ICAM2009
11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25

Chalcogenide Glass Micro-lenses Fabrication for Sensing Devices

Eric Sanchez(1)* and Craig Arnold(2)

(1) Department of Electrical Engineering, The City College of New York, New York, New York 10031, U. S. A. e-mail: esanche05@ccny.cuny.edu
(2) Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, New Jersey 08540, U. S. A.
* Corresponding author.

Abstract – Quantum Cascade Lasers (QCLs) have emerged as a leading method to produce Mid-IR laser light for sensing applications. Due to the small size of QCLs, they have the potential to significantly reduce overall device size and even to be directly integrated for on-chip sensing. Thus, corresponding optics must be scaled down creating a need for micro-lenses at mid-IR frequencies. A solution-based method for fabrication of chalcogenide glass micro-lenses is described. The micro-lenses achieved size in the range of 5 to 300µm with a have a focal length of about 16µm. These are found to behave geometrically after being characterized.

Quantum Cascade Lasers (QCLs) have emerged as a leading method to produce mid-infrared (Mid-IR) laser light for sensing applications for health and the environment [1]. Due to the small size of QCLs, they have the potential to significantly reduce overall device size allowing miniaturization and integration of multiple sensors and their optics components. In order to successfully implement this technology, corresponding optics must be scaled down creating a need for micro-lenses and waveguides at mid-IR frequencies. In this way, the coupling efficiency of an optical system is increased [2], while maintaining a compact, high performance and, cost effective field deployable sensors.

In developing optical elements, the method used plays a critical role in reaching the small feature sizes. We describe a solution-based method for the fabrication of chalcogenide glass micro-lenses. Chalcogenide glasses have become an important material for mid-IR technology due to their favorable physical and optical properties [3]. Chalcogenide glasses outweigh optical plastics such as the family of the cyclic olefin copolymers (COC) due to its higher optical transmission, and lower thermal expansion coefficient [4]. All this is particularly beneficial for development of precision trace gas sensing. Possible applications of this technology include medical and industrial endoscopy, imaging processing applications that require material penetration of the illumination of multiple detector elements [5], and breath biomarkers of oxide stress among others.

This particular method consists of two components: dispensation of the solution and solidification by heat treatment. Using a microjet system 10 µl of an As_2S_3 solution are placed in a capillary with a 50µm nozzle tip at a constant pressure of -10mPas in order to keep the solution inside the capillary glass. Then, the nozzle is positioned over the surface (InP in this case due to its widely use in Mid-IR technology as a substrate) at a height of ~500µm. A voltage of 130V is applied to the piezoelectric actuator for a period of 10µs generating positive pressure of 3.5 MPa, which release small droplets of the solution on the surface. In the heat treatment phase, the micro-droplets are placed in an oven and baked at 50°C for 50 minutes, allowing the solvent to evaporate. After solidification, the micro-droplets become plano-convex micro-lenses with focal lengths given in table 1 and sample profiles as shown in figure 1.

Lens	Substrate	Diameter (µm)	Height (µm)	*f*(µm)
AD1	InP	25.8	9.2	13.6
AD2	InP	29.5	7.3	18.6
AD3	InP	17.7	3.5	12.9
AD4	InP	12.0	0.8	22.9

Table 1: Micro-lenses measurements.

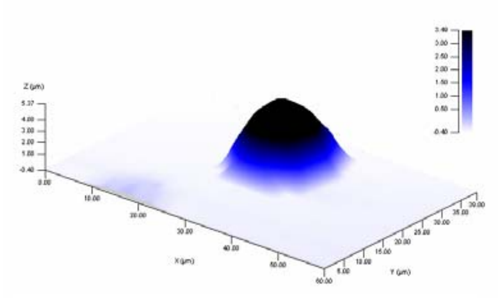

Figure 1: 3D Profilometry of micro-lens AD3.

References

[1] C. Gmachl, F. Capasso, D. L. Sivco, and A. Cho. Recent progress in quantum cascade lasers and Applications. Reports on Progress in Physics. 64, 1533–1601 (2001).
[2] C.T. Pana and C.Y. Su. Study of micro-lens array by reflow process. Journal of Modern Optics, Vol. 55, No. 17, 10 (2008), 2843–2856.
[3] H. Hisakuni and K. Tanaka Optical fabrication of microlenses in chalcogenide glasses. Optics letters, Vol. 20, No. 9, (1995).
[4] A . H. Ottevaere, R. Cox, H. P. Herzig, T. Miyashita, K. Naessens, M. Taghizadeh, R Volkel, H. J. Woo, H Thienpont. Comparing glass and plastic refractive microlenses fabricated with different technologies. J. Opt. A: Pure Appl. Opt. 8 (2006) S407–S429
[5] A.W.M.Lee, B.S. Williams, S. Kumar, Q. Hu, and J.L. Reno "Real-time imaging using a 4.3-THz quantum-cascade laser and a 320×240 microbolometer focal-plane array," Phot. Tech. Lett., 18, 1415-1417 (2006). B. S. Williams, S. Kumar, Q. Hu, and J.L. Reno, "High-power terahertz quantum-cascade lasers," Elec. Lett., 42, 89-91 (2006).