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## Highly Efficient Collective Coupling Between Laser Diode Array and Lensed Fibre Ribbon.

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**Abstract** A new concept is proposed for lensed fibres fabricated according to a collective and low cost process. This process is based on cleaving and splicing of optical fibre ribbons and is suitable for the coupling of laser diode arrays and fibre ribbons.

### 1. Introduction

The introduction of optical communications into the access network involves reducing the cost of optical components. Regarding transceiver modules in the central office, a way to lower packaging cost, could be to apply the collective and passive alignment process ( without activating the laser array during alignment ). For this the reason the characteristics of optics should be compatible with the packaging tolerances and allow to achieve an effective coupling [1]. The main features [2,3] of this coupling arrangement are high efficiency coupling, relaxed alignment tolerances, long working distance, small packaging volume and low cost fabrication process.

### 2. Principle and fabrication

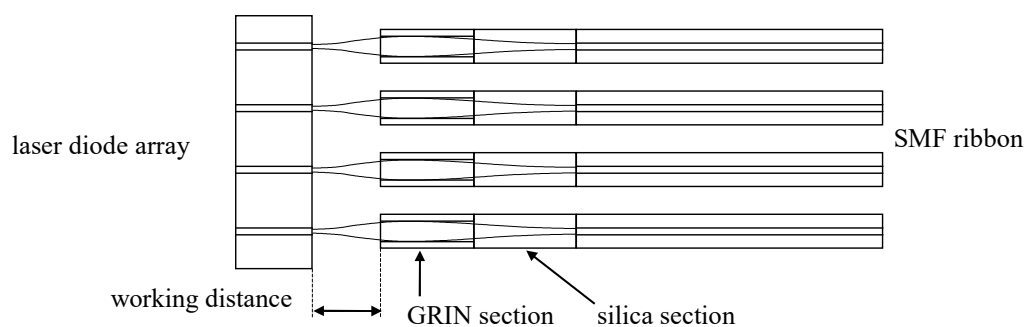


Fig. 1. Schematic representation of optical coupling arrangement between the LD array and SMF ribbon.

In the present paper, a new concept [4] proposed for a lensed fibre ribbon, requires a simple collective fabrication process. As shown in Fig. 1., this optics consists of a graded index (GRIN) fibre section which acts as a GRIN lens [5]. This latter is maintained at the proper distance to the single-mode fibre (SMF) by a coreless silica fibre section. The micro-optics are made with standard ribbons composed of four 250  $\mu\text{m}$  spaced fibres. We used the G652 single-mode fibre and 85/125/250-Alcatel graded index fibre.

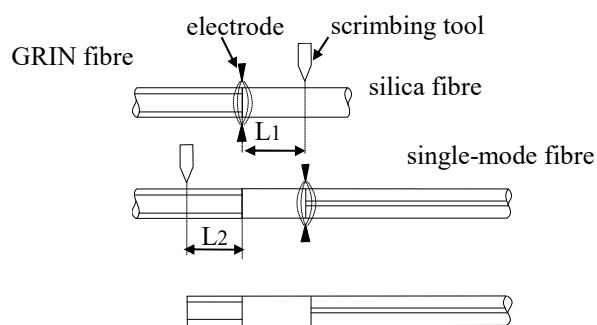


Fig. 2. Schematic illustration of the micro-optics fabrication process.

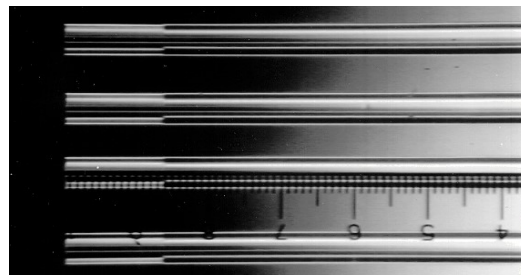


Fig. 3. Photograph of the micro-optics ribbon.

The fabrication process is illustrated in Fig. 2. Using an arc-discharge fibre splicer, the GRIN ribbon is first spliced to the silica ribbon. The silica ribbon is then cut at a distance  $L_1$  from the silica/GRIN splicing. The GRIN and silica ribbon are spliced to the SMF ribbon. Finally the GRIN part of ribbon is cut at a distance  $L_2$  from the silica/GRIN splicing. The two splicing losses are below 0.1 dB. Fig. 3 shows a view of the micro-optics ribbon. The reproducibility of the lengths is about 2  $\mu\text{m}$  for each section of ribbon. The external fibre diameter of 125  $\mu\text{m}$  is maintained along the lensed fibres. Note that this collective micro-optics ribbon only requires a collective fibre splicer and cleaver.

### 3. Optical Coupling Characteristics

The micro-optic ribbon is held in a silicon fibre-carrier fitted with four 250  $\mu\text{m}$  spaced v-grooves. The LD used in experiments had an operating wavelength of 1.3  $\mu\text{m}$ . Light emitting half angles (and radius mode) defined by the far-field at  $1/e^2$  of the maximum intensity are 25° ( $\omega = 0.89 \mu\text{m}$ ) and 30° ( $\omega = 0.71 \mu\text{m}$ ) in the parallel and perpendicular directions against the epitaxial surface, respectively. Fig. 4. shows the lensed ribbon coupled with the LD array. In order to measure the homogeneity of the micro-optic ( Fig. 5. ), the coupling efficiency of each fibre of the ribbon is measured at the optimum position in front of the same LD. The coupling efficiency defined as  $10\log(P_{\text{coupled}}/P_{\text{emitted LD}})$  is  $-4.54 \pm 0.04$  dB for a working distance of  $48 \pm 0.8 \mu\text{m}$ .

Theoretical coupling loss either by beam propagation method, or by propagation of gaussian beam [6] is -4.5 dB ( not detailed in this paper ).

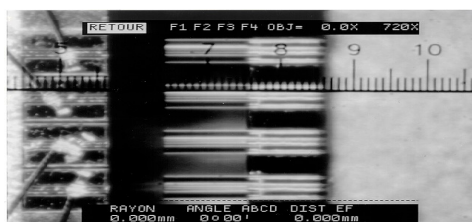


Fig. 4. Photograph of four-channel LD array chip coupled with a micro-optic ribbon.

Laser Diode	Coupling Loss dB	Working Distance $\mu\text{m}$
fibre 1	-4.5	48.7
fibre 2	-4.58	48.2
fibre 3	-4.55	47.6
fibre 4	-4.54	47.2

Fig. 5. Optical coupling efficiency of each fibre of the ribbon measured at the optimum position in front of the same LD.

The measurements of the coupling loss as a function of axial and lateral displacements are shown in Fig. 6. The optical coupling of the micro optic is compared with a butt coupling of SMF. Loss increments due to displacements in the x and y directions are roughly the same, that is why only one curve is plotted. The optical alignment tolerance is  $\pm 9 \mu\text{m}$  for the axial

direction for 1 dB loss. The micro-optics is better than SMF in the range between +20  $\mu\text{m}$  and -40  $\mu\text{m}$  for axial displacement. The lateral tolerance is  $\pm 1 \mu\text{m}$  for 1 dB loss. For this displacement the micro-optic is better than SMF in the  $\pm 2.4 \mu\text{m}$  range.

Since no anti-reflecting coating was applied, the -26 dB Fresnel reflection of the air/GRIN interface was measured using an optical coherent domain reflectometer. The two other splicing interface reflections were as low as -80 dB. Nevertheless the oscillation amplitude of the coupling loss along z axis was less than  $\pm 0.2 \text{ dB}$  due to the rather long working distance.

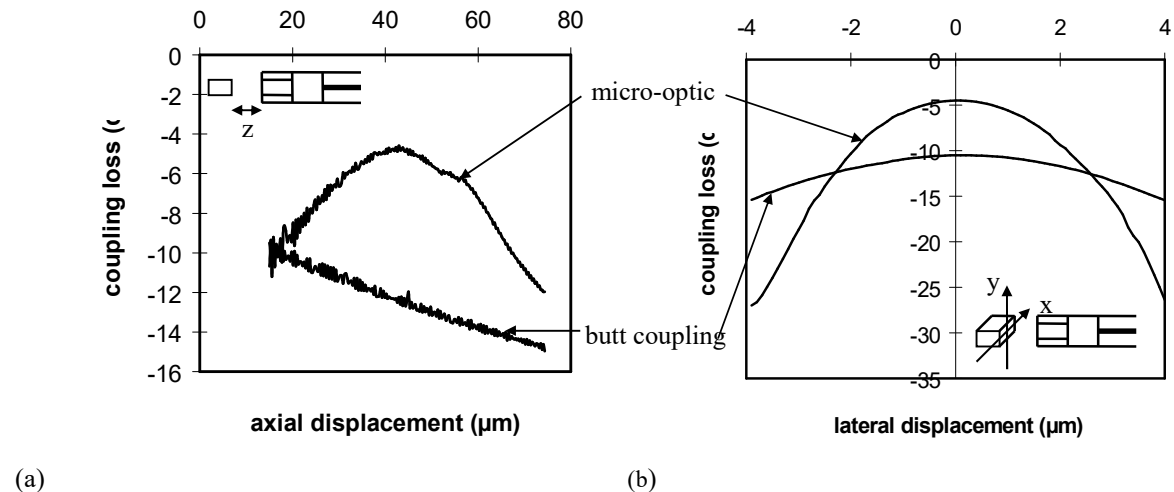


Fig. 6. Coupling-loss characteristics as a function of axial displacement (a) and lateral displacement (b).

#### 4. Conclusion

Our arrangement provides several attractive features with respect to conventional coupling techniques. The lensed fibre ribbon is fabricated using a collective and simple process which allows reproducibility and mass-production. Long working distances, relatively high coupling efficiency and large positioning tolerances have been obtained. The new concept is promising for production of multichannel optoelectronic modules.

#### Acknowledgement

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#### References

- [1] L. G. Cohen, "Microlenses for coupling junction lasers to optical fibers", *Appl. Opt.*, Jan 1974, Vol. 13., N°1, pp 89-94.
- [2] N. Kalonji, J. Semo, "High efficiency long working distance laser diode to single-mode fiber coupling arrangement", *Electronics Letters*, 1994, Vol.30 N°11, pp. 892-893.
- [3] K. Shiraishi, "A fiber with a long working distance for integrated coupling between laser diodes and single-mode fibers", *Journal of Lightwave Technology*, August 1995, Vol.13, N°8, pp 1736-1744.
- [4] M. Thual, J. Lostec, P. Auvray, B. Clavel, French patent N° 96 10327, August 1996.
- [5] William L. Emkey, Curtis A. Jack, "Analysis and evaluation of graded-index fiber lenses", *Journal of Lightwave Technology*, sept. 1987, Vol. 5, N°9, pp 1156-1164.
- [6] H. Kogelnick, "Laser Beams and Resonators", *Proc. IEEE*, Oct. 1966, vol.54, N°10, pp. 1312-1329.