Setting up an autonomous multi-axis alignment system – nanophotonics interface with optical fibers

Background and motivation
The market of photonic integrated circuits (PICs) has grown rapidly in recent years, with applications ranging from photonic quantum computing to lidar for autonomous driving and 3D imaging. PICs are composed of multiple elements to attain functionality at the system level. Practical applications often require interfacing PICs with optical fibers. This, however, poses a great challenge because there is a large mismatch between the size of nanophotonic waveguides and the fiber diameter. Coupling the light from a fiber to a photonic chip is a crucial step in the integration of PICs and the operation outside the laboratory.

Problem description
At the ultrafast photonics laboratory (www.vtc-lab.com) we routinely couple laser light to nanophotonic circuits using piezo-controlled coupling stages with nanometer resolution. However, the coupling is done in a manual fashion. This project aims to produce an automated system that makes use of multi-axis stages to scan XYZ coordinates and read the optical power along with each position. The fiber is then translated to the position where the highest peak power is found, this process is iterated to find and maintain the maximum coupling power. The main tasks of the project are:

- Revisit the manual process of light coupling between a lensed fiber and a waveguide on-chip.
- Control the XYZ positions of the stages using their piezo-controllers in Matlab/Python and read the optical power data to retrieve a distribution of the beam.
- Implement an algorithm to obtain high coupling efficiency of light in a closed loop.
- Get acquainted with the literature of photonic integrated circuits.
- Perform electromagnetic simulations with industrial software to analyze quantitatively the coupling efficiency between nanophotonic circuits and optical fibers.

Overall, this project gives you a nice blend between building a lab setup, numerical simulations and an overview of state of the art photonics research.

Supervision in English, report can be written in Swedish.

Group size: 3-4 students
Target group: E, M, F, GU fysik. Interest in signal processing and programming.

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Extra material:
https://www.youtube.com/watch?v=CBhdLTTbYoM