Dual Signal Optical Logic Architecture (DSOLA)

All-Optical Logic for a Post-electronic Era

HOT CHIPS 2025

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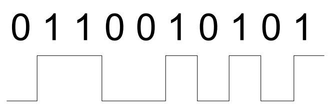
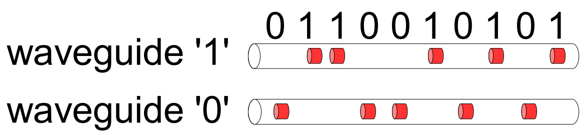
① Dual-Signal Optical Encoding:

-Logic Without NOT Gates-

Traditional binary encoding: **1** wire; **2** signals (**1**,**0**)



DSOLA uses **dual optical waveguides**: signal in waveguide '**1**' represents logic high (**1**), while signal in waveguide '**0**' represents logic low (**0**)



Dual-encoded logic gates **double** waveguides:

Logic reconfiguration made easy. Simply reverse Y1 ↔ Y0 to turn an AND into a NAND, **without the need for additional NOT gates**

ADVANTAGE #1

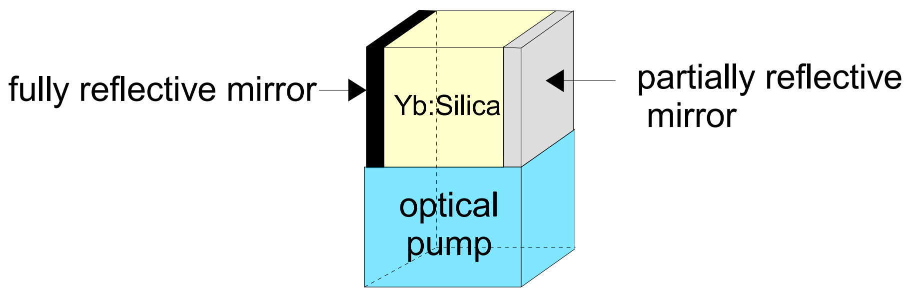
-Data **robustness** (transmission & processing)

-No need for **NOT gates** → simpler, faster, lower-power design

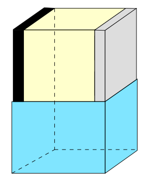
② Laser-threshold transistor:

-A Building Block for Optical Logic Gates-

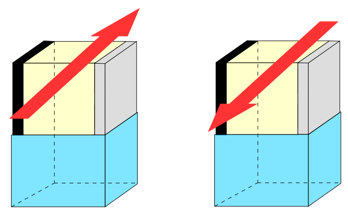
The **laser-threshold transistor**:



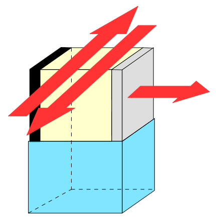
Pumped just below lasing threshold



One input = no output

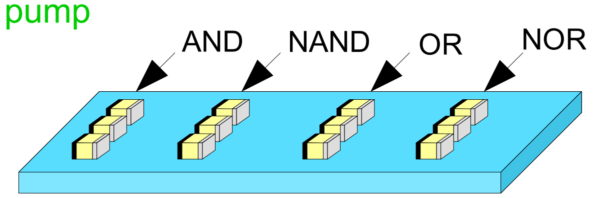


Two inputs → threshold surpassed → laser fires



ADVANTAGE #2

-No individual pumps needed. All transistors share one optical pump



③ All-optical Logic Gates:

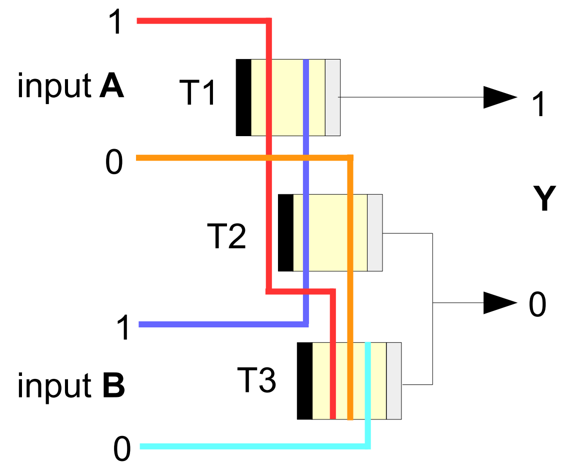
-Laser Speed Logic-

DSOLA AND gate:

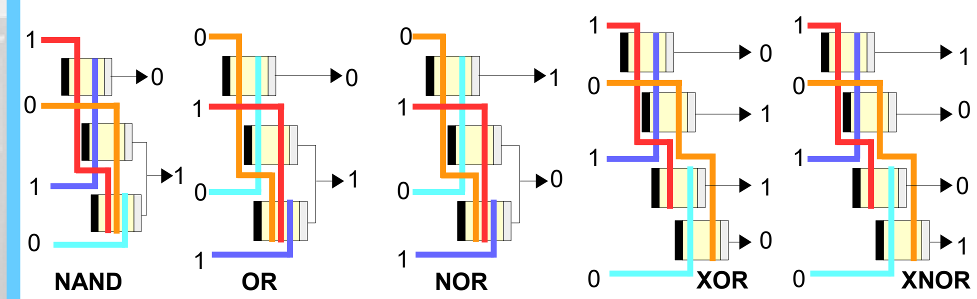
Uses **3** laser-threshold transistors.

Only when both inputs (**A1** and **B1**) are active, output goes to waveguide '**1**' (logic **1**).

All other cases → waveguide '**0**' (logic **0**)



Other gates (**NAND**, **OR**, **NOR**, **XOR**, **XNOR**) use similar transistor layouts with adjusted output routing.



ADVANTAGE #3

-Only one laser-transistor is activated per input combination for any logic operation:

extremely fast logic execution