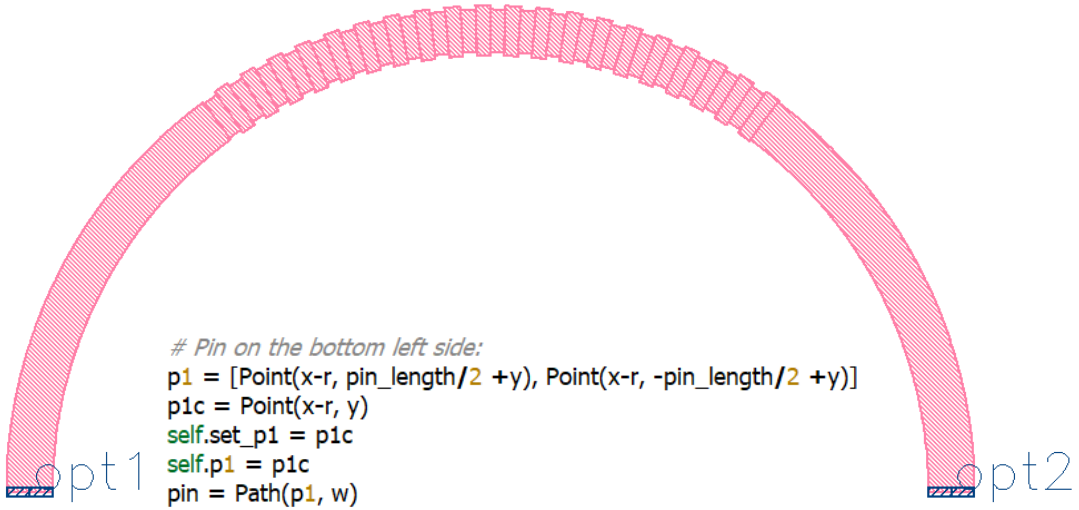
```
# bend non-corrugated left
self.cell.shapes(LayerSiN).insert(arc_wg_xy(x,y, r, w, 180-(90-bendAngle), 180))

# bend non-corrugated right
self.cell.shapes(LayerSiN).insert(arc_wg_xy(x,y, r, w, 0, 90-bendAngle))
```

Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw optical input pins**
- **As wide as waveguides width**
- **Be aware of orientation!**

- **This enables component snapping**

- **Used for connectivity/netlist**

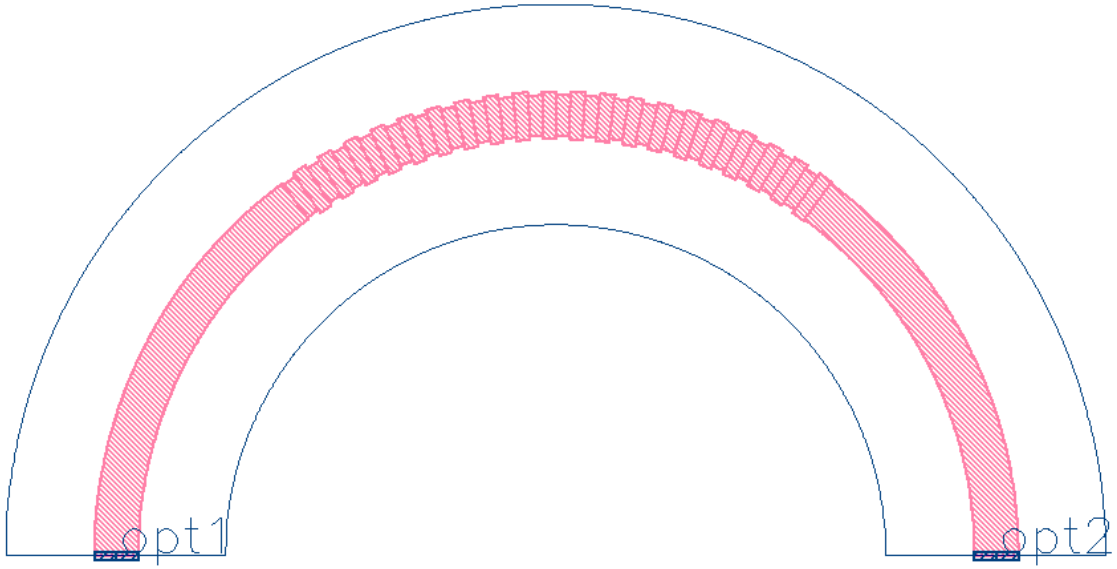



```
# Pin on the bottom left side:
p1 = [Point(x-r, pin_length/2 +y), Point(x-r, -pin_length/2 +y)]
p1c = Point(x-r, y)
self.set_p1 = p1c
self.p1 = p1c
pin = Path(p1, w)
self.cell.shapes(LayerPinRecN).insert(pin)
t = Trans(Trans.R0, x-r, y)
text = Text ("opt1", t)
shape = self.cell.shapes(LayerPinRecN).insert(text)
shape.text_size = 0.4/dbu

# Pin on the bottom right side:
p2 = [Point(x+r, y+pin_length/2), Point(x+r,y-pin_length/2)]
p2c = Point(x+r,y)
self.set_p2 = p2c
self.p2 = p2c
pin = Path(p2, w)
self.cell.shapes(LayerPinRecN).insert(pin)
t = Trans(Trans.R0, x+r, y)
text = Text ("opt2", t)
shape = self.cell.shapes(LayerPinRecN).insert(text)
shape.text_size = 0.4/dbu
```

Pcell: Produce: Draw layout!

- **Method: Produce**
- **Draw device recognition (bounding) box**

- **Used for device area recognition, prevents from overlapping with other components**




```
# Create the device recognition layer -- make it 1 * wg_width away from the waveguides.
self.cell.shapes(LayerDevRecN).insert(arc_wg_xy(x ,y, r, w*5, 0, 180))
```

Pcell examples:

- **MMI**
- **Ring Resonator**
- **Bragg Grating**
- **Directional Coupler**
- **Taper**