Photonic Integrated Circuitry

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Jack Kilby's revolutionary integrated circuit

Introduction

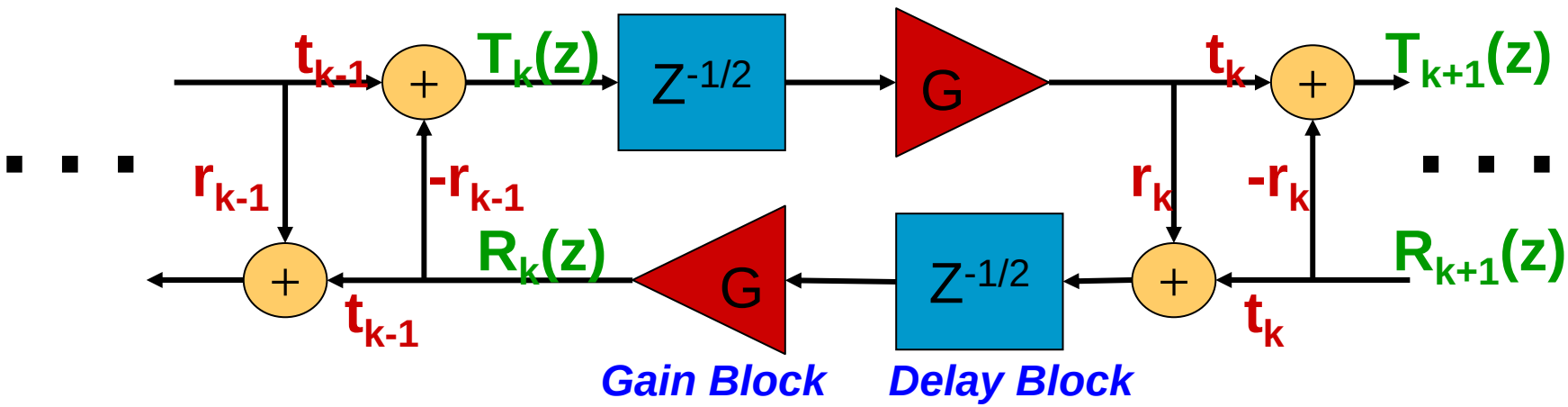
- Early electronic filters used only L, C and R's – "Passive Filters"
- Gain elements, first vacuum tubes, later transistors, allowed "Active Filters"
- Current optical filters are purely passive
- It is time to develop optical filters with gain that are higher performance, and adaptive

We are developing a manufacturable, programmable, Photonic Integrated Circuit!

Active Lattice Filters

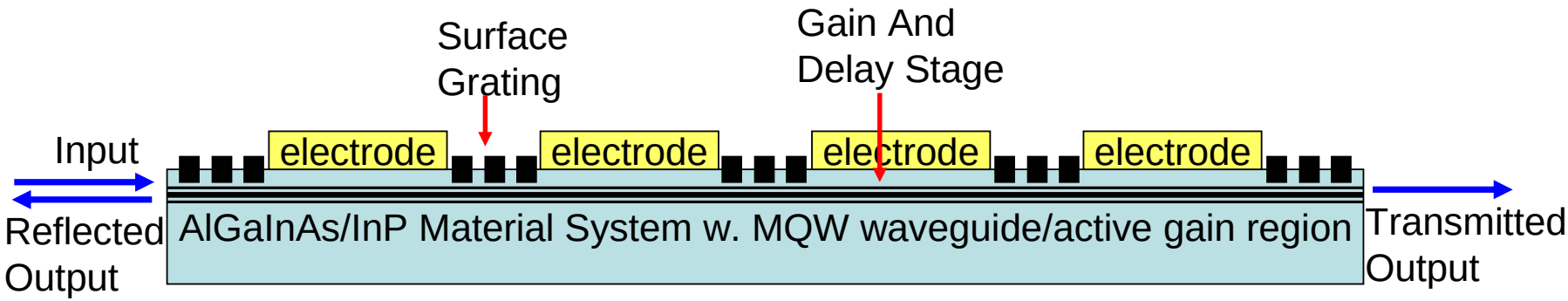
An active optical filter has a gain element that allows the weights associated with the different poles and zeroes to be tuned.

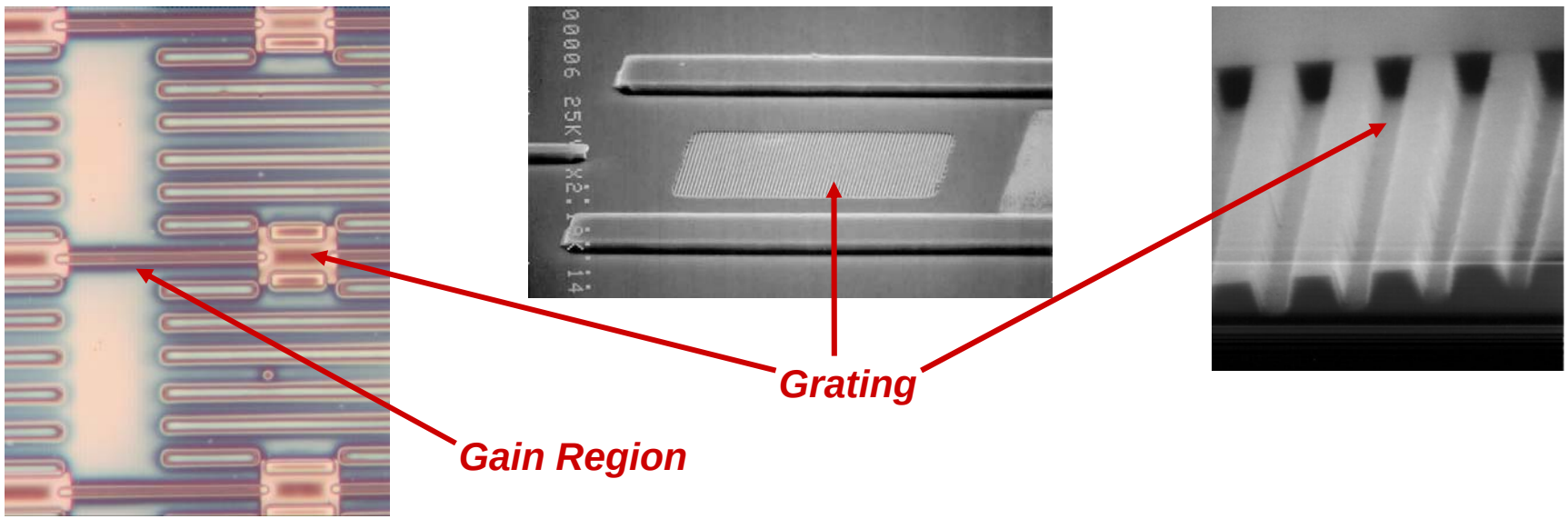
- Lattice Filters good for:
  - Linear Prediction
  - Frequency Discrimination
  - Robust wrt realization limitations
- Gain allows:
  - Improved quality factors
  - Adaptive filters



Surface Grating Photonic IC

We are using the GSE technology for integrated active optical filters

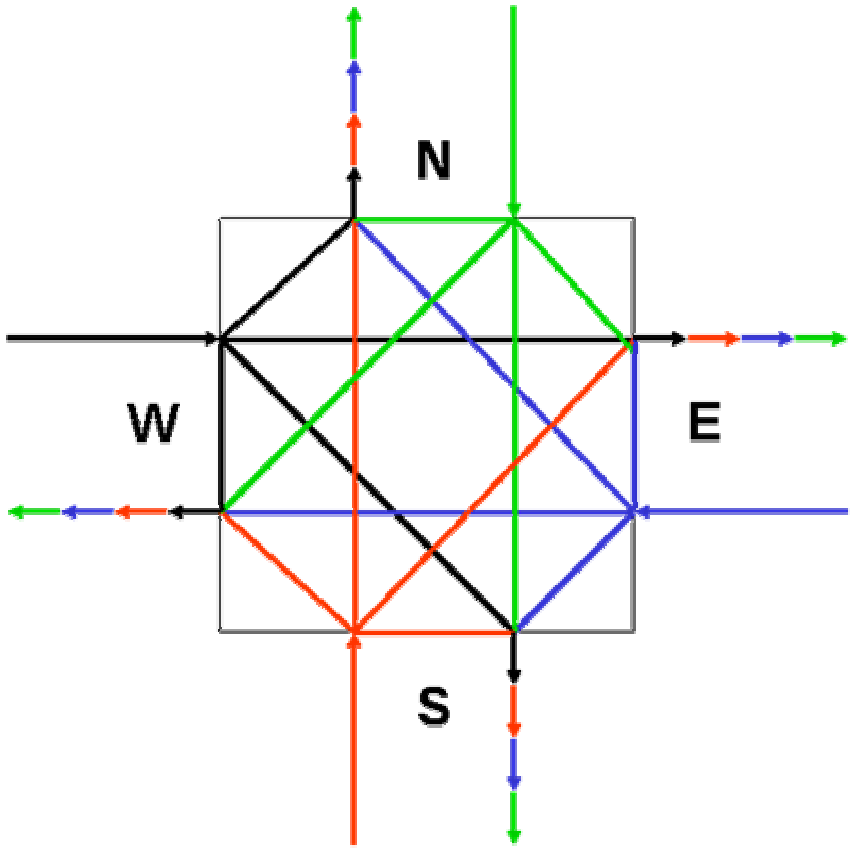


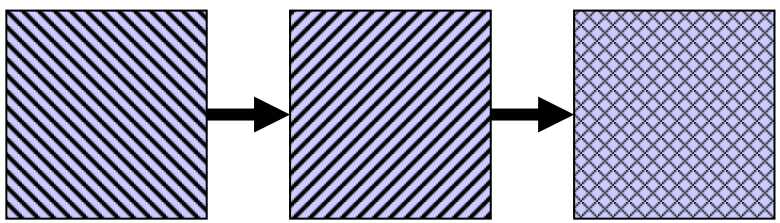


The Erik Jonsson School of Engineering and Computer Science

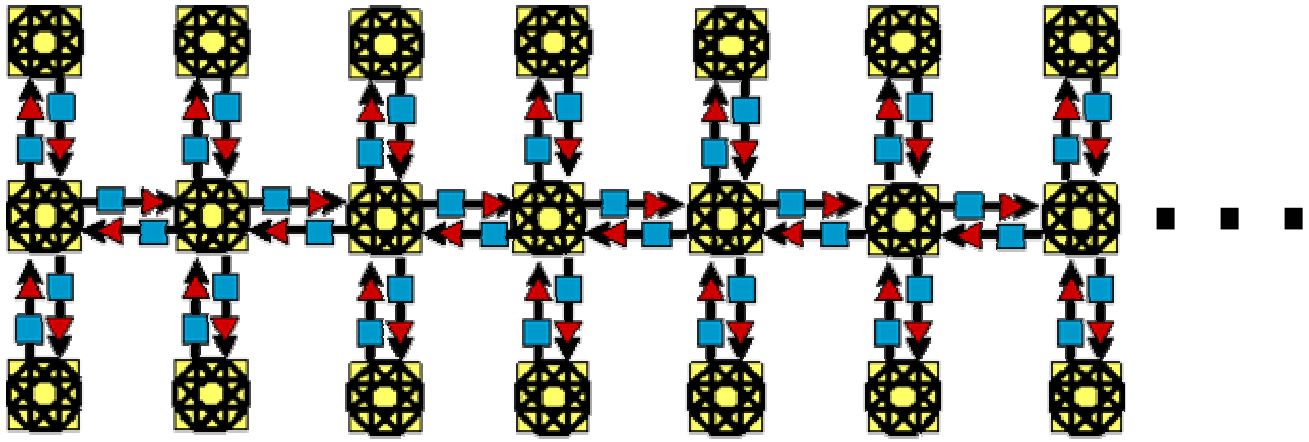
Four Directional Couplers

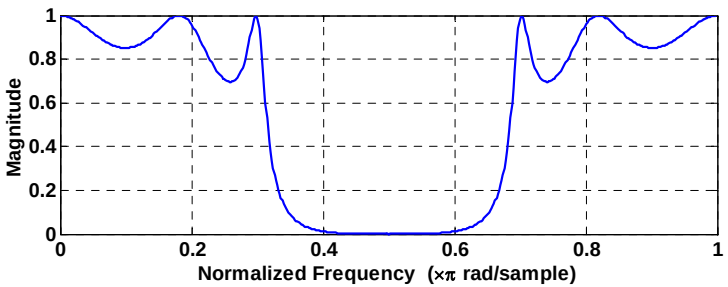
- Grating can couple in multiple directions
  - Input/output
  - Mesh structure
- FIB nanostructure
- Holographic lithography
  - Two step process
  - Crossed Gratings

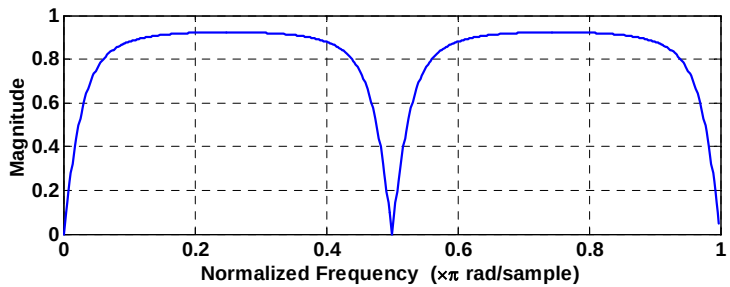


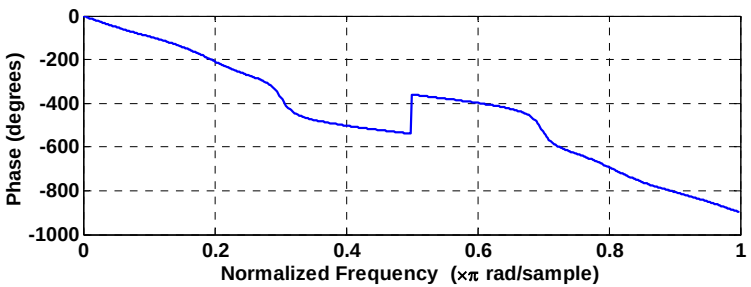


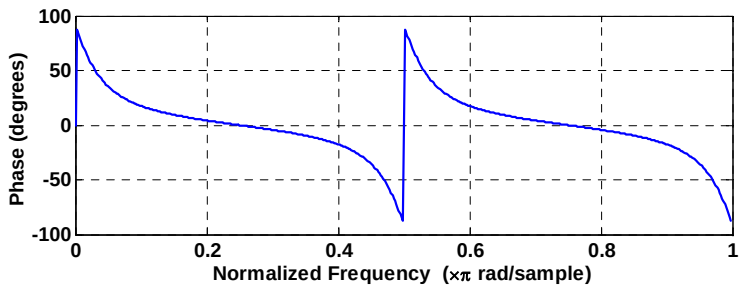
2D GSE Lattices: “Thick Linear”





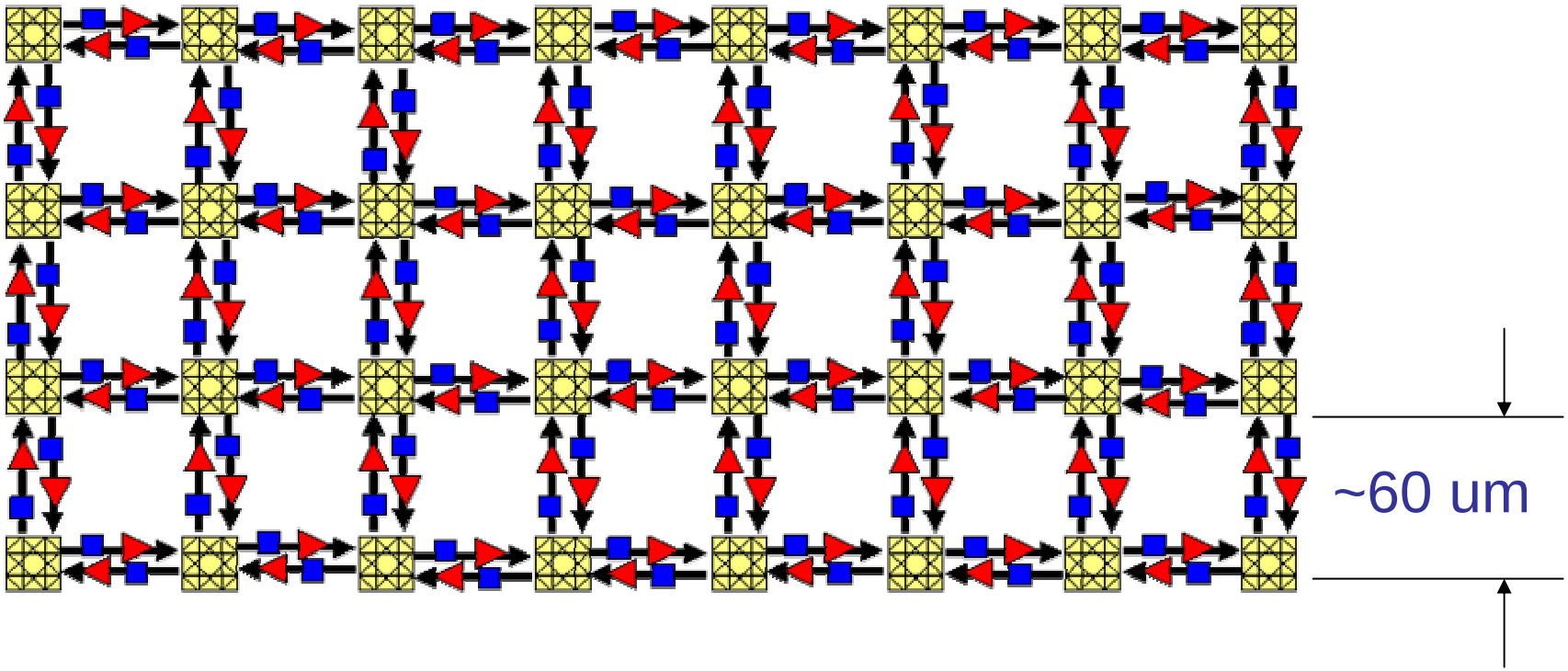






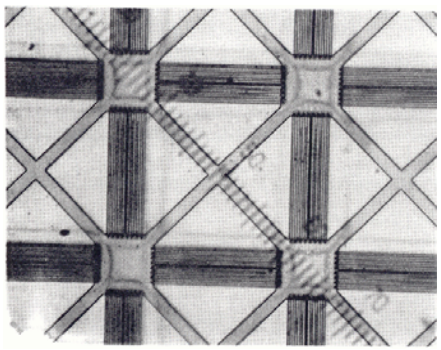
Two Dimensional GSE Lattices

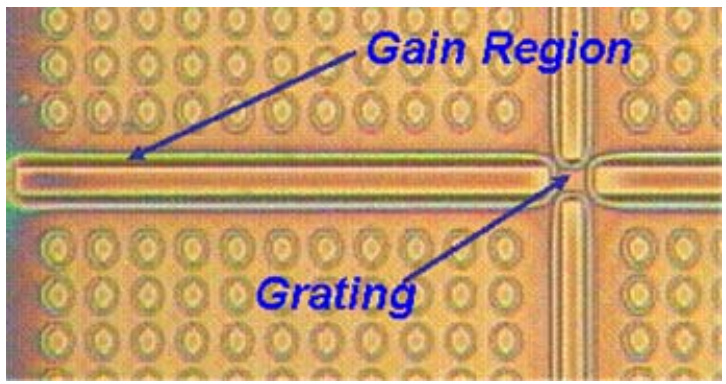
Completely new filter structure solved by layer peeling with 2nx2n matrices … Research is benefiting fundamental DSP engineering

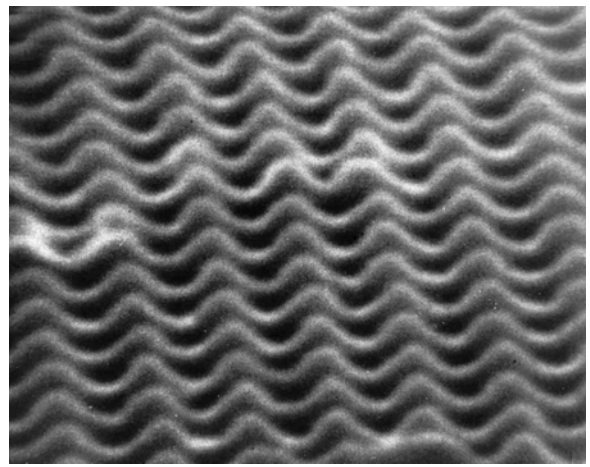


Two Dimensional GSE Lattices

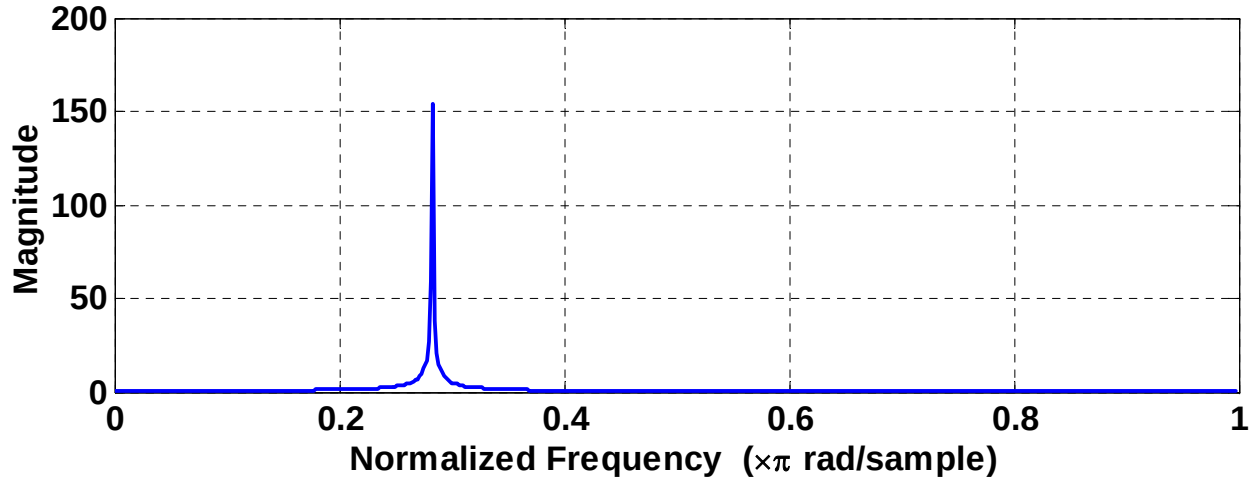
- Multiple Input, Multiple Output Applications
  - Add/drop applications, dwdm, o-cdma on same chip
  - Cross correlators, decouplers, cross-talk cancelation
  - multi-trajectory tracking, joint process estimation
- Fully Tunable … programmable
- Extends the palette of filter realizations for optimal implementations

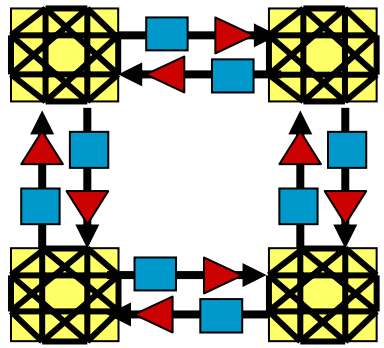


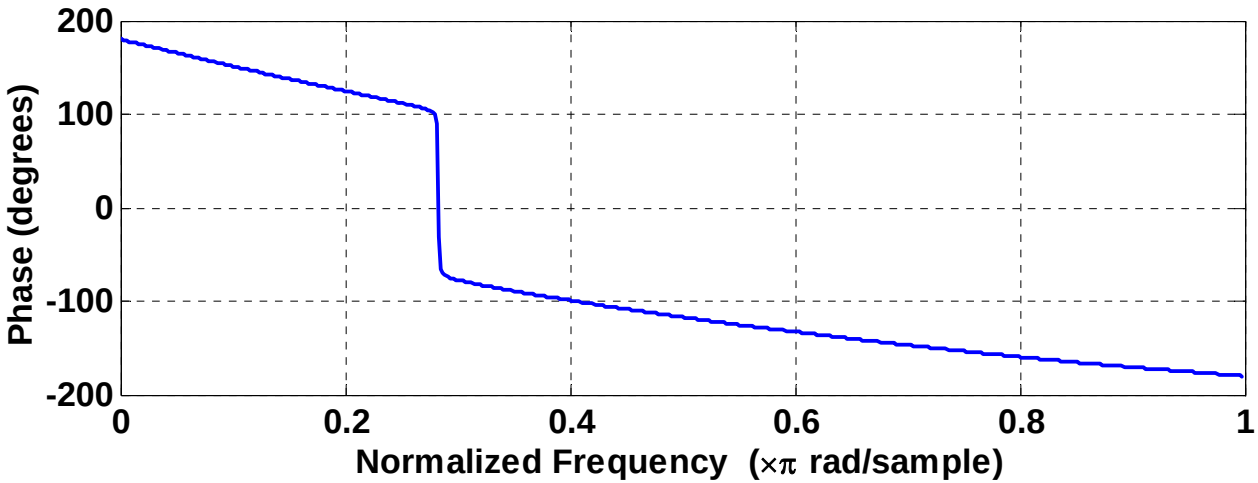




Frequency Selection

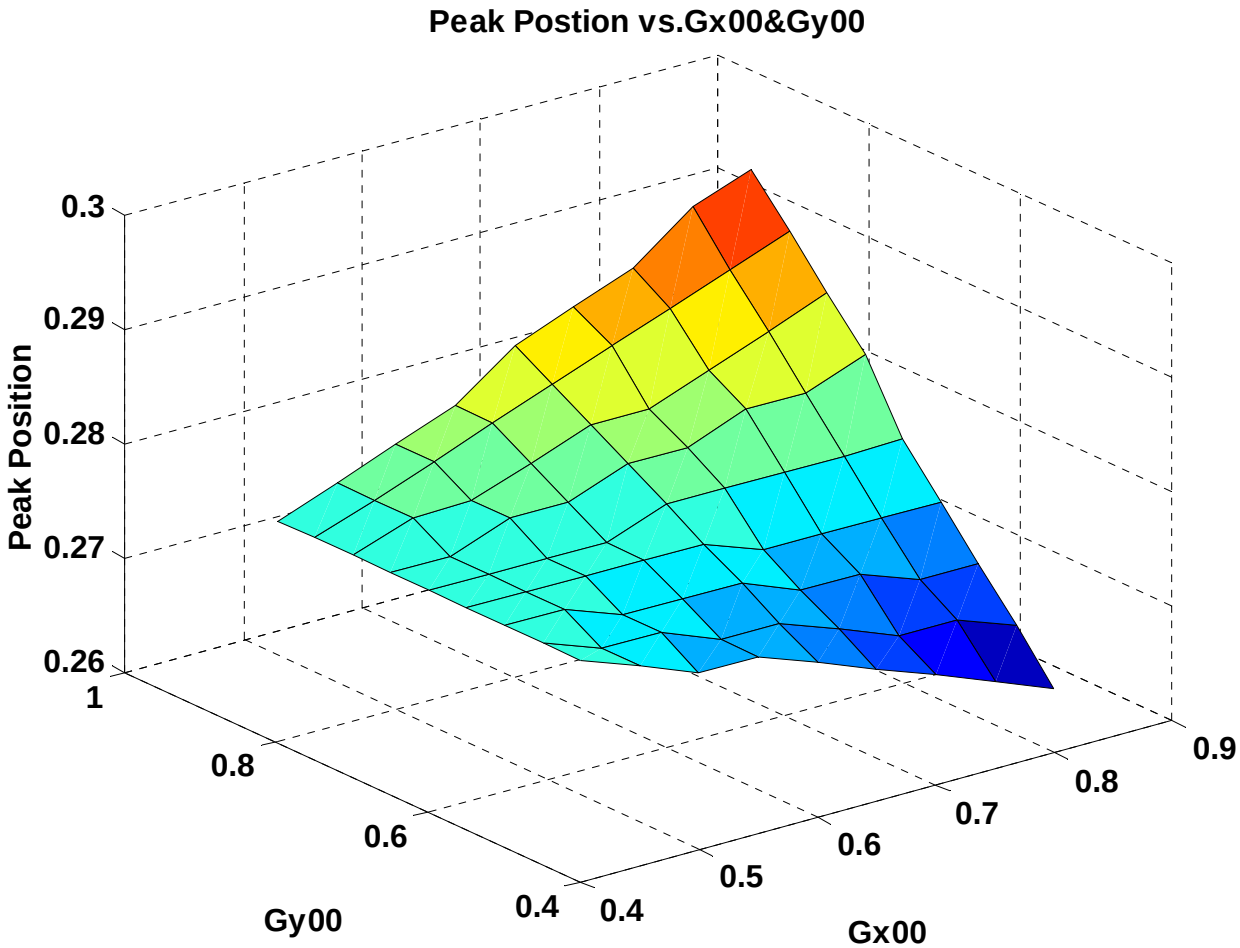


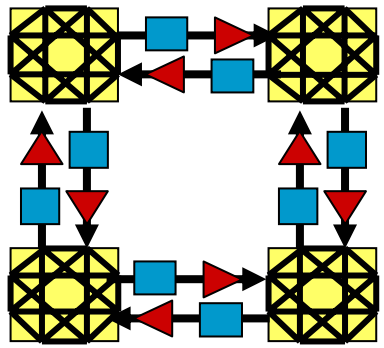




Stable operation with Q >75,000

Bandpass Frequency Tuning via Gain





Economically Viable Device

- Structure is highly manufacturable
  - Standard Epitaxy
  - Photolithographic gratings
    - Last step in process
    - No regrowth
    - Chip scale process (parallel)
  - Being commercialized for lasers
- Basic structure can be standardized for fabrication purposes
  - Individual users may then program them for a particular application
  - ***Just like an FPGA or a DSP***

Outcome of the Research Program

- Standardized Photonics
  - Two dimensional lattice has wealth of transfer functions supporting widespread applications
  - Programming determines application
- Basic advances in DSP
  - Two dimensional structure is new
  - Highly appropriate for MIMO applications

100 GHz clock rates and GHz tuning rates will enable high volume information engineering applications