Photolithographically Manufactured Acrylate Multimode Optical Waveguide Translation and Rotation Misalignment Tolerances

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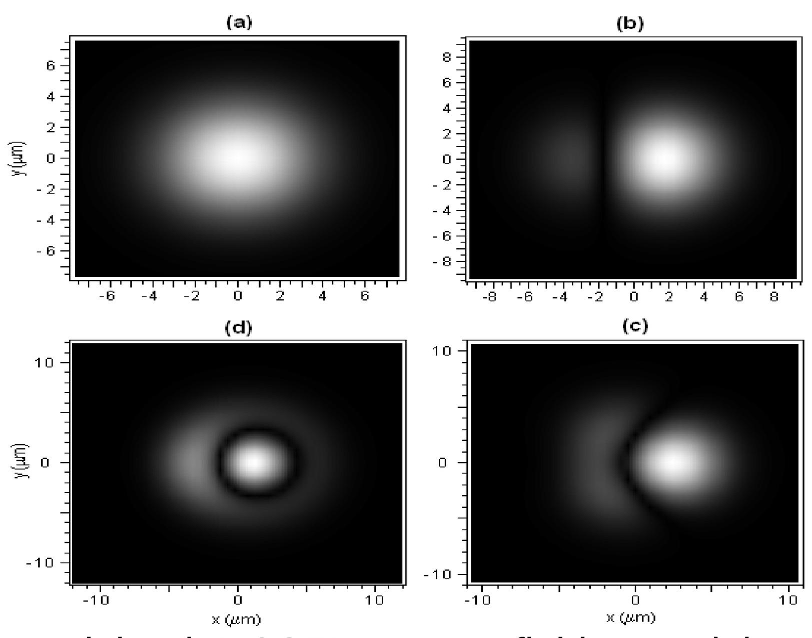
INTRODUCTION

A very precise active alignment is required to align the light source to a single mode waveguide due to the small size of waveguide's core. The light source and connector must be made to tight tolerances and designed to allow precise connection. The aim of the experiments and modelling is to find an efficient and cost effective solution to implement the system.

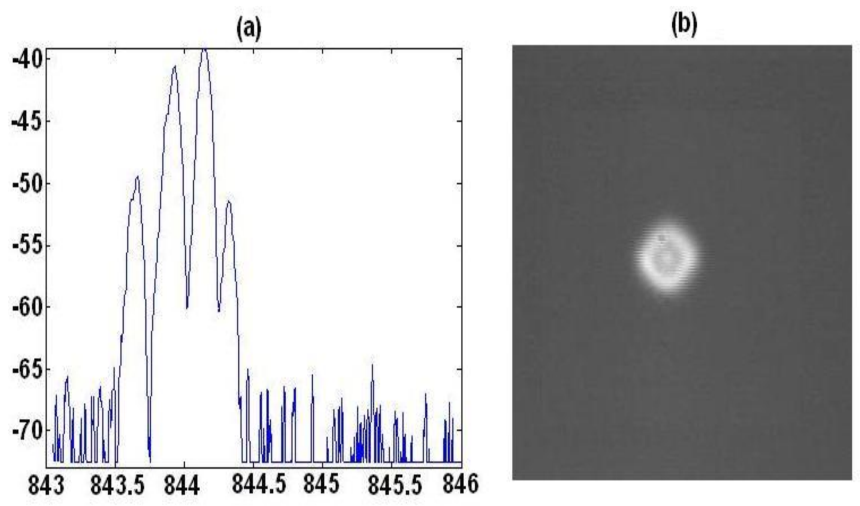
Wider multimode waveguides are used in preference to single mode waveguides, with waveguide cores are typically 50 – 100 microns. Even so the connectors have to be sufficiently well aligned to minimise possible misalignments. To have a robust system it is essential for the connector to be able to withstand relative misalignments within a certain tolerance.

Due to assess the performance of this system, the optical field generated from the VCSEL is passed through a model of the functional blocks in the system. The coupling losses at VCSEL-waveguide and waveguide-receiver interfaces are investigated by modelling and experiment to evaluate lateral and axial misalignment tolerance.

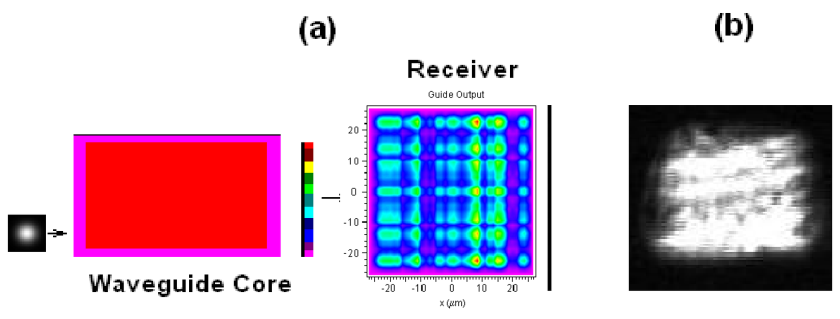
Modelling



Weighted VCSEL output field containing (a) one mode, (b) two modes, (c) three modes and (d) four modes.



Measured wavelength spectrum of a 10 Gbit/s VCSEL and a photograph of output field of a VCSEL from ULM photonics.

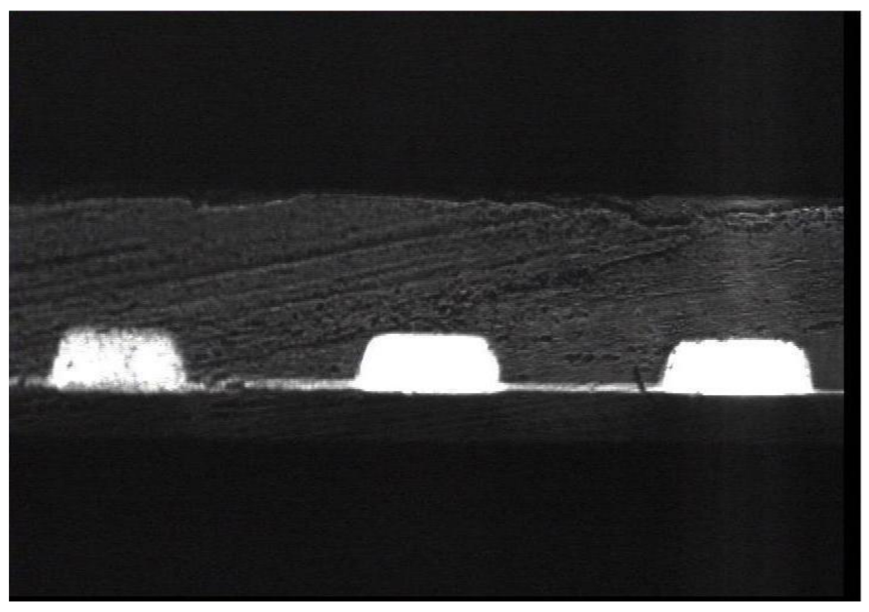


(a) Modelled result of waveguide output with guide core size of 50 x 50 micron. (b) A photograph taken from waveguide output

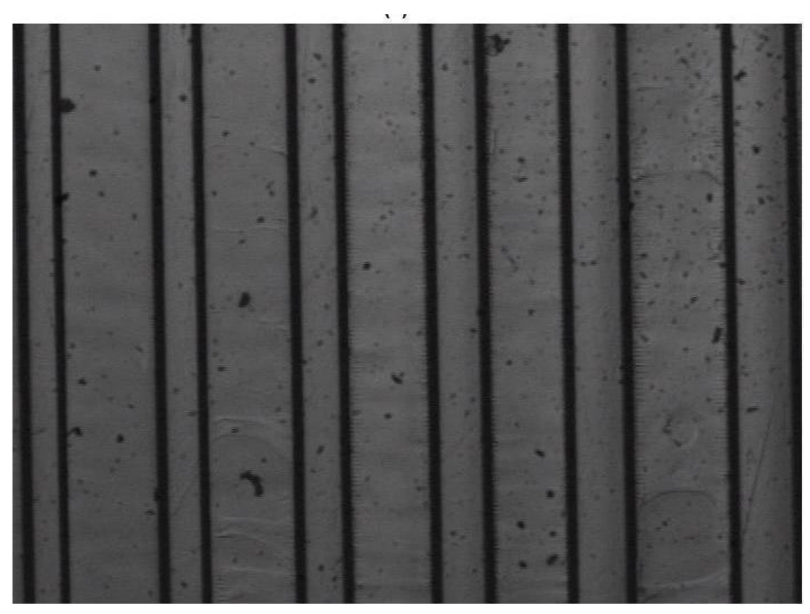
For the simulation process, first, individual models of the components are set up. At the next step the Beam Propagation Method (BPM) is used to determine the power lost due to axial and lateral misalignment and the power distribution at the output end of waveguide.

The launch field is swept across the waveguide simulating the misalignments between VCSEL and waveguide. The launched field is first swept laterally from x=-50 μm to 50 μm with a step of 4 μm. (x is in the horizontal direction).Then the field is moved longitudinally 100 μm away from waveguide and the lateral sweep is performed as before. This action finishes at z = 1000 μm.

Experiment



Cross section showing guides of width 100, 110 waveguide and 120 μm.



Fabricated straight waveguide of 30, 40, 50, 60, 70 and 80 μm.

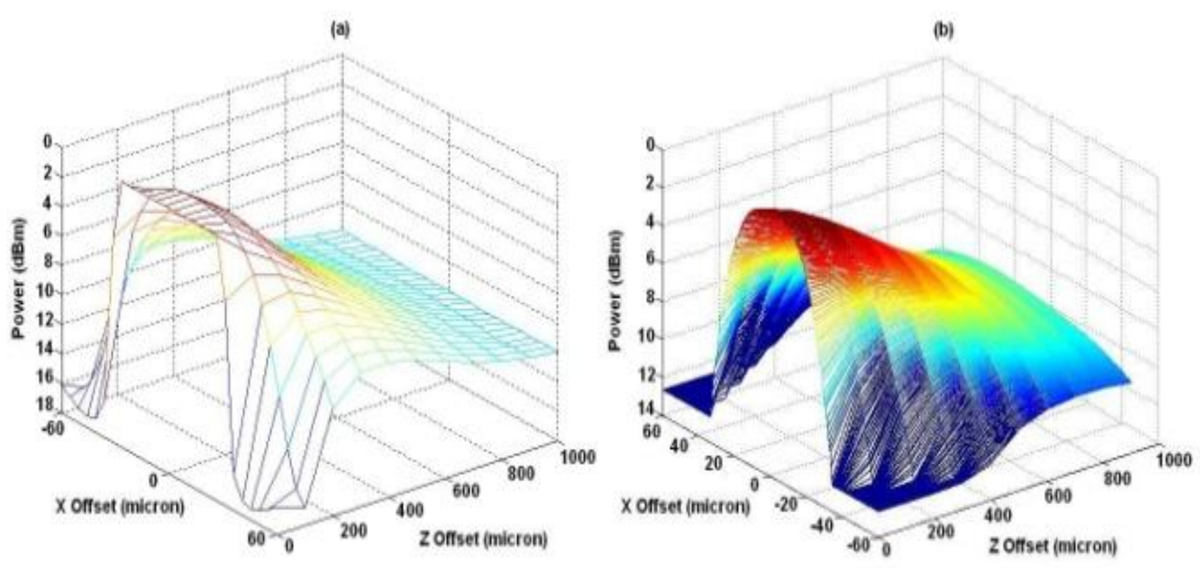
A six-axis stage was built by mounting three linear translation stages, one rotation stage and two tilt stages together. This six-axis stage is used to align the optical source to the waveguide and offset the source to the waveguides to test translation tolerance between them.

Polymer	Truemode® acrylate
Core refractive index	1.5560
Cladding refractive index	1.5264
Wavelength	850 nm
Light source	VCSEL
Waveguide	Multimode square cross section

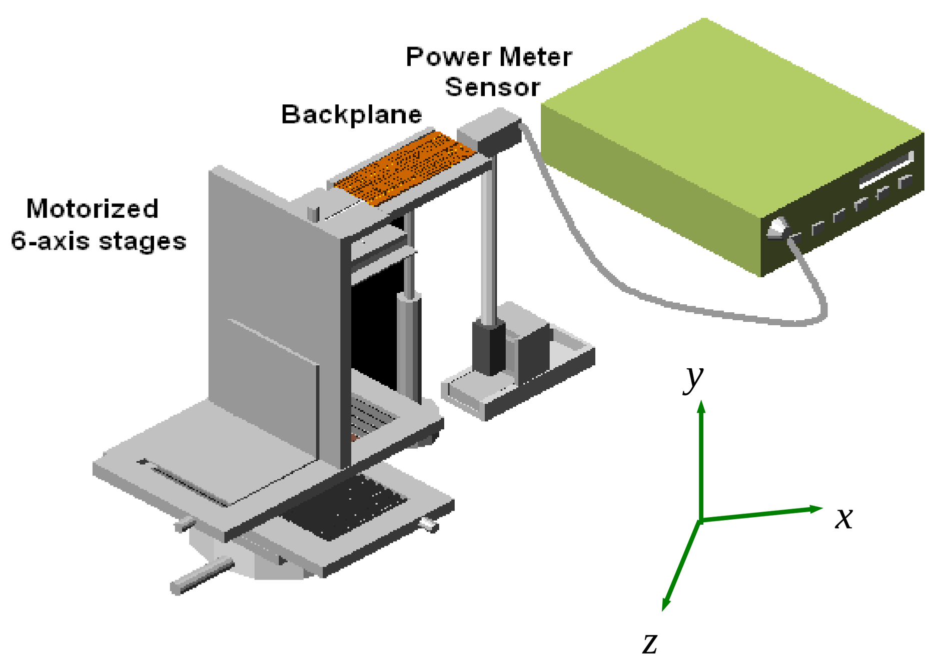
Parameter for the modelling and experiment

The light source was moved step by step towards waveguide core and the output power of the waveguide was recorded. The scan was designed to finish at some place of other end of waveguide core. The source was then moved away from the waveguide, going back to the original lateral place and scanned again.

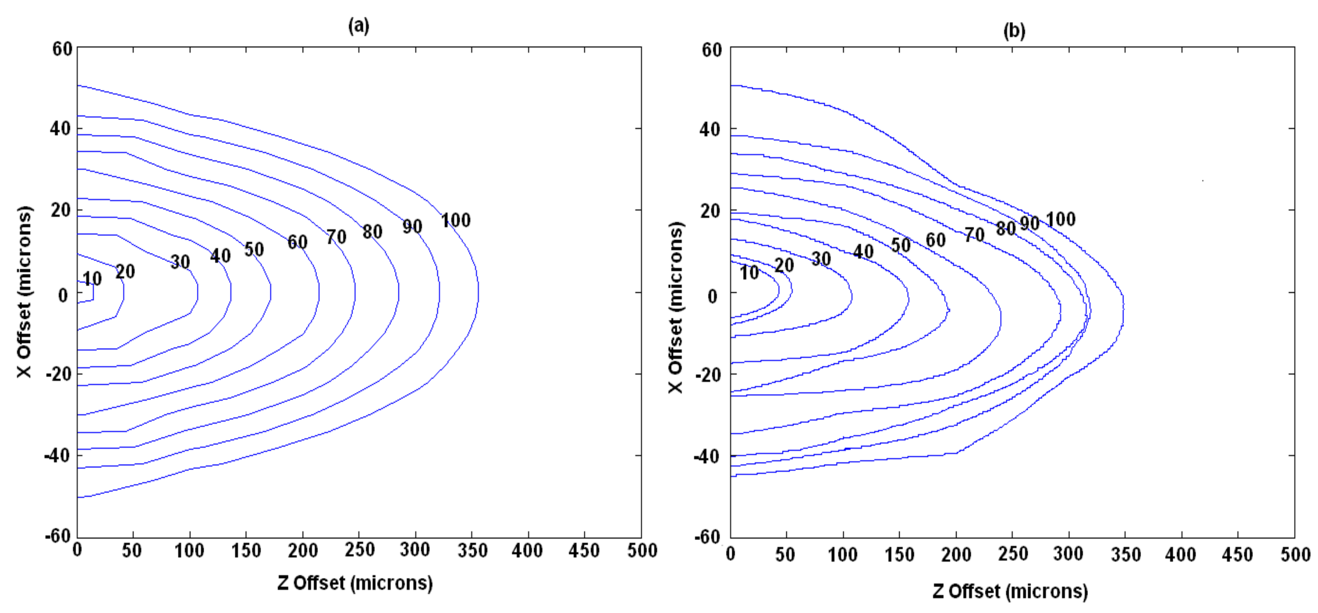
Translation Misalignment



Output power due to lateral and axial misalignment between VCSEL and waveguide (50 x 50 μm). (a) Modelled result. (b) Experimental result. Values along x axis represent lateral misalignment. Values along z axis represent axial misalignment between the optical source and the waveguide.

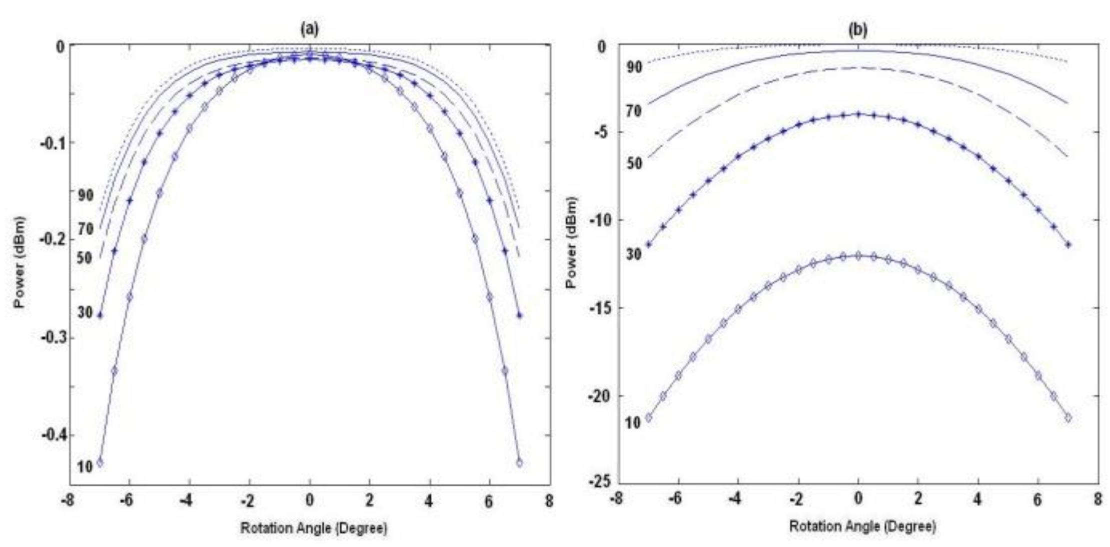


Experimental set-up of translation tolerance test

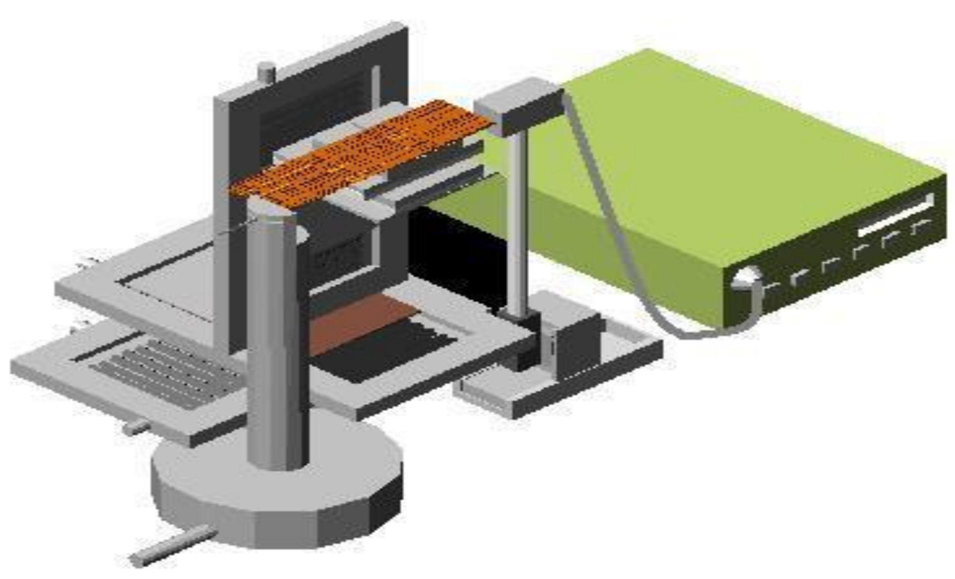


Output power due to lateral and axial misalignment between VCSEL and waveguide(a) Modelled result. (b) Experimental result. Different guide widths of 10, 20, 30…100 μm.

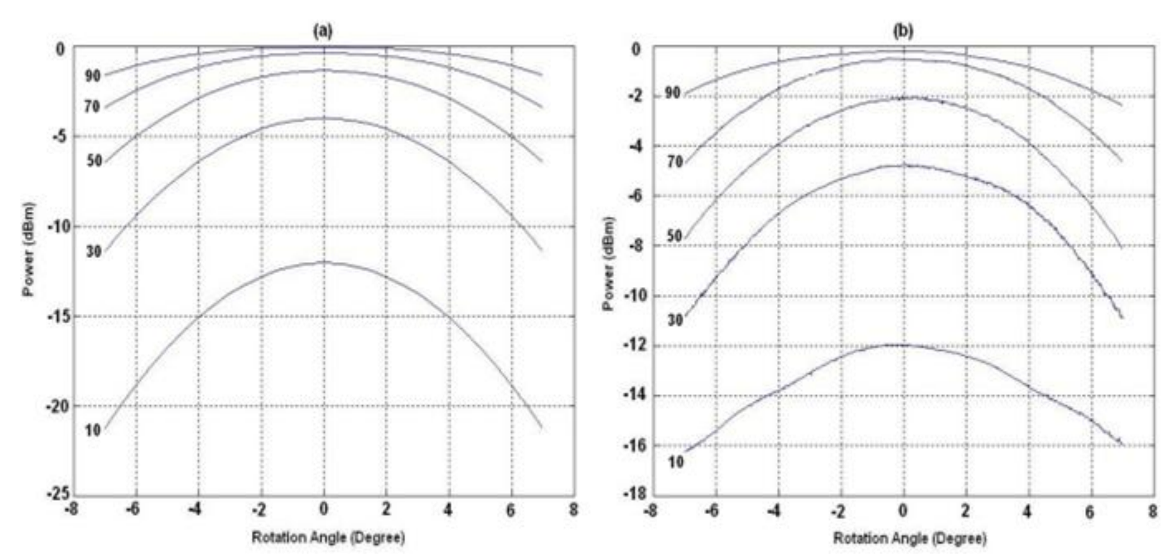
Rotational Misalignment



Modelled results show rotation tolerance for different guide widths for an axial distance between source and waveguide of (a) zero and (b) 200 μm.



Experimental set-up of rotation tolerance test



Comparison of (a) modelled result and (b) experimental result of rotation tolerance for different guide widths.

Result

The experiments and modelling show the same results. Depends on how much loss can be tolerated in the system, the possible misalignment can be determined from the graphs. The graphs also show which kind of misalignment is dominant and is more serious in the system.

Acknowledgments

The lead author thanks Science and Technology Facilities Council (STFC) for providing funding via Dorothy Hodgkin Postgraduate Awards and authors also thank EPSRC for their financial support via IeMRC during the project. We also thank Ioannis Papakonstantinou for his help and advices.

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