$LiNbO_3$ V-Groove Fabrication for Optical Fibre Pigtailing

(Student Paper)

Ercan Karagöz[1,2], Evren Öztekin[1,2], Mutlu Gökkavas[1], Şadan Özcan[2,3], Ekmel Özbay[1,4]

[1]*Nanotechnology Research Center-NANOTAM, Bilkent University, Ankara, Turkey*
[2]*Department of Nanotechnology and Nanomedicine, Hacettepe University, Ankara, Turkey*
[3]*Department of Physics Engineering, Hacettepe University, Ankara, Turkey*
[4]*Department of Electrical and Electronics Engineering, Bilkent University, Ankara, Turkey*
e-mail: ercan.karagoz@bilkent.edu.tr

INTRODUCTION

Due to its unique electro-optical properties, lithium niobate has an important role in telecommunication and inertial navigation systems. Proper packaging of lithium niobate devices is essential for mechanical and thermal stability. Fibre carriers are commonly used for better mechanical stability of pigtailed lithium niobate devices [1],[2],[3].

This study aims fabrication of V-grooves in lithium niobate (LiNbO3) crystals for producing optical fibre carrier pigtails. Due to anisotropic thermal expansion of lithium niobate, it is important to use the lithium niobate based fibre optic carriers for pigtailing lithium niobate devices to achieve better thermal stability.

V-shaped grooves are generally used as precise fibre mounts for fibre carriers [4]. Unlike silicon or glass, lithium niobate is not suitable for V-groove wet etching or moulding process [5],[6],[7],[8]. In this study, lithium niobate based V-grooves are machined with a V-shaped diamond wheel by using a computer controlled dicing saw.

Keywords: $LiNbO_3$, V-groove, fibre pigtailing, packaging.

METHOD AND ANALYSIS

1mm thick X-cut lithium niobate wafers from Delmar Photonics are used as fibre carrier material. With the help of a Disco DAD3220 dicing saw, lithium niobate pieces are grooved using a V-shaped diamond wheel. To obtain a set of controlled variation of V-groove depths, multiple groove cuts in parallel order are done. This set of V-grooves are analysed for optimum depth and shape. In order to determine optimum machining parameters, a dummy fibre is placed in machined set of parametrically varying V-groove samples, and the position of the fibre core is checked under an optical microscope.

Figure 1 shows illustration of the diamond wheel and different depth V-grooves on lithium niobate sample. Figure 2 shows SEM image of two parallel 45° V-grooves with same depth.

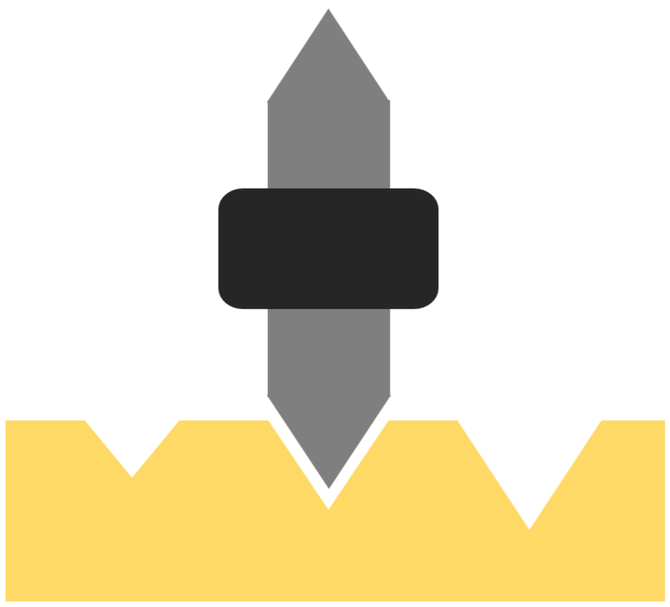

Figure 1. Illustration of V-shaped wheel and different depth V-groove cuts on lithium niobate sample.

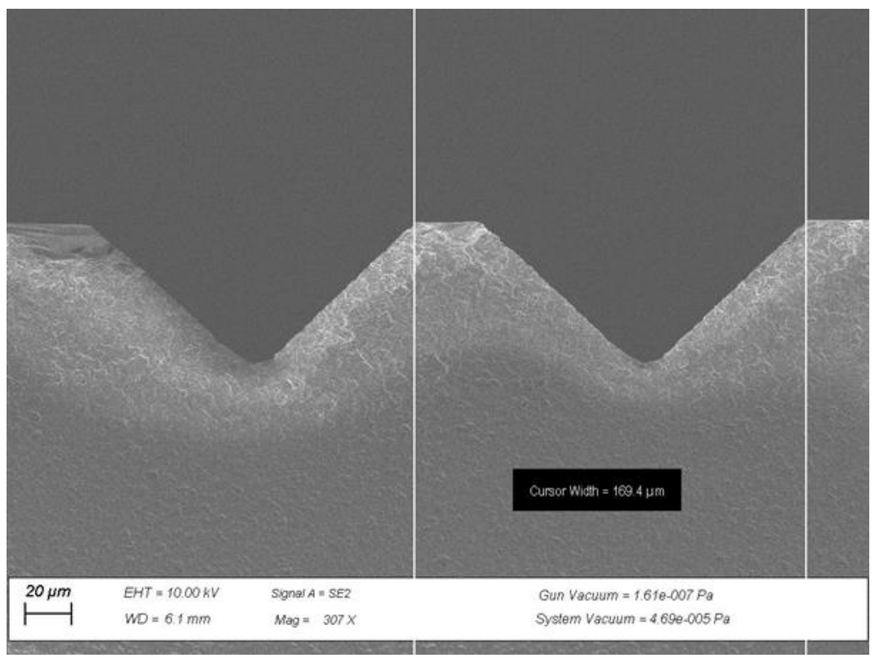

Figure 2. SEM image of LiNbO3 V-grooves.

Fibres are placed in these V-groove mounts using an optical microscope. To fix the fibres, a UV curable epoxy is applied on top of the fibres and compressed with a separate lithium niobate lid. The sample is cured using a UV source and the sample surface with fibre-end is chemical-mechanical polished. Figure 3 shows an optical microscope image of the polished surface of a complete lithium niobate fibre carrier with an 80µm polarization-maintaining (PM) optical fibre.

RESULTS AND DISCUSSION

Figure 3 shows an optical microscope image of the polished surface of a complete lithium niobate fibre carrier with an 80µm polarization-maintaining (PM) optical fibre. The position of the PM fiber was confirmed using an optical measurement setup with a nanopositioning stage, a powermeter and a polarizer.

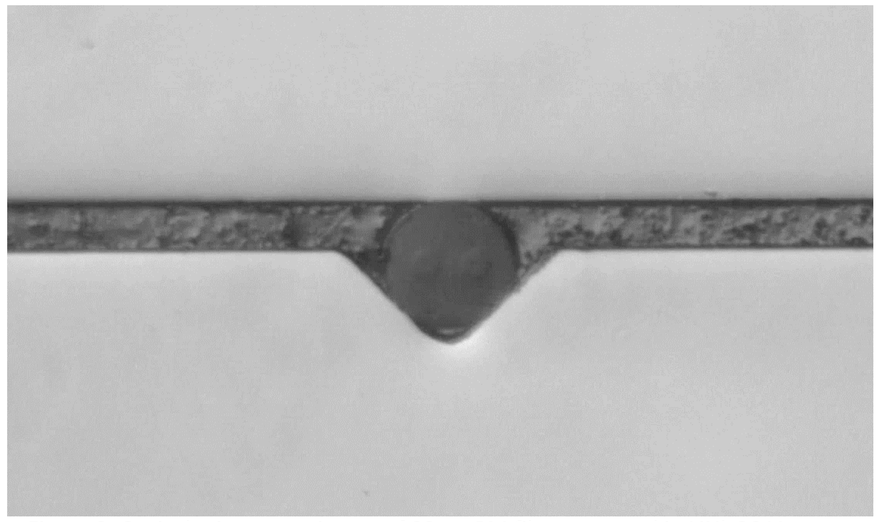

Figure 3. Optical microscope image of 80µm PM fibre mounted in LiNbO3 V-groove.

REFERENCES

[1] R. S. Weis and T. K. Gaylord, “Lithium niobate: Summary of physical properties and crystal structure,” Appl. Phys. A, vol. 37, no. 4, pp. 191–203, 1985, doi: 10.1007/BF00614817.
[2] A. S. Greenblatt, C. H. Bulmer, R. P. Moeller, and W. K. Burns, “Thermal stability of bias point of packaged linear modulators in lithium niobate,” J. Light. Technol., vol. 13, no. 12, pp. 2314–2319, 1995.
[3] Y. S. Kim and R. T. Smith, “Thermal expansion of lithium tantalate and lithium niobate single crystals,” J. Appl. Phys., vol. 40, no. 11, pp. 4637–4641, 1969.
[4] M. A. Uddin, M. Y. Ali, H. P. Chan, and others, “Materials and fabrication issues of optical fiber array,” Rev. Adv. Mater. Sci, vol. 21, no. 2, pp. 155–164, 2009.
[5] C. Strandman, L. Rosengren, H. G. A. Elderstig, and Y. Backlund, “Fabrication of 45/spl deg/mirrors together with well-defined v-grooves using wet anisotropic etching of silicon,” J. microelectromechanical Syst., vol. 4, no. 4, pp. 213–219, 1995.
[6] T. Zhou, X. Liu, Z. Liang, Y. Liu, J. Xie, and X. Wang, “Recent advancements in optical microstructure fabrication through glass molding process,” Front. Mech. Eng., vol. 12, no. 1, pp. 46–65, 2017.
[7] R. W. Eason, I. E. Barry, G. W. Ross, and P. G. R. Smith, “Fabrication of alignment grooves in LiNbO3 substrates for simplified optical fibre pigtailing,” Electron. Lett., vol. 35, no. 4, pp. 328–329, 1999.
[8] I. E. Barry, G. W. Ross, P. G. R. Smith, R. W. Eason, and G. Cook, “Microstructuring of lithium niobate using differential etch-rate between inverted and non-inverted ferroelectric domains,” Mater. Lett., vol. 37, no. 4–5, pp. 246–254, 1998.
[9] J. Guo, J. Zhang, H. Wang, K. Liu, and A. S. Kumar, “Surface quality characterisation of diamond cut V-groove structures made of rapidly solidified aluminium RSA-905,” Precis. Eng., vol. 53, pp. 120–133, 2018.

BİLKENT ÜNİVERSİTESİ NANOTAM nanoteknoloji araştırma merkezi

Bilkent 06800, Ankara, Türkiye
T: +90-312-290 1966 F: +90-312-266 4042
nanotam@bilkent.edu.tr