



Sponsored by the IOP Photonic Devices



"UV-RGB": The integrated UV-RGB laser beam-combiner

UV-RGB

The integrated UV-RGB laser beam-combiner

Ger Folkersma

UNIVERSITY OF TWENTE.

Prof. dr. ir. A.J. Huis in 't Veld
Dr. ir. D.M. Brouwer
Dr. ir. G.R.B.E. Römer

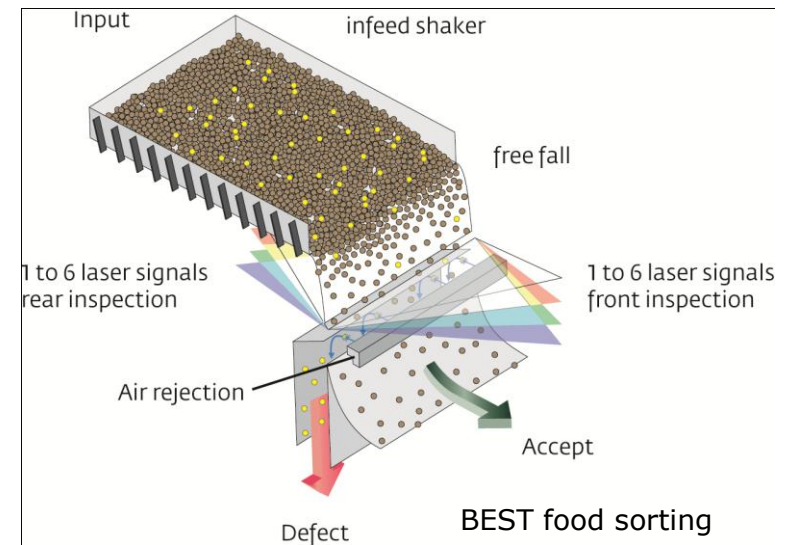
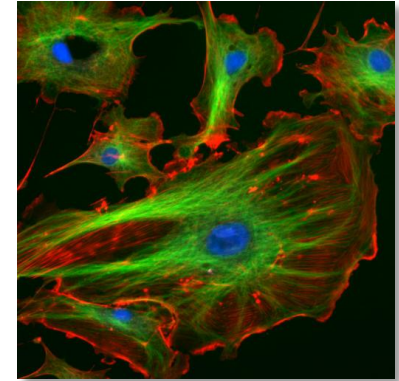


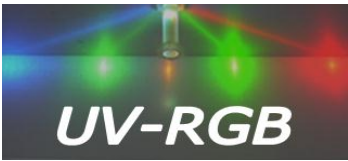


Laser beam combiner: Applications

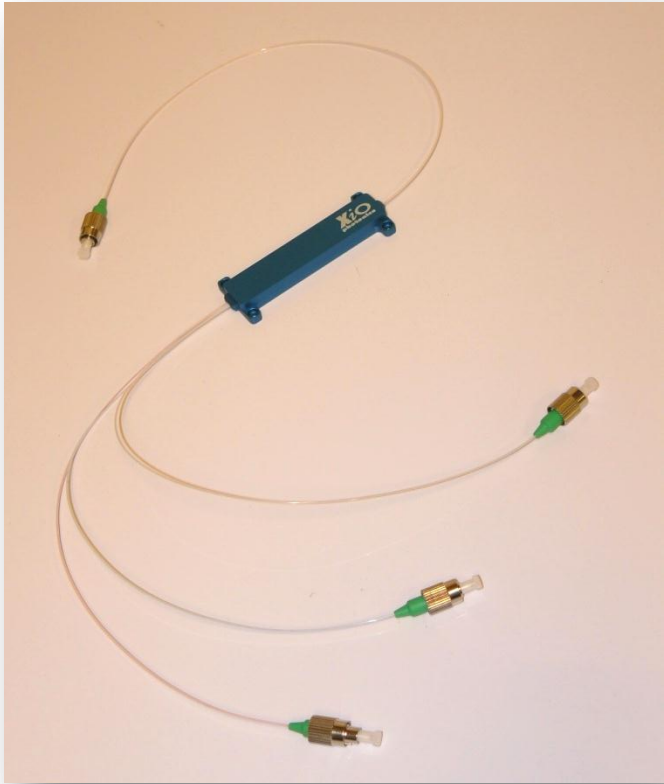
Multiple wavelengths of laser light in one beam

- Health and medicine
 - Confocal microscopy
 - Fluorescence microscopy
 - Flow cytometry
- Lithography
- Optical inspection
- Consumer entertainment
- Etc.





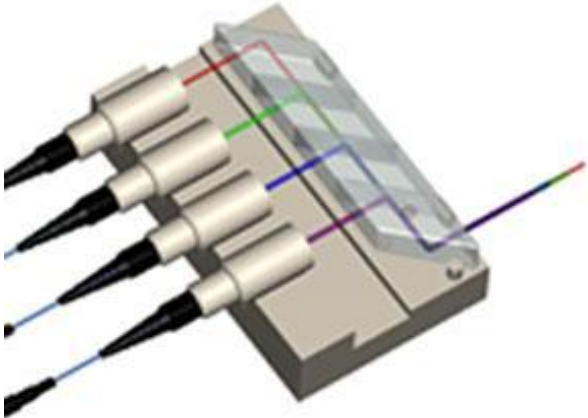
Laser beam combiners



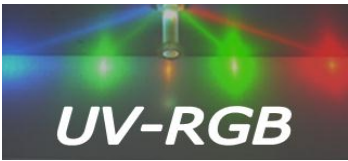
- XiO ILBC: Integrated Laser-Beam Combiner**
- Robust
 - Small
 - No (re)alignment
 - Convenient



Schäfter & Kirchhoff (D)

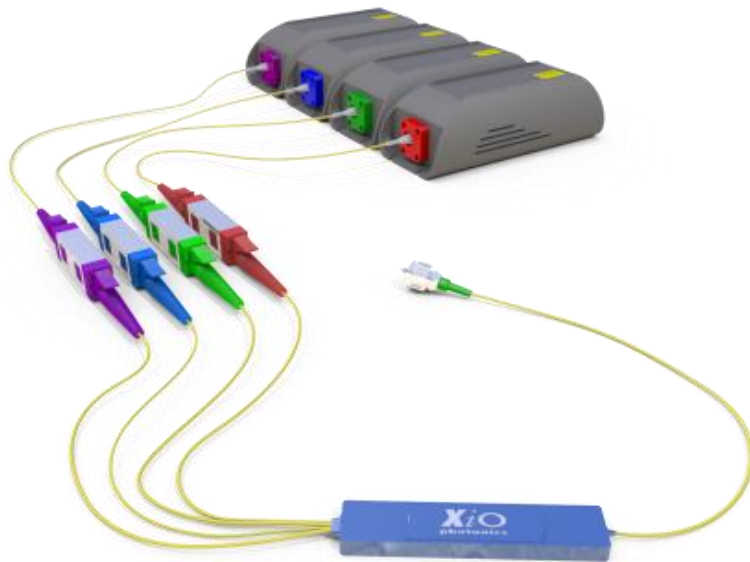


MLC 400 monolithic laser combiner, Agilent (US)



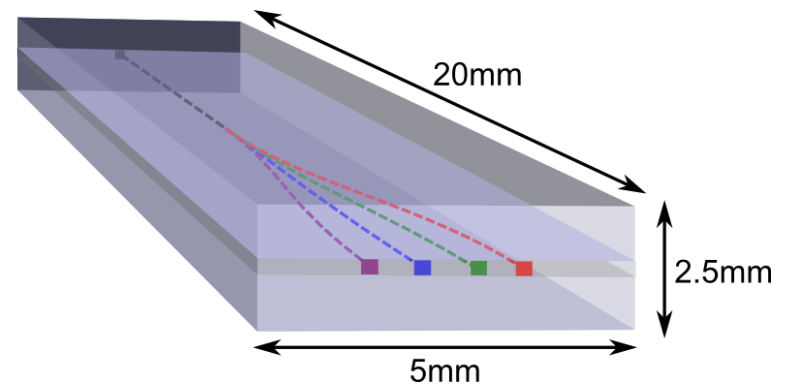
Introduction

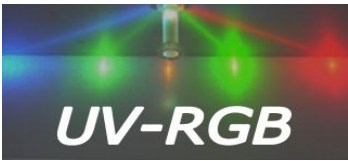
- ILBC: Integrated Laser-Beam Combiner
 - Combine multiple wavelengths of laser light into one optical fiber
 - Beam combiner on a single optical chip from XiO Photonics



Specs

- Single mode, polarization maintaining
- 100mW input power
- Wavelength 375 – 785 nm
- Low-loss (50% overall)

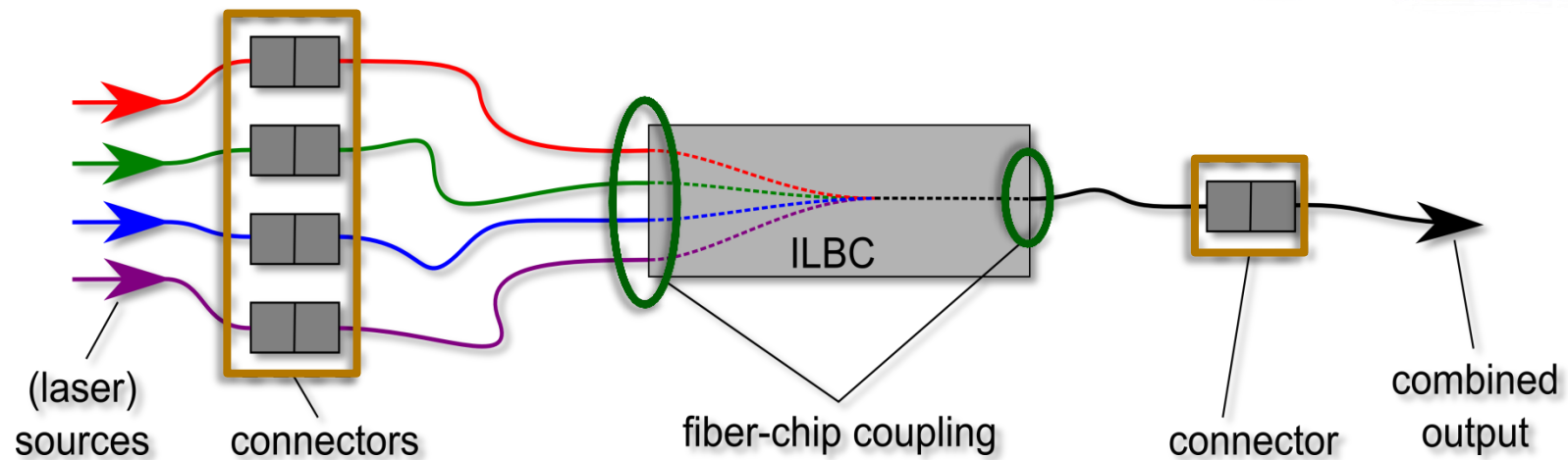
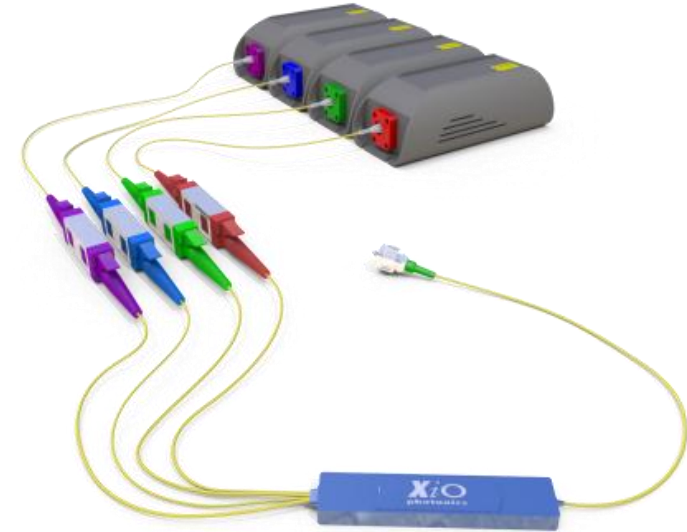




Research areas

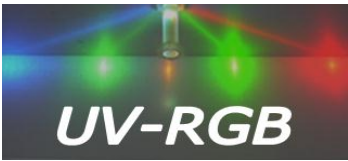
Fiber – fiber pluggable connectors

Fiber – chip interconnect





- Current problems
 - Alignment requirements
 - Tolerances
 - Fixation/ bonding
- Conceptual solution
 - Post-bond alignment
 - Laser adjusting
- Future work



Alignment requirements

- Power loss directly related to misalignment
- Required alignment precision <math><0.2\mu\text{m}</math> for max. 15% power loss at 488nm

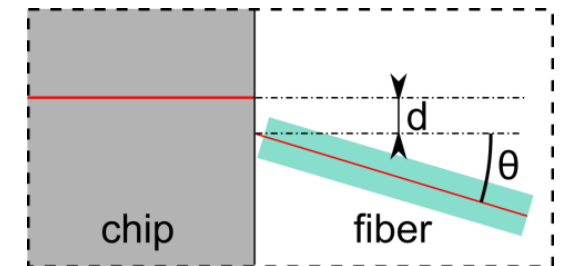
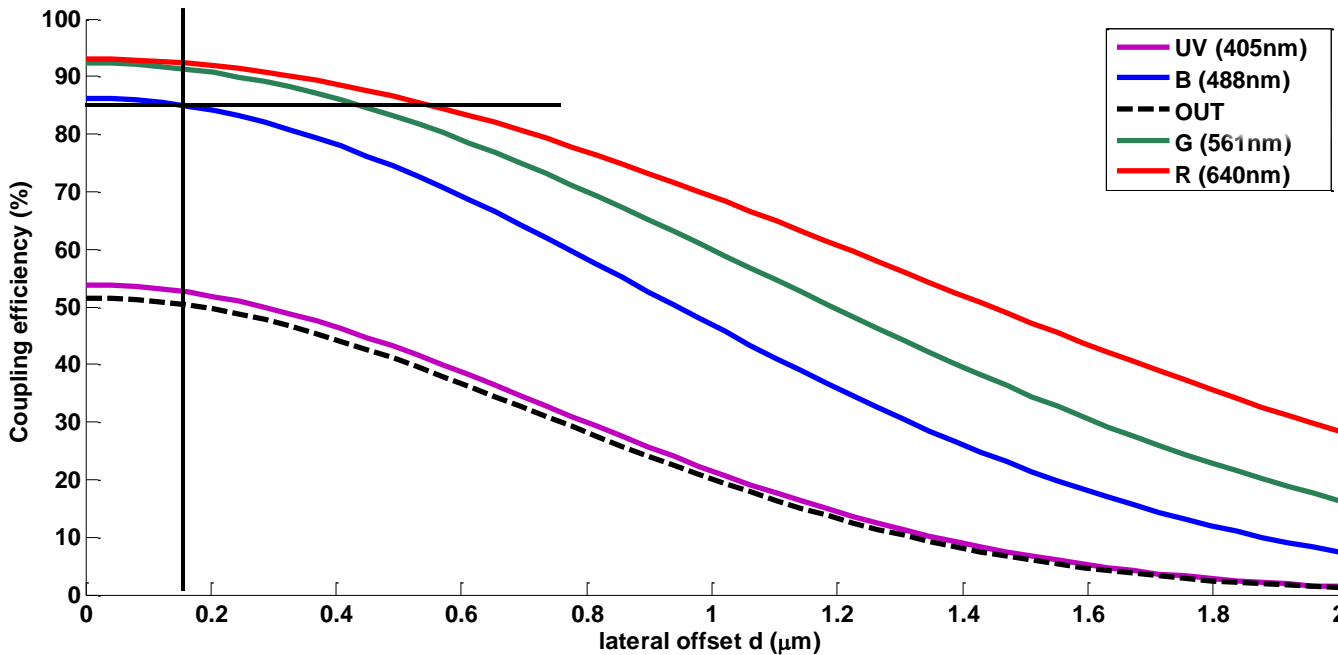
$$T_{mode} = \frac{4\omega_{fiber}^2\omega_x\omega_y}{(\omega_x^2 + \omega_{fiber}^2)(\omega_y^2 + \omega_{fiber}^2)}$$

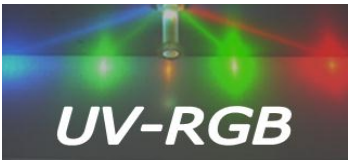
$$T_{tilt} = \exp\left(\frac{-2\pi^2\omega_{fiber}^2}{\lambda^2}\left(\frac{\omega_x^2\theta_x^2}{\omega_x^2 + \omega_{fiber}^2} + \frac{\omega_y^2\theta_y^2}{\omega_y^2 + \omega_{fiber}^2}\right)\right)$$

$$T_{lat} = \exp\left(-\frac{2d_x^2}{\omega_x^2 + \omega_{fiber}^2} - \frac{2d_y^2}{\omega_y^2 + \omega_{fiber}^2}\right)$$

$$T_{tot} = T_{mode} \cdot T_{tilt} \cdot T_{lat}$$

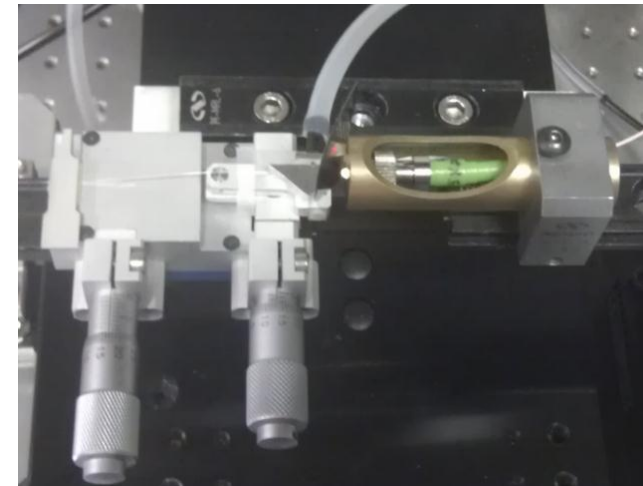
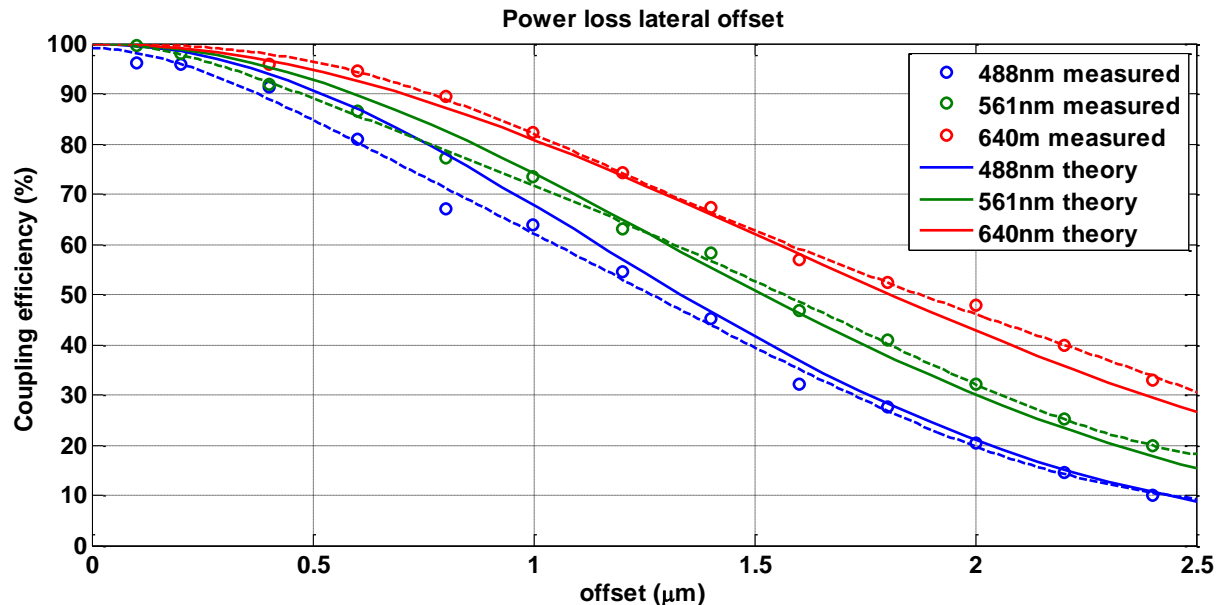
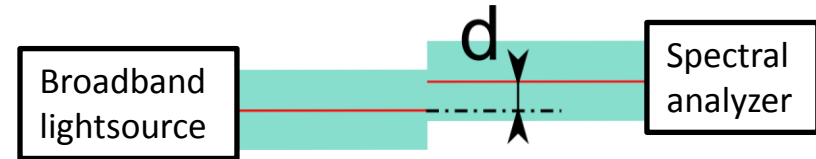
Marcuse (1976)

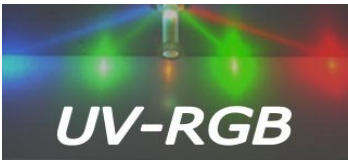




Alignment requirements

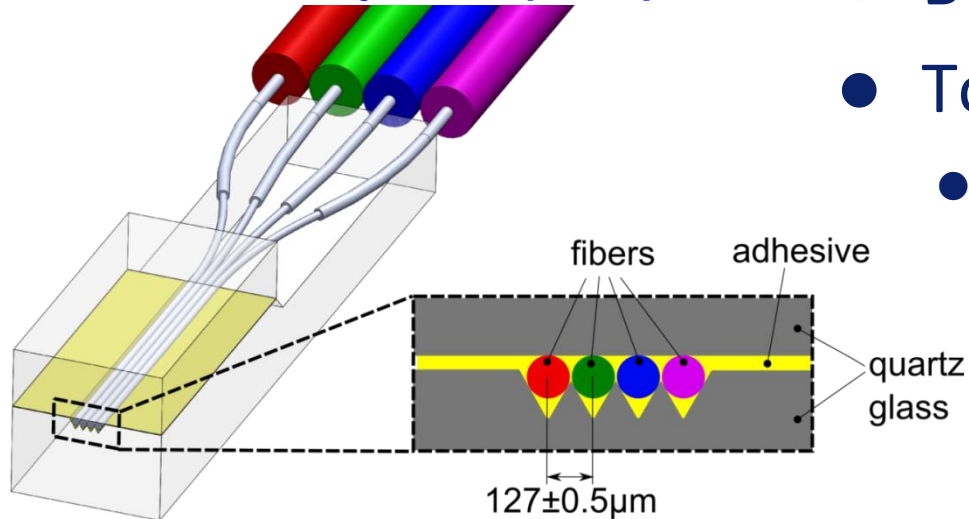
- Experiment to validate model
 - Two fibers, lateral offset
 - Spectral power measurement
 - First results show good agreement





Current fiber-chip connection

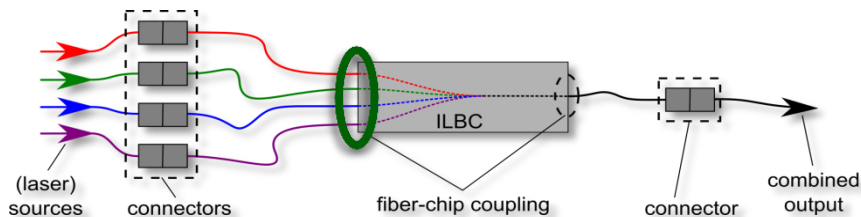
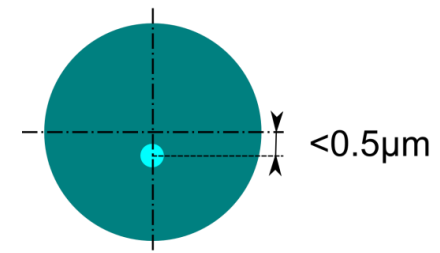
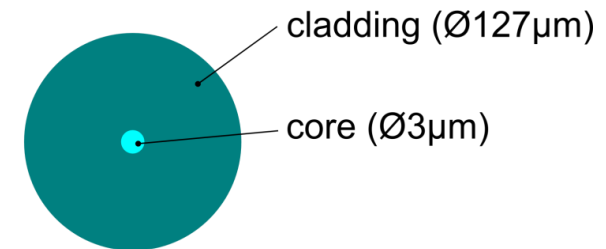
Fiber Array Unit (FAU)

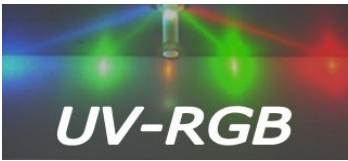


- Bond multiple ports at once
- Tolerances $\pm 0.5 \mu\text{m}$
 - Limited by micromachining process

- Optical fibers

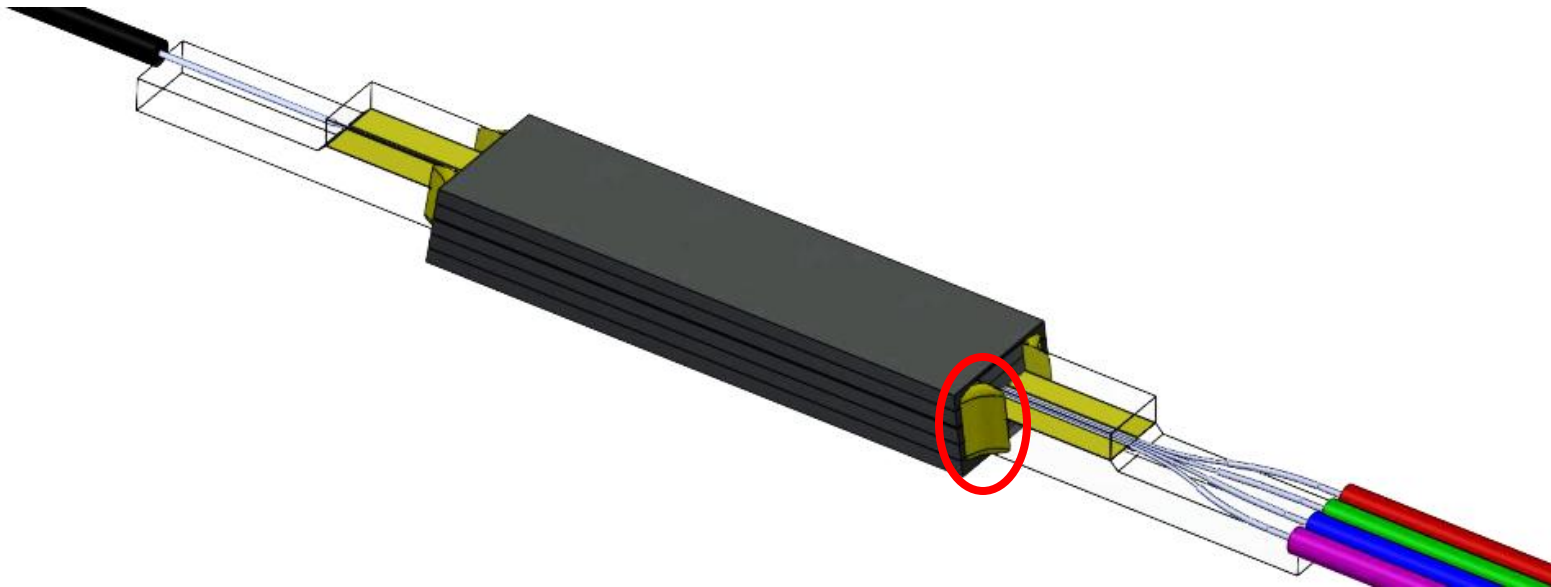
- Polarization maintaining, single mode
- Core-Clad concentricity $< 0.5 \mu\text{m}$

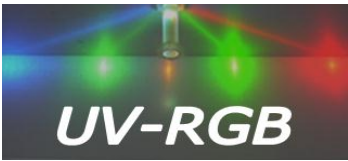




Current fiber-chip connection

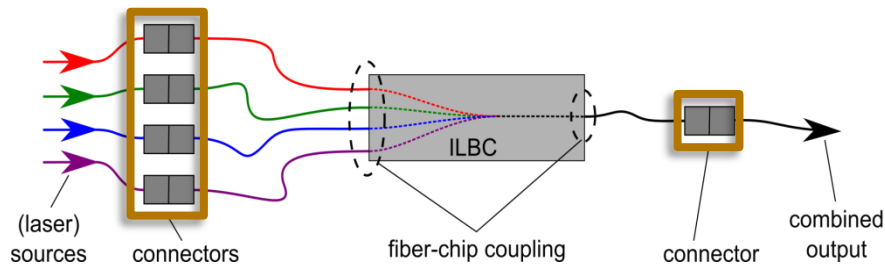
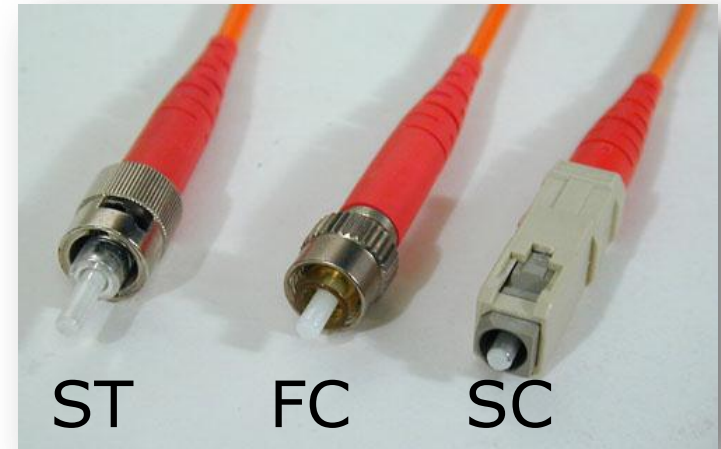
- Alignment by power loss minimization
- Adhesives bond FAU to chip
 - Shrinkage during curing problematic for alignment
 - Adhesives exposed to UV degrade

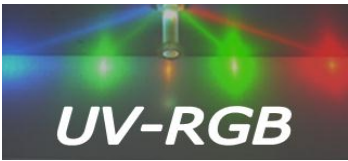




Fiber connectors

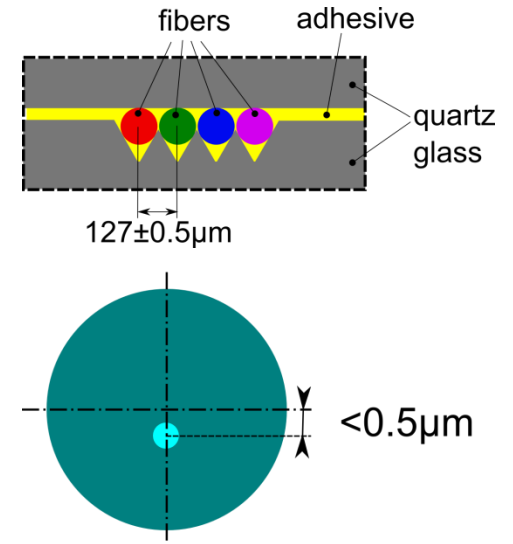
- Connectors from telecommunication
 - Widely used -> cheap
 - Too wide tolerances
 - Not suitable for UV wavelengths
- High performance connectors
 - Expensive
 - Assembled and aligned at manufacturer



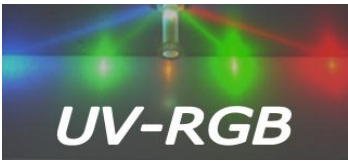


Problem overview

- Fiber – chip coupling
 - Required alignment accuracy $<0.2\mu\text{m}$
 - FAU and fiber tolerances at $0.5\mu\text{m}$.
 - passive alignment unsuitable for UV
 - Shrinkage during bonding process

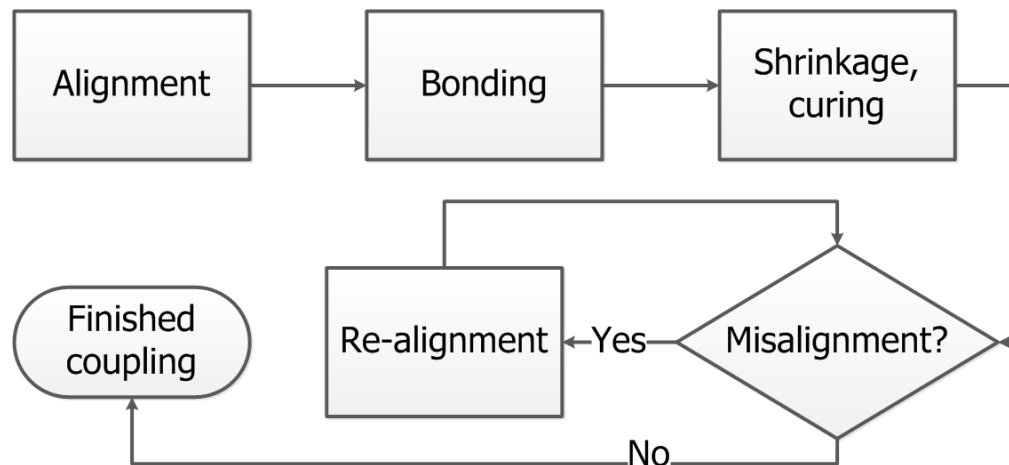
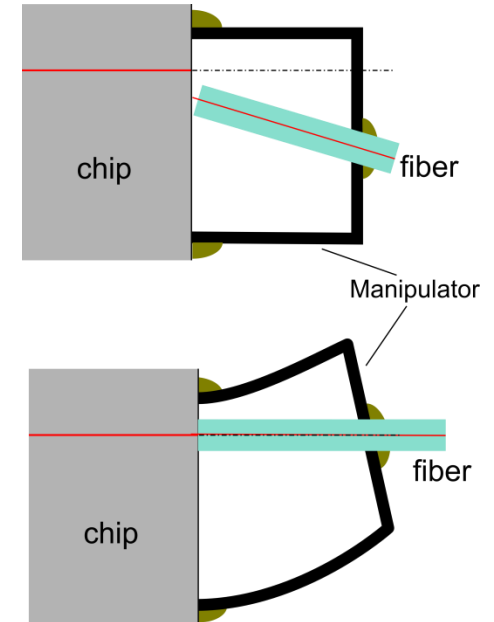


Post-bonding alignment

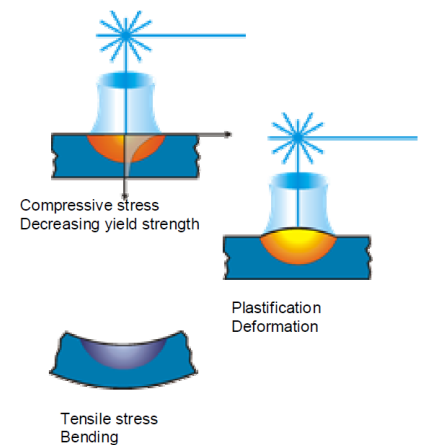
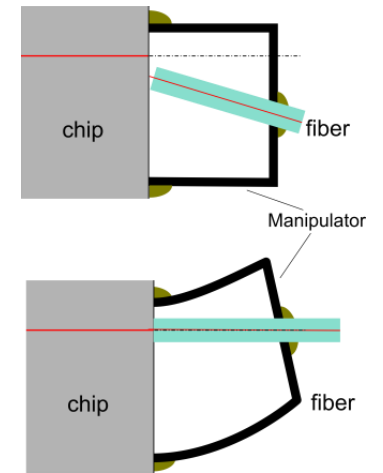
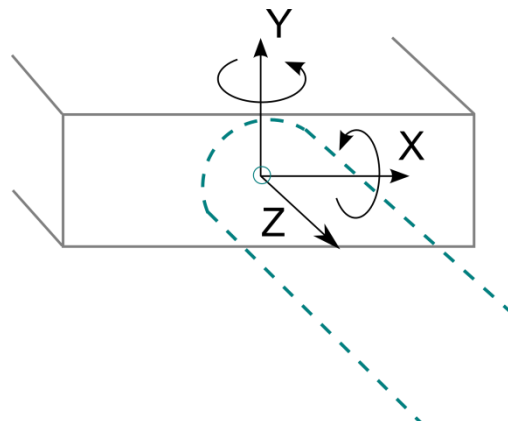


Post bonding alignment

- Re-align after bonding
 - Less demanding alignment during bonding
 - Correction of shrinkage
- Manipulator to move the fiber
 - Integrated in the product



- Deformation due to laser heating
 - Contactless
 - Good ‘resolution’
 - Suitable for miniaturization
- Model required to predict “actuator” behavior
- Design 5-DOF manipulator for aligning the fiber

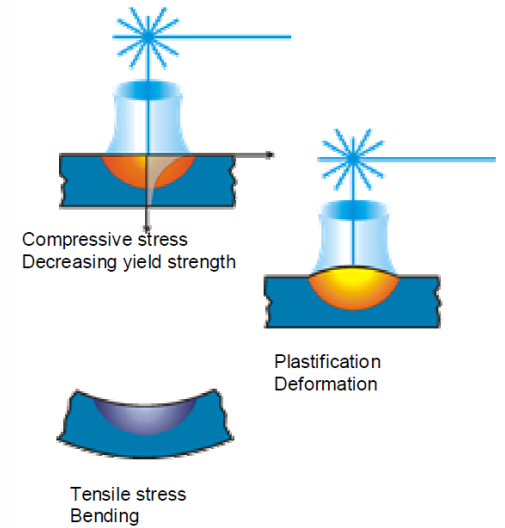
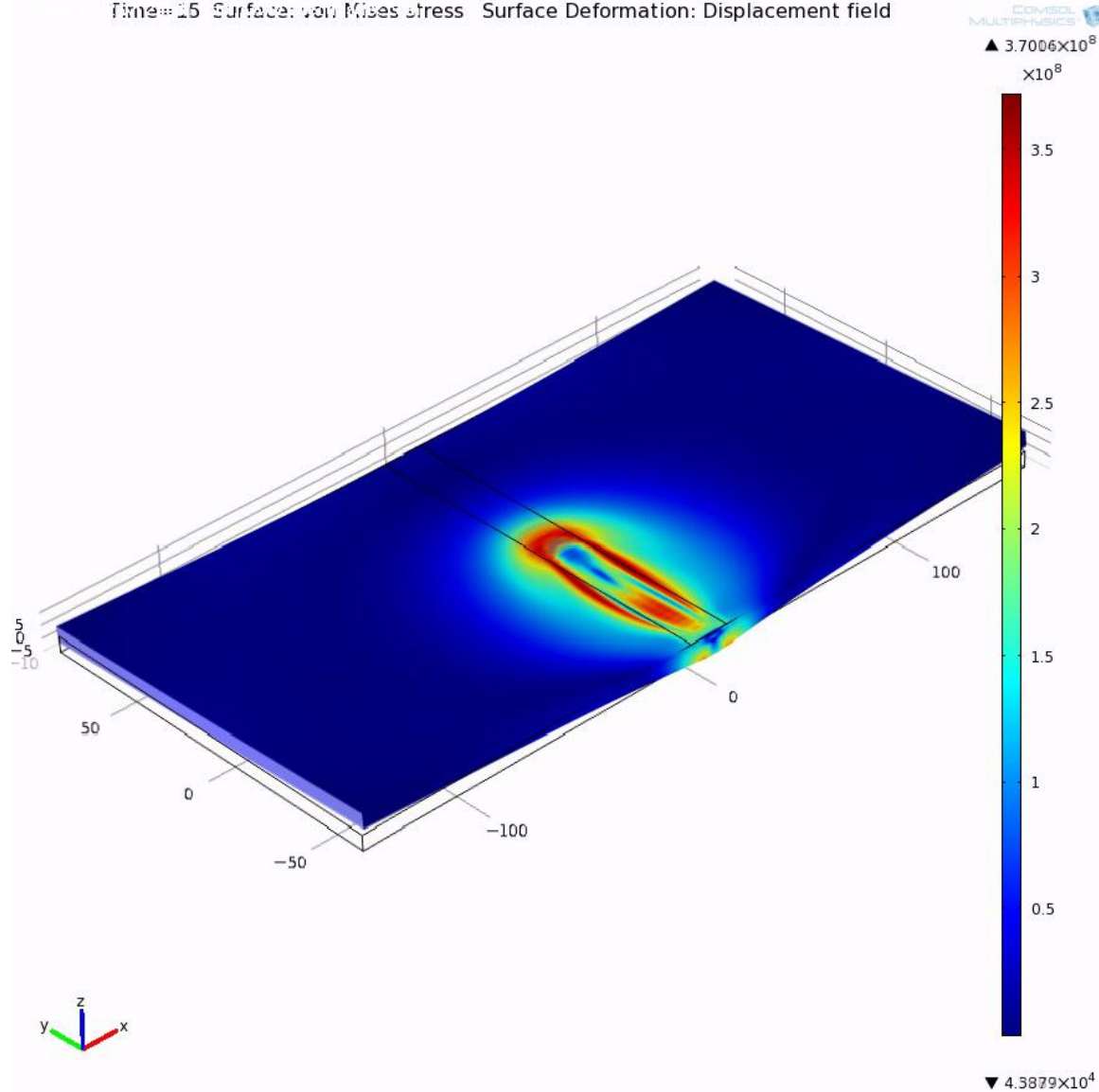


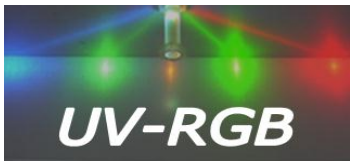
M. Dirscherl (D), 2006



Laser adjusting, first model

Time: 15 Surface: von Mises stress Surface Deformation: Displacement field





- Design integrated manipulator
 - Modeling and experimenting with laser adjusting
 - Predictive model for laser adjustment
- Investigate bonding methods
 - (laser) welding
 - Soldering
- Perform bonding + alignment experiments
 - Bonding and aligning a fiber to a chip
- Expand to generic method