Micro-optical eye-safe steered-beam platform capable of ultra-high-speed pointing, acquisition, tracking and data communication

Overall Goals:

1. Demonstrate technology for fast beam acquisition / initiation to establish a covert, high speed free space optical link between two platforms without a prior knowledge of each other's locations

2. Demonstrate high-speed, low-error-rate optical transmission between the two moving platforms

Overriding performance requirement: covertness

Means to achieve requirement: Burst mode operation: rapid accomplishment of operation (acquisition + data transmission) then cut link and shut up

Technology required to achieve Means:

A. Rapid acquisition:

1. Fast MEMS scanners:
   a. MEMS mechanical design for fast scanning (Solgaard)
   b. lightweight, rigid, high optical quality scanning mirrors (Lau)
   c. phased-array MEMS scanning structure exploration(Solgaard)
2. Position-sensitive detector-array for locating direction of incoming beam
   a. high resolution detector array with integrated HEMT (Forrest)
   b. wide-field reception optics (Kahn)
   c. sub-pixel accuracy beam-locating algorithm (Kahn)

3. Fast beam acquisition / initiation / handshake / tracking
    a. algorithm development and demonstration (Lau, Kahn)
    b. high accuracy feedback control of 2-axis MEMS scanners (Lau)

B. Data transmission :

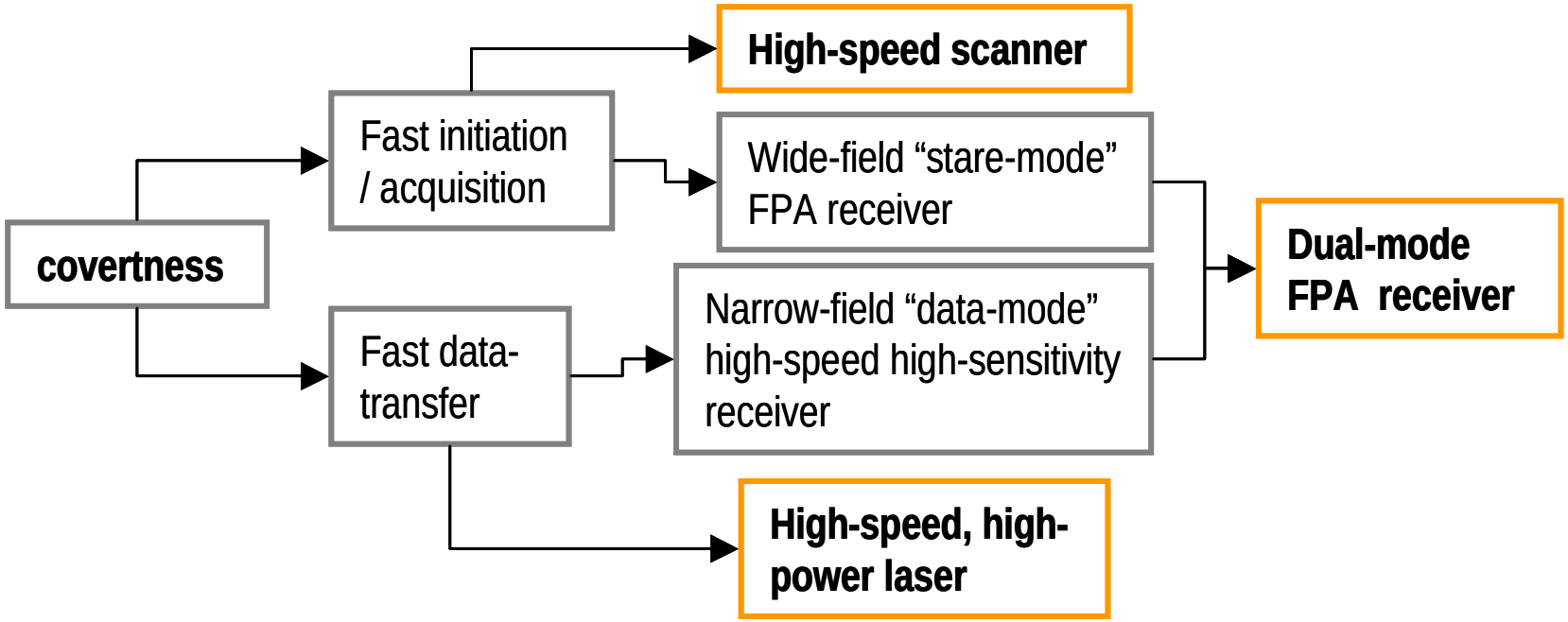
1. High power 1.55μm laser source (Forrest)
2. High speed receiver array with wide-field reception optics (preferably the same one as in A-2 above) (Forrest)
3. Optimum signal processing algorithm of receiver array output for maximum transmission performance (Kahn)
4. Coding / data-packetization techniques to negate effect of atmospheric turbulence (Kahn)

C. Packaging of transceiver module:

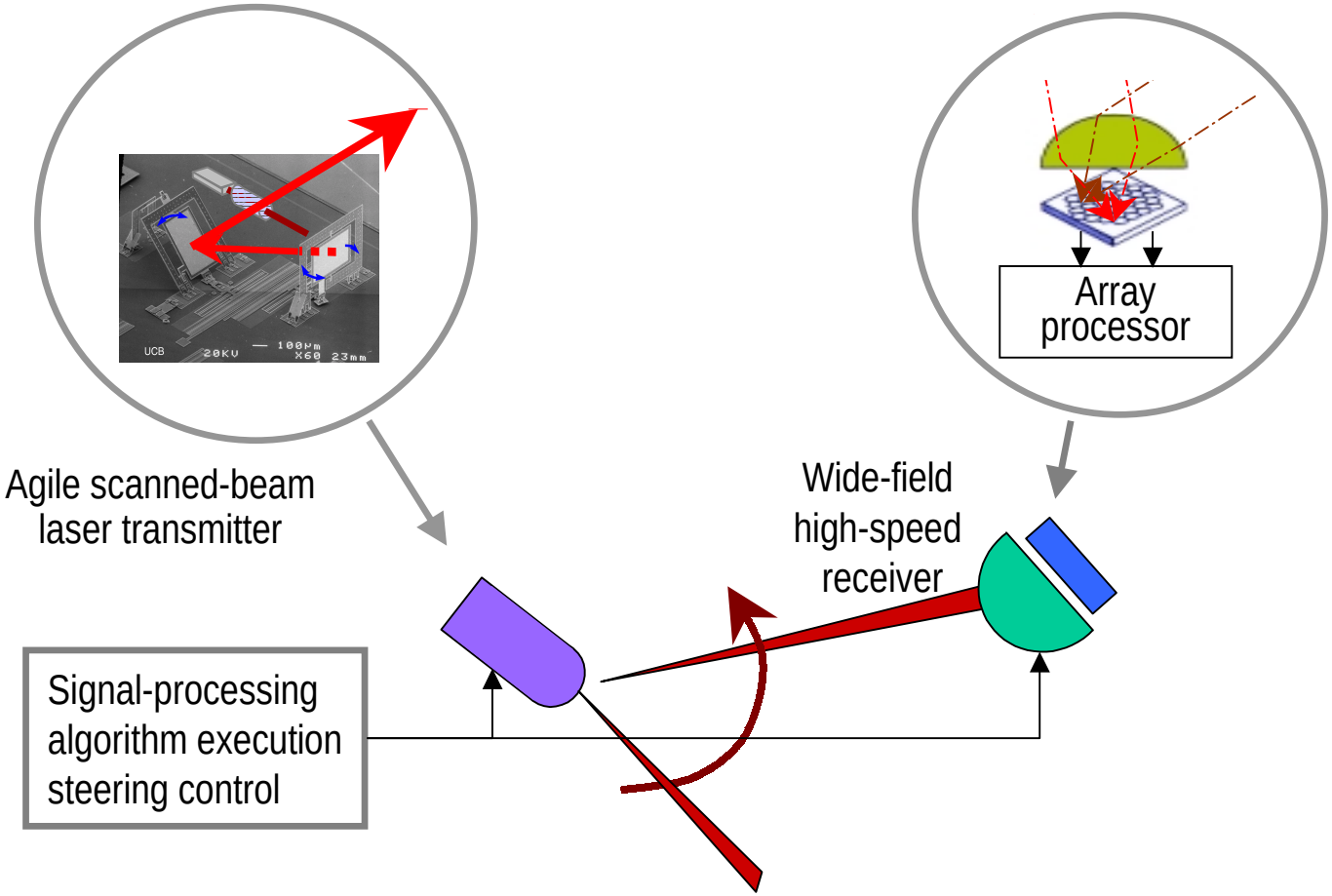
Hybrid integration of micro-optical platform of MEMS scanner(s), receiver array, monitoring / projection optics onto a compact micro-optical platform (Solgaard)

System integration (all)

Rationale for technology development – top-down approach

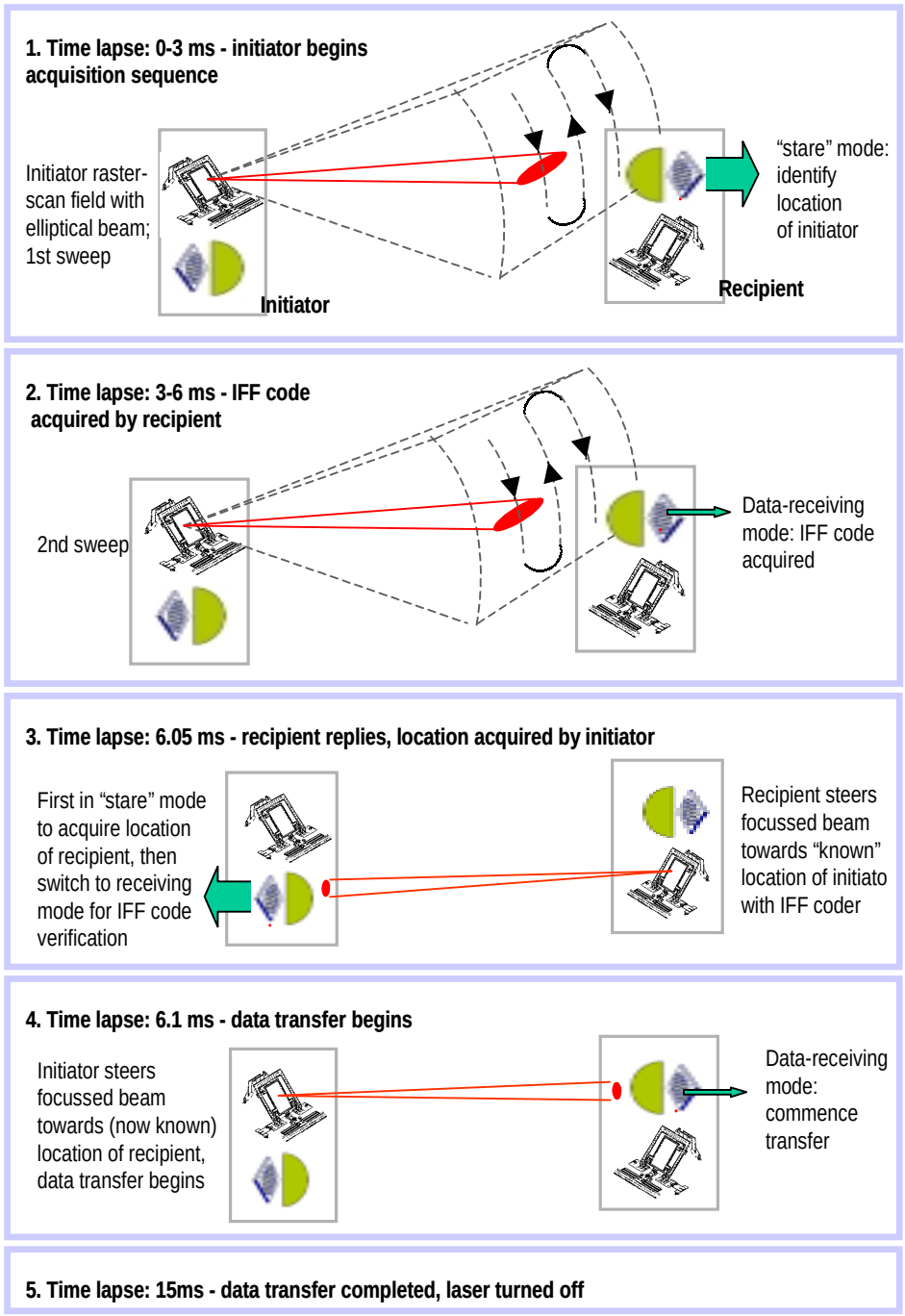


Basic components of a steered-agile-beam communication platform

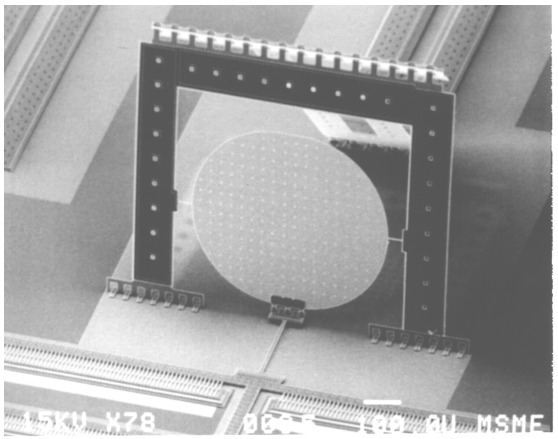


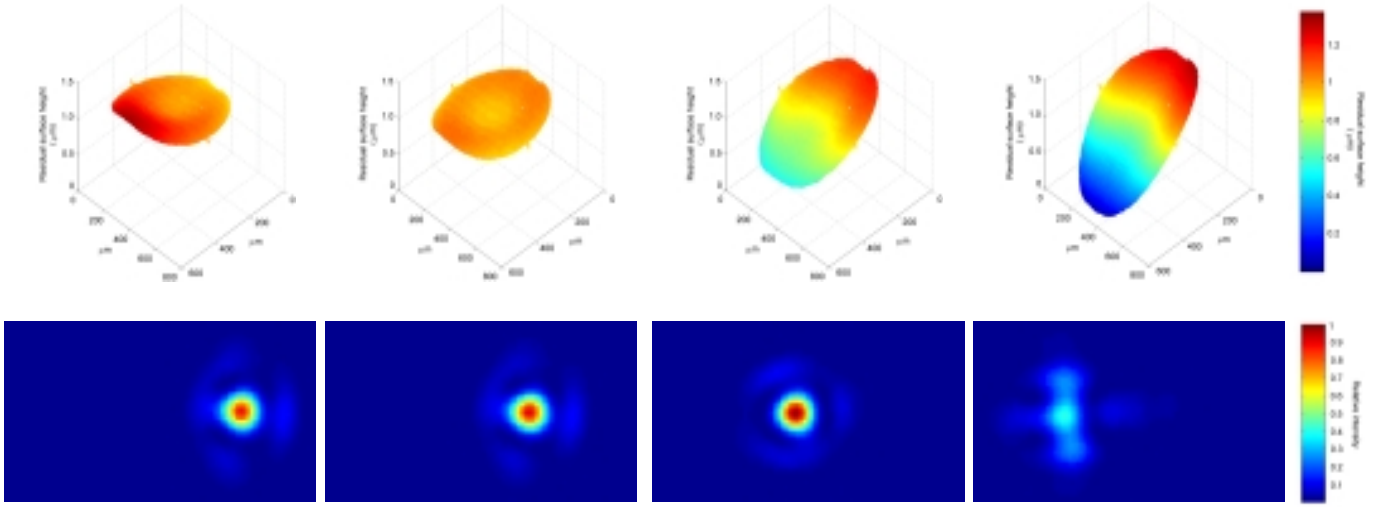
Fast acquisition and handshake procedure

From a blind start, sender and recipient acquire each other's location within 6ms and begin data transfer at Gb/s rate.

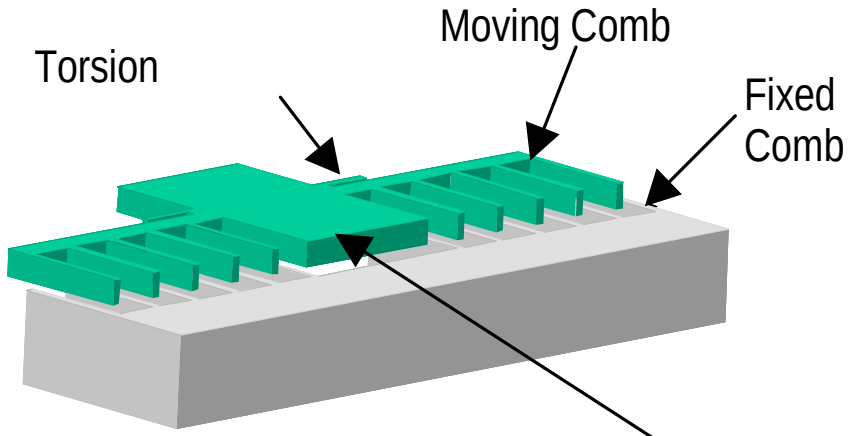


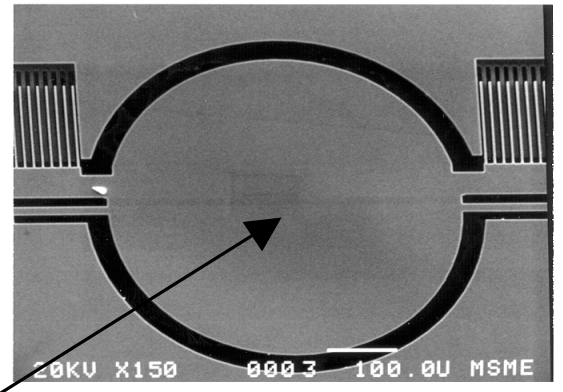
Issues with polysilicon MEMS scanning mirrors – dynamic deformation

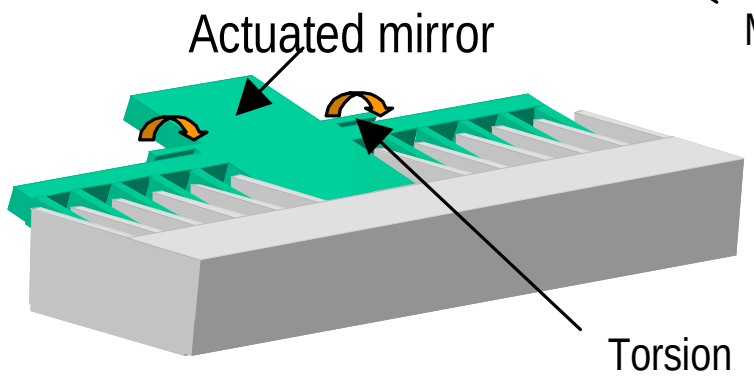


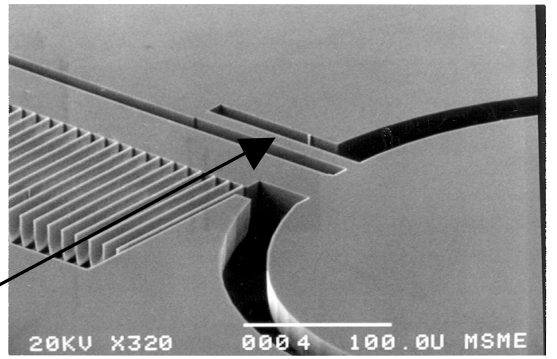


New high-speed high-quality scanners – staggered vertical comb drive

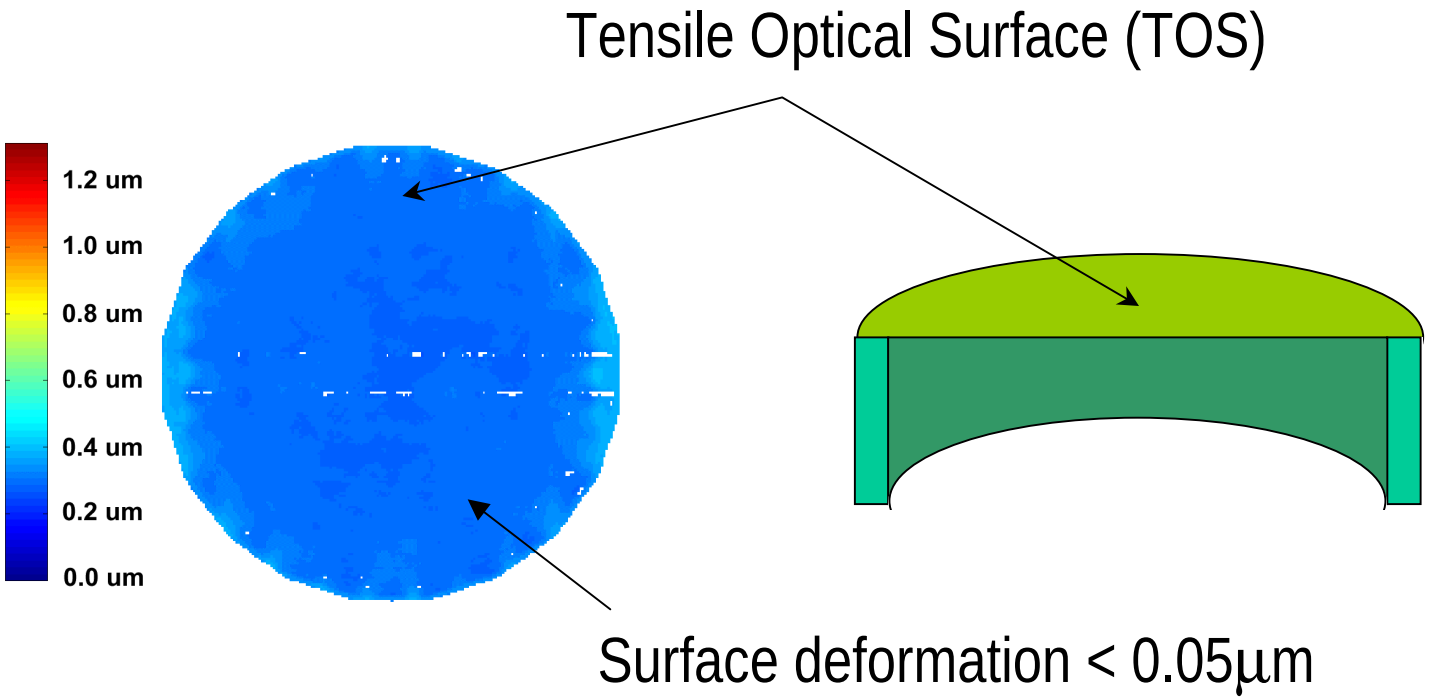




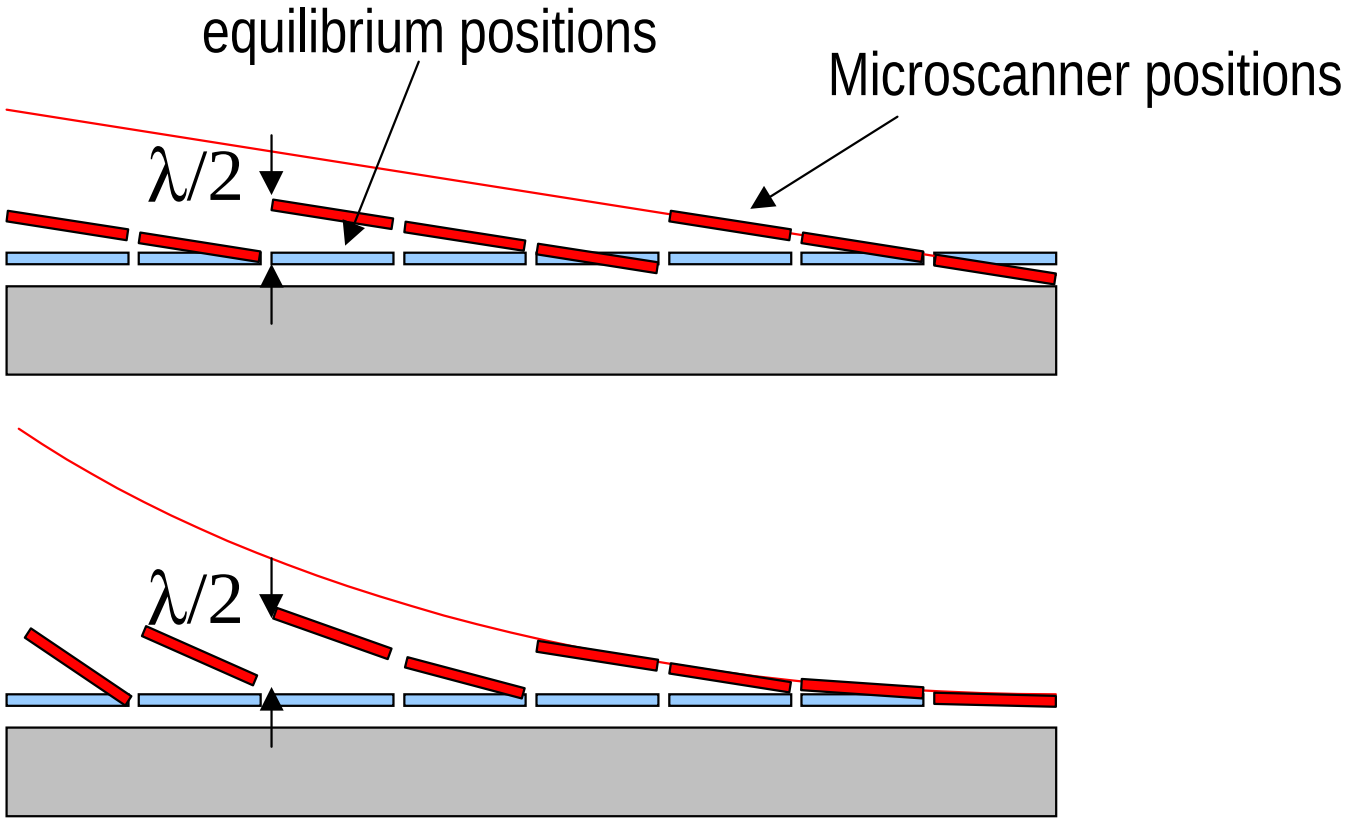




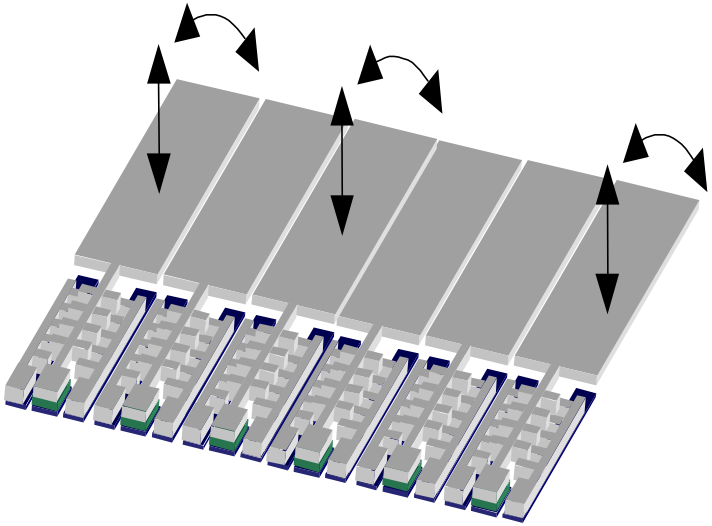
Ultra-high quality lightweight MEMS mirrors by TOS

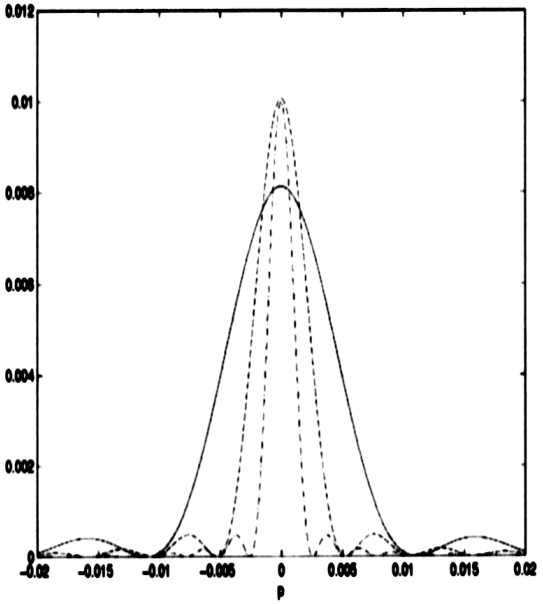


Ultrafast beam scanning MEMS optical phased-array



MEMS optical phased-array implementation

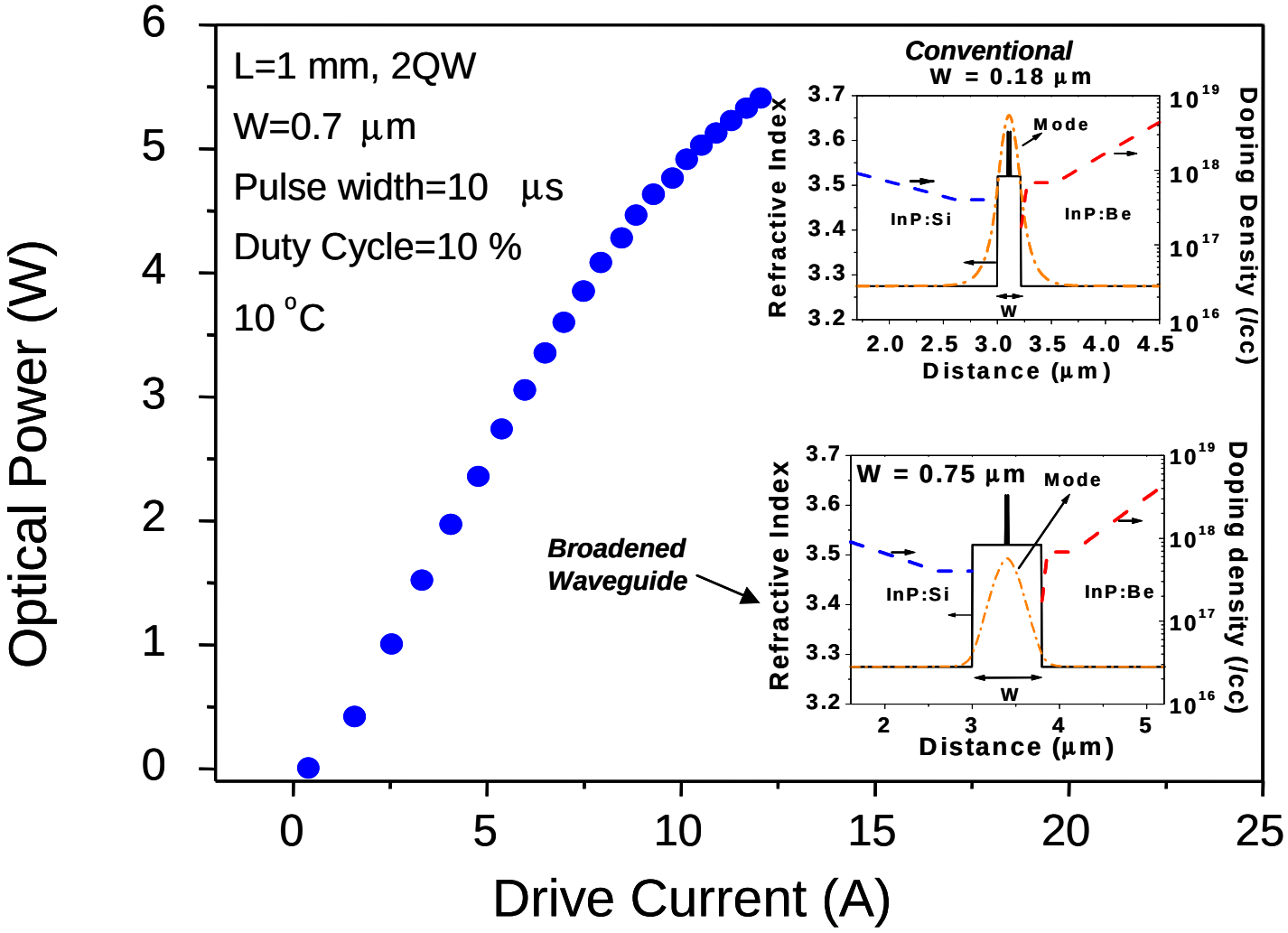




High power lasers for beam acquisition and data transmission

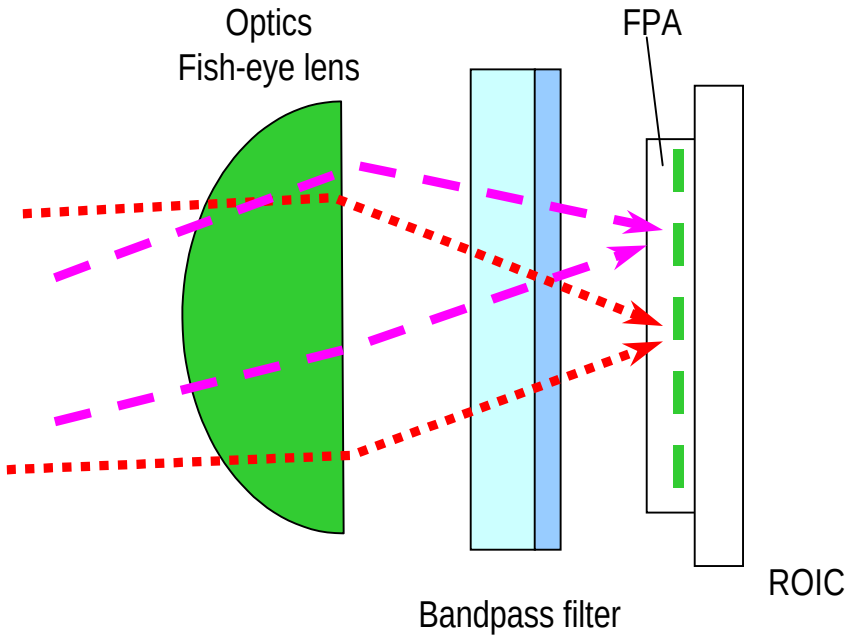
- Ultrafast Data transmission (> 1 Gb/s)
- Output power up to 2 W
- Wavelength at 1.6 μm
  - Eye-safe operation
  - Reduced scattering
  - Wavelength match to the angle-independent optical filter

Broadened Waveguide (BW) Laser



Dual-Mode Receiver

- *Stare Mode (wide-field reception)*
- *High Speed Data-receiving Mode*



- Wide field optics (fish-eye lens)
- Bandpass filter (angle independent background light removal)
  - Bulk InP/InGaAsP(l_{cutoff}=1.55 mm)
- High speed detector arrays
  - PIN/HEMT IC Focal Plan Array (FPA)
  - GaAs-based readout IC (ROIC)

InGaAs detector arrays + readout electronics integration