Generation of Failure Inspection Pattern without Design Impact during P&R in BSPDN Design

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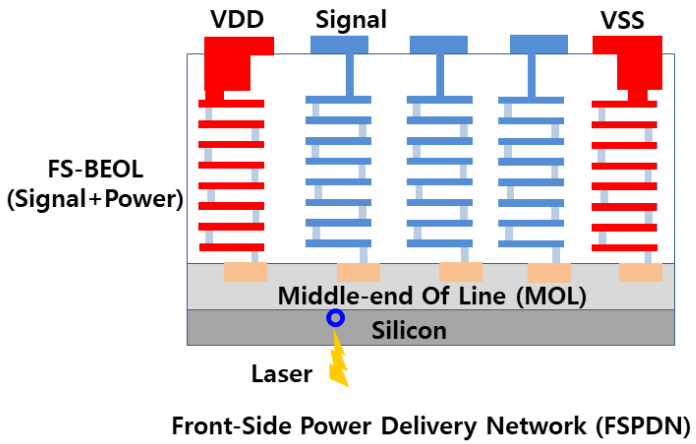
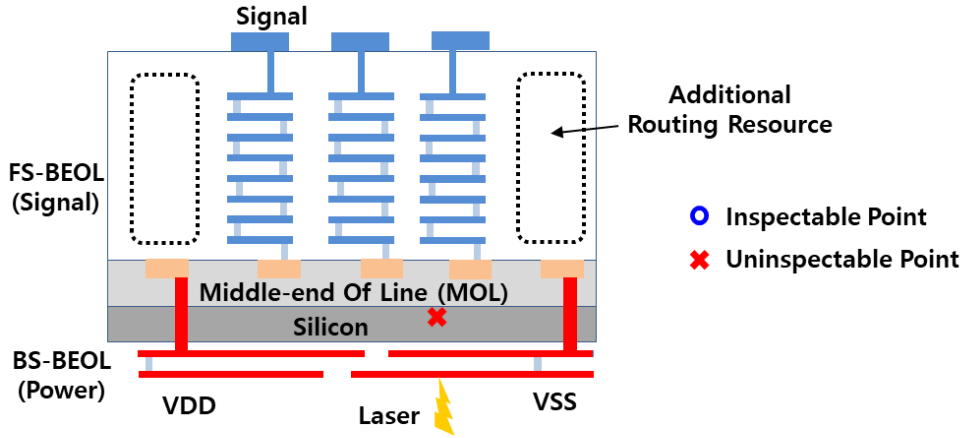
Motivation

- Back-Side Power Delivery Network (BSPDN)
  - Signal routing in front side of BEOL (FS-BEOL) and power delivery in back side of BEOL (BS-BEOL)
- Motivation
  - BSPDN's advantage: mitigation of IR-drop and additional routing resource due to increased number of signal tracks in FS-BEOL
  - Dense metals on both sides, i.e., FS-BEOL and BS-BEOL
  - ➢ **Challenges in optical/electrical silicon failure inspection due to metal on both sides**
- ➢ Need Appropriated Failure Inspection Patterns in BSPDN Designs



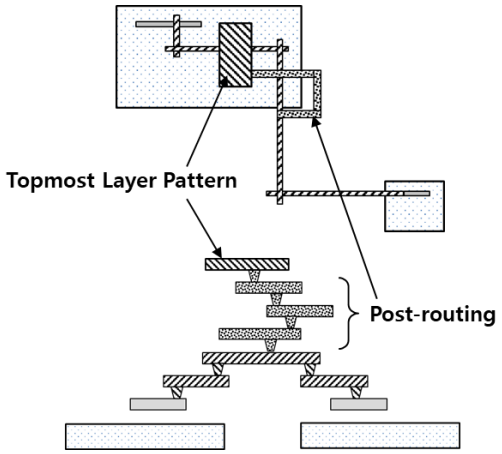
Front-Side Power Delivery Network (FSPDN)



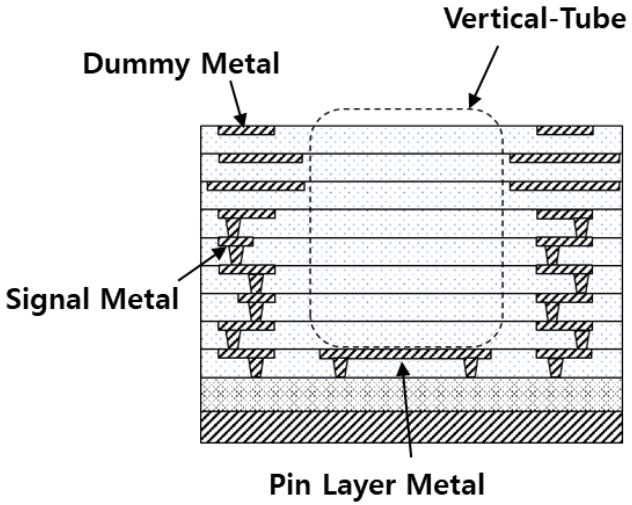
Back-Side Power Delivery Network (BSPDN)

Main Idea

- Basic Concept
  - Need topmost layer patterns for eBeam-based Failure Isolation (EFI), which is connected to target net
  - Need empty region for Optical-based Failure Isolation (OFI), which is not metal but only dielectric materials
  - Minimized design impact without change of existing nets
- Failure Inspection Patterns
  - For EFI: Post auto routing after generating topmost layer inspection patterns
  - For OFI: Vertical-Tube generation using routing blockages of target pins



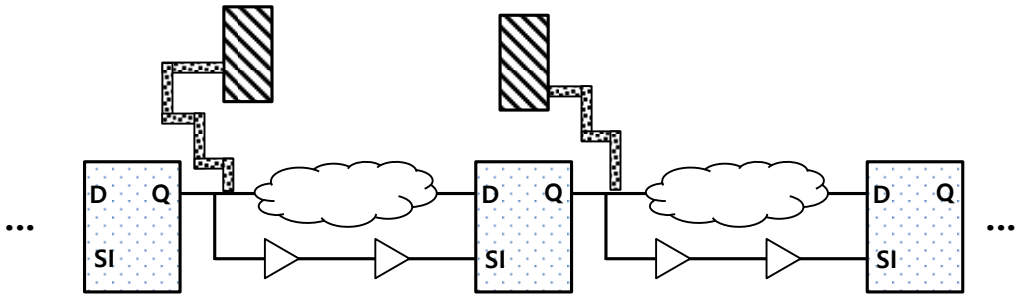
Post Auto Routing for Failure Inspection Pattern



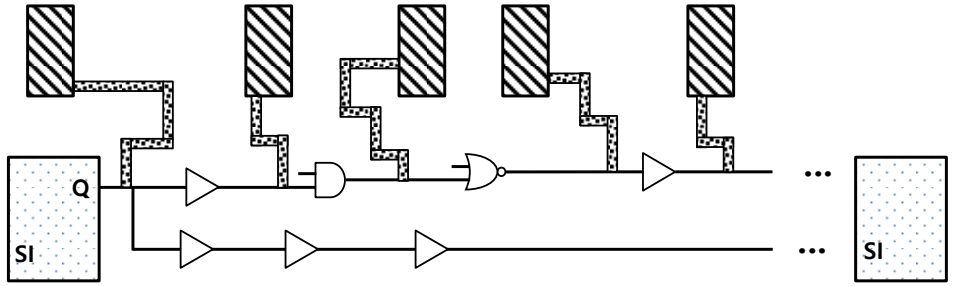
Vertical-Tube Generation for Failure Inspection

Main Idea

- For EFI
  - Post Auto Routing for Failure Inspection Patterns
    - Insert inspection patterns after route step
    - Select target net → Generation of Temporary port for target nets at topmost layer → Connection to target net using ECO Route command → Timing optimize → Remove temp port & Physical Sign-off
  - Can select any net for inspection



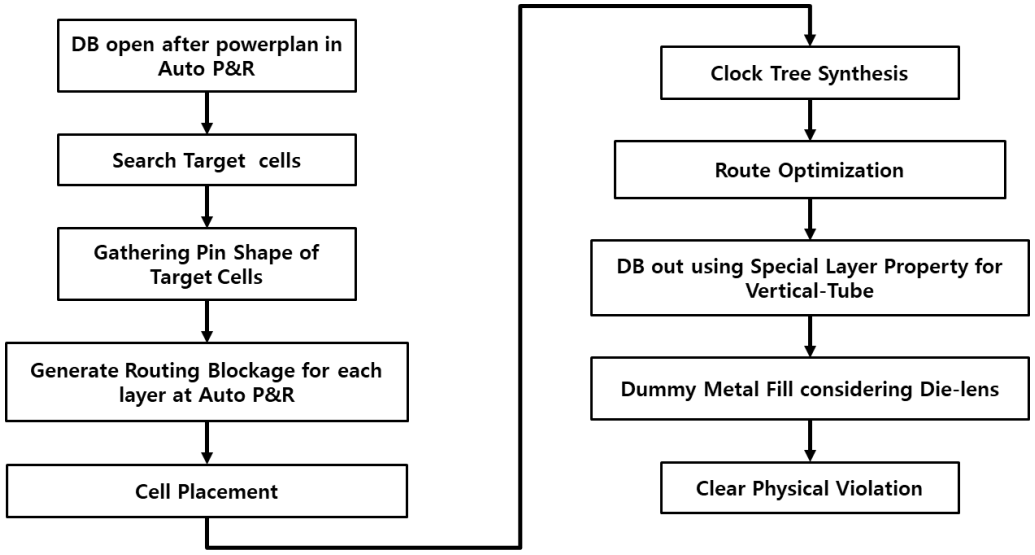
Inspect Waveform at Q-pin of FFs

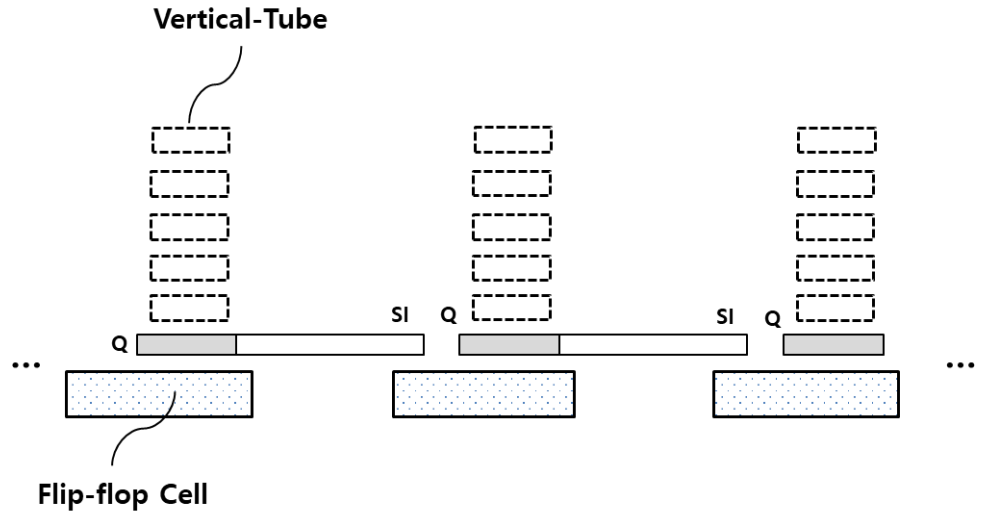


Inspect Waveform at Combinational Pins

Main Idea

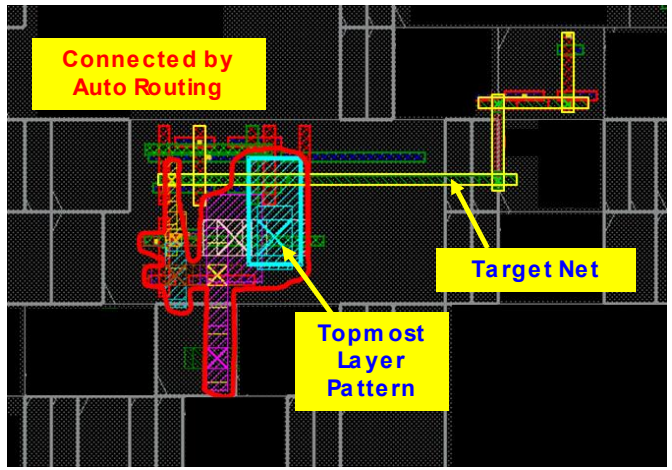
- For OFI
  - Vertical-Tube
    - Vertical-Tube should be applied before route step
    - Cell-based application via LEF modification at design stage
    - Instance-based application using different LEF library
    - Dummy Fill insertion considering Vertical-Tube



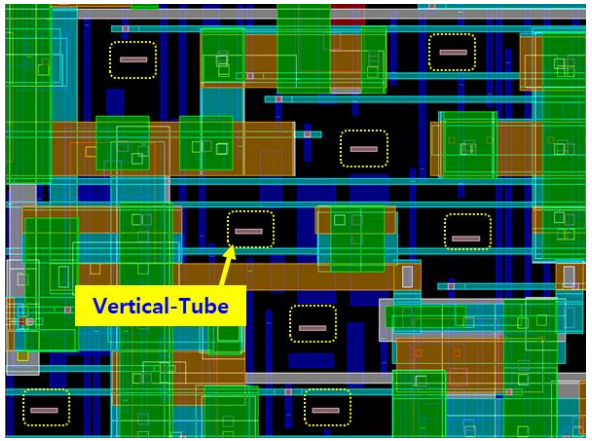


Validation in Physical Design

- Test Vehicle using Samsung BSPDN Process
- Generation of Failure Inspection Patterns
  - Post auto routing for failure inspection patterns: All nets related to flip-flops
  - Cell-based Vertical-Tube: Q or SI pins of flip-flops



Post Auto Routing for Failure Inspection Pattern in P&R



Vertical-Tube for Failure Inspection in Design

Summary

- In advanced nodes, BSPDN can mitigate IR-drop and provide more relaxed routing congestion in FS-BEOL
- However, failure inspection patterns should be inserted in design to directly approach failure points
- Auto post routing method to connect topmost inspection patterns to target nets can be applied without change of existing nets, for EFI
- Vertical-Tube can provide direct empty region, which is occupied by only dielectric materials, for OFI
- Using the proposed generation method, BSPDN design can be readily tested in case of silicon failures