Building Photonic and Analog Circuits with

Self Introduction

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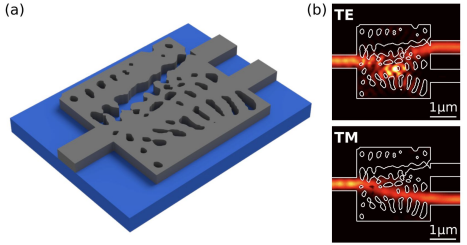
MIT	B.S. Mechanical Engineering, 2010
SAMSUNG	Simulation and optimization of Fluid Dynamic Bearings (FDBs) for HDD motors
JUNIPER NETWORKS	Design automation for transceivers with integrated lasers and photonic circuits
Rockley®	Design automation for photonic bio-sensors. Saved $2M/year with open source strategy
DoPlayDo	Enabling companies to accelerate their chip development cycle with open source tools

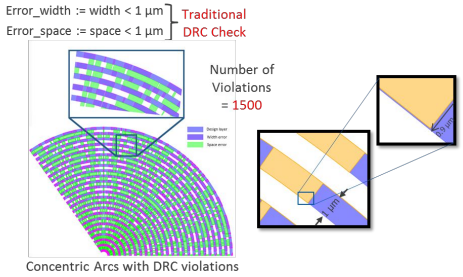
Challenges in Photonics

- PDKs are not great
  - Most companies are designing starting at the device level
  - Many companies start even at the *process* level
  - Often difficult to fully validate a circuit

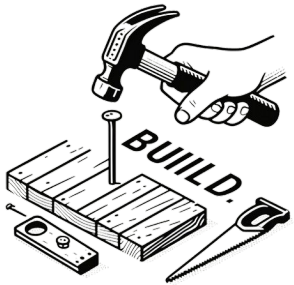


- Little standardization in packaging, test
  - Companies often waste time re-inventing
  - Requirements can vary by application

- Requirements are different from electronics
  - Often can't use "industry standard" tools as-is
  - Time is wasted building new tools or badgering vendors



Software strategies



In-House Development

Limited by your engineers **time and abilities.**

Buy

Bound by vendor **limitations**.

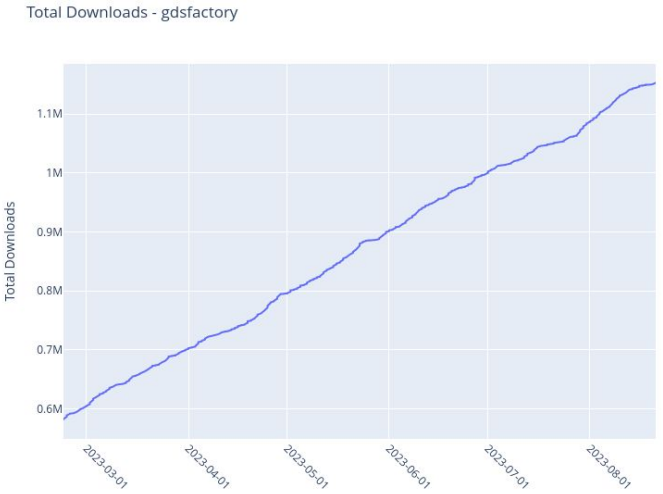
Open Source

- **Open:** Software is maintained and tested by a large community. Code is transparent. Bugs are not mysterious.
- **Extensible:** Customize and enhance with home-built features tailored to your needs.

$ Cost	staff	licenses + (support + services)	(staff + support)
Time	developing + training + using	learning + interacting + waiting + using	learning + contributing + using

GDSFACTORY

- Highlights
  - 2M+ downloads
  - 60+ contributors
  - 10+ PDKs
- 100% Open source, Python based
  - Works on Linux, Windows and MacOs
- Extensible Plugins



FEMWELL

Device and Circuit simulations

Ansys LUMERICAL

Tidy3D

Soux

Simulation API

PROBE SW Test Plan

Wafer Level Prober

Wafer Level Die Bonder

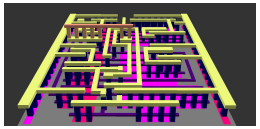
Python Environment

GDS FACTORY

Design Feedback

Test Feedback

3D view



Layout + DRC API

Tech File and PDK

Tower Semiconductor Where Analog and Value Meet

GlobalFoundries

CompoundTek

skywater

amf ADVANCED MICRO FOUNDRY

AIM PHOTONICS

CORNERSTONE

VTT

Fraunhofer HHI

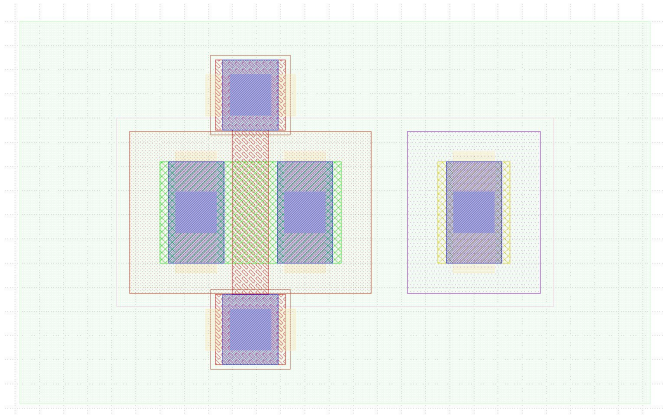
SMART PHOTONICS

ANT APPLIED NANOTOOLS

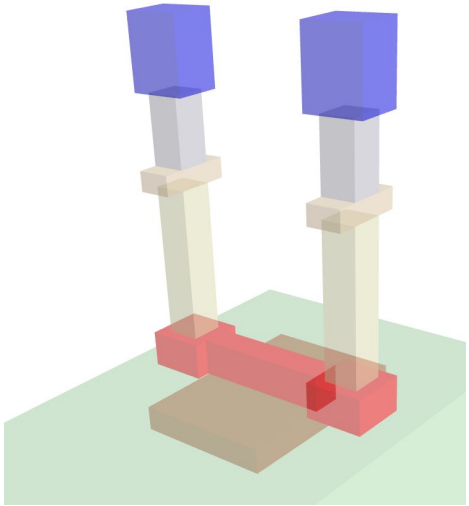
CNM Centre Nacional de Microelectrònica IMB

Programmatic layout

```
c = nmos(gate_length=0.15, gate_width=0.42)
c.show()
```

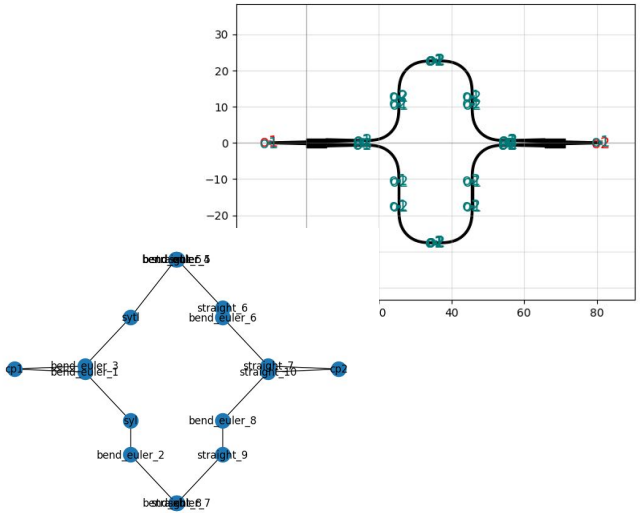


Layout → simulation



Components to circuits

Hierarchical layout and simulation



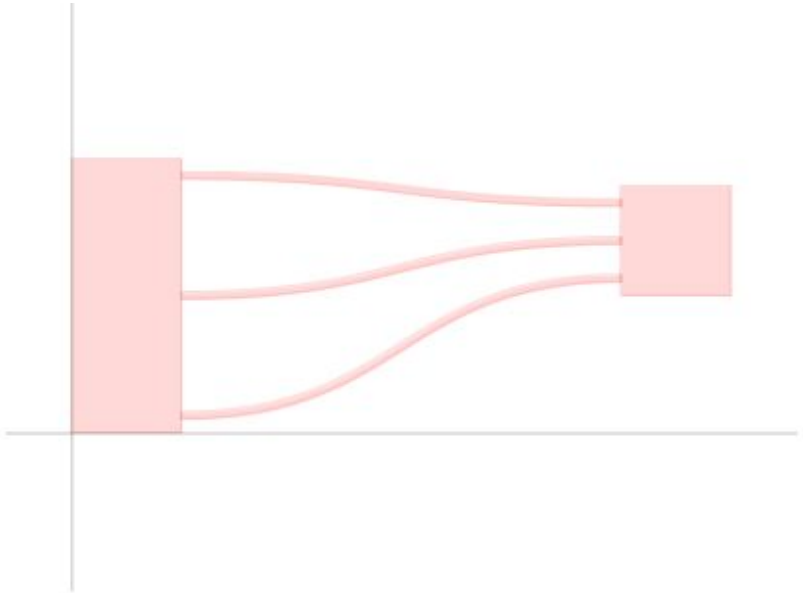
Python flow

1. run python code

```python
@gf.cell
def nxn_to_nxn() -> gf.Component:
      c = gf.Component()
      c1 = c.add_ref(gf.components.nxn(east=3, ysize=20))
      c2 = c.add_ref(gf.components.nxn(west=3))
      c2.move((40, 10))
      routes = gf.routing.get_bundle(
        c1.get_ports_list(orientation=0),
        c2.get_ports_list(orientation=180),
        with_sbend=True,
        enforce_port_ordering=False,
      )
      for route in routes:
         c.add(route.references)
      return c


c = nxn_to_nxn()
c.show()
```

2. Visualize GDS

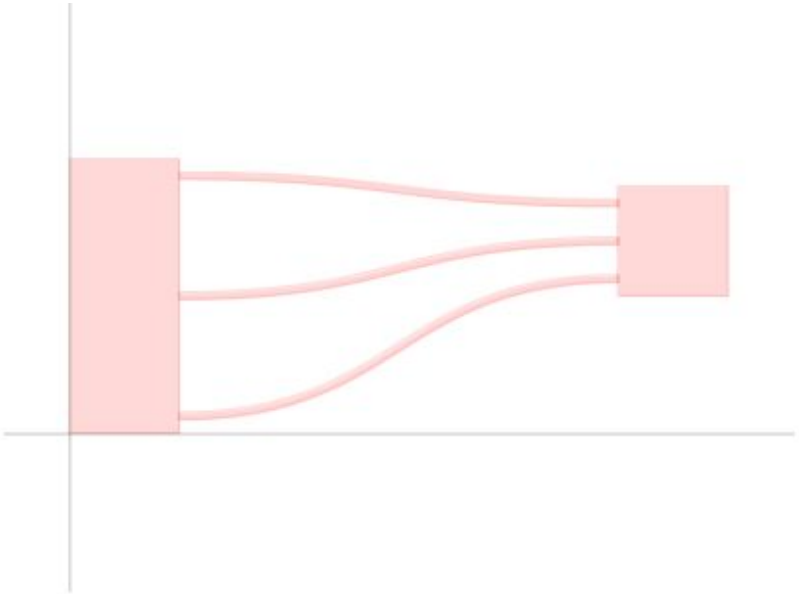


YAML flow

1. YAML

```yaml
name: nxn_to_nxn
instances:
  c1:
        component: nxn
        settings:
        east: 3
        ysize: 20
  c2:
        component: nxn
        settings:
        west: 3
placements:
  c2:
        x: 40
        y: 10
routes:
  optical:
    routing_strategy: get_bundle
    settings:
      with_sbend: True
    links:
      c1,o4: c2,o1
      c1,o3: c2,o2
      c1,o2: c2,o3
```

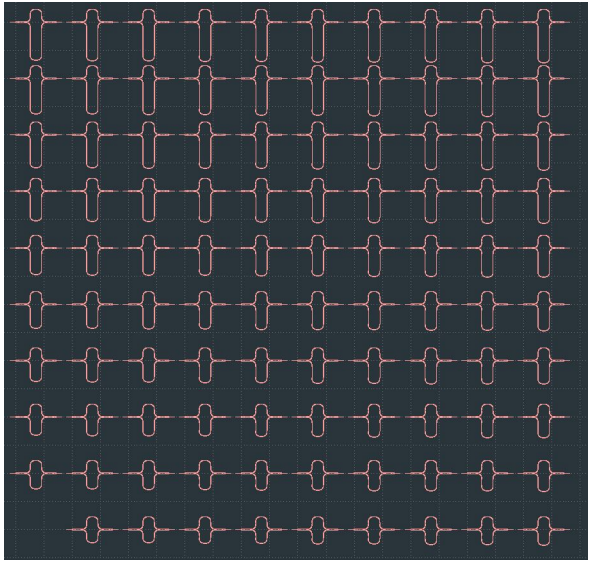
2. See GDS in klayout



Key Advantages

- Free and open source
  - Extensible
  - Community support
  - No vendor lock-in
- Python-based
  - Powerful
  - Easy to learn
- Fast, C++ backend

Benchmark	gdspy	gdsfactory	Gain
10k_rectangles	80.2 ms	4.87 ms	16.5
boolean-offset	187 µs	44.7 µs	4.19
bounding_box	36.7 ms	170 µs	216
flatten	465 µs	8.17 µs	56.9
read_gds	2.68 ms	94 µs	28.5



gdsfactory
100 MZI variations in
1.4 seconds


Google


PsiQuantum


FREEDOM
PHOTONICS
A LUMINAR COMPANY


Meta


SRI International


LightIC
Technologies


UNIVERSITY OF
MICHIGAN


amf
ADVANCED
MICRO
FOUNDRY


UNIVERSITY OF
MARYLAND


Georgia
Tech


black
semiconductor


EHVA
Photonics


AIM
PHOTONICS


Lumiphase


Massachusetts
Institute of
Technology


University of
BRISTOL


PRINCETON
UNIVERSITY


Queen's
UNIVERSITY

Hands-on introduction

1. Building devices and PDKs
2. Building a photonic circuit
3. Building an analog circuit