

## Improvement of coupling tolerances of 850 nm single-mode optical links using self-aligned NIR photopolymerization

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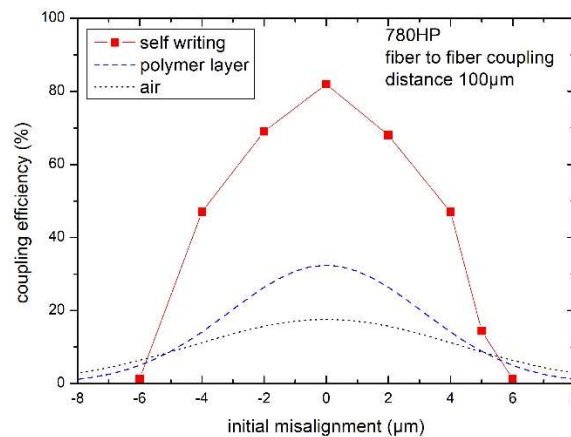
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Coupling VCSEL to optical fibers is a key step for their integration in optical interconnects or remote sensing systems, especially in the case of single mode devices. Many passive or active coupling methods were developed to improve VCSEL-fiber positioning precision and/or to increase alignment tolerances, using microlenses, V-grooves holders and/or polymer index matching layers. Nevertheless, alignment procedures remain tricky and time consuming. To address this issue, we recently developed a simple method to create a self-written waveguide between two single mode optical elements. The general principle of our process relies on the use of an innovative NIR photopolymer able to generate a gradient of refractive index under structured light irradiation [1] and to build two waveguides that can merge even if their centers are not perfectly aligned [2].

This method was recently tested for the coupling of two optical fibers which are truly single mode at 850nm (780HP, core diameter: 4 $\mu$ m). As seen in figure 1, the output power was enhanced by a factor 4 compared to coupling in the air (82% vs 18%), and by a factor 2.5 compared to coupling in a simple polymer layer (82% vs 32%). In addition, we show that this approach improves also the alignment tolerances, with a coupling efficiency remaining above 68% for a lateral detuning of  $\pm 2\mu$ m. Application to the coupling of a 850nm single mode VCSEL to a 780HP fiber is undergoing.



**Fig. 1** Fiber to fiber coupling efficiency (780HP SM fibers/ core diameters = 4 $\mu$ m) at a distance of 100 $\mu$ m as a function of the initial lateral misalignment. Black dotted line: in the air / blue dashed line: in a polymer index matching layer / solid red curve: with NIR photopolymer self-writing process.

### References

- [1] I. Dika, F. Diot, V. Bardinal, J.-P. Malval, C. Ecoffet, A. Bruyant, D. Barat, B. Reig, J.-B. Doucet, T. Camps, O. Soppera "Near infrared photopolymer for micro-optics applications" *Journal of Polymer Science*, 2020.
- [2] O. Soppera, V. Bardinal, F. Diot, et al. "Method for making a self-aligned optical guide between an optical source and an optical fiber, and related kit". U.S. Patent No 11,054,579, 6 juill. 2021