# An innovative approach to generate polymer-base vibrating mesh for nebulization therapy

Lucas Ting-Kai Tsai[1], Sheng-Kai Lin[1], Shen-Hao Lai[2,3], Wei-Chun Chin[4], Eric Yi-Tong Chen[1]
[1]R&D Department, MicroBase Technology Corp, Taoyuan City, Taiwan
[2]Department of Pediatrics, Chang Gung Memorial Hospital, Taoyuan City, Taiwan
[3]Chang Gung University, Taoyuan City, Taiwan
[4]Bioengineering program, School of Engineering, University of California, Merced, CA, USA
ericchen@microbase.com

## Abstract

Inhalation therapy has been a cardinal way to deliver medication topically into pulmonary system in order to alleviate various symptoms associated with respiratory disorders. In particular, drug delivered via the vibrating mesh nebulizer has gained much momentum in recent years due to its versatility and relatively affordable retail price. However, traditional method of manufacturing the critical nebulizing module involved micro-eletroforming of metal-alloy mesh which proved to be costly, time-consuming and unstable at times. Whether an alternative strategy existed that potentially circumvents persisting dilemma has never, heretofore, been considered. Our data showed for the first time that a novel laser dry-etching based technology can effectively generate smooth and clean micro-pores on the surface of a polymer-based mesh. Using 248 nm UV range excimer laser processing, consistent aperture diameter can be rapidly drilled on our polyimide mesh. When atomizing Ventolin, our nebulizer (Pocket Air) showed superior aerosol diameter (MMAD), lung deposition rate, and drug delivery efficiency compared to a world leading brand, NE-U22 from Omron. Evidence provided here also demonstrated that our innovative mesh manufacturing capacity and Pocket Air enabled successful nebulization to potentially enhance patient compliance and drug delivery efficacy.

## Experimental equipment and method

In brief, the 248 nm UV range excimer laser source (with output power 350 mJ and firing frequency of 100 kHz), optical path system, and laser dynamic control module were integrated to explore the relationship between different laser shots and the size of micro-pore generated (Fig. 1). Upon finishing PI mesh, it was assembled together with a piezo-electric actuator and a stainless steel plate to make nebulizing module. When an electric current was applied, all three components worked in unison where by the oscillatory motion created the final aerosol (Fig. 3). Completed nebulizing module was then incorporated into our product (Pocket Air from MicroBase Technology Corp) whereby the aerosol generating and airway deposition performances were compared against a commercially available predicate device NE-U22 from OMRON (Fig. 4). A common nebulizing medication Ventolin was used in the evaluation where the aerosol particle size, deposition quantity and rate were measured and analyzed by breathing simulator (BRS; Copley), next generation impactor (NGI; Copley) and HPLC (Waters) (Fig. 2).

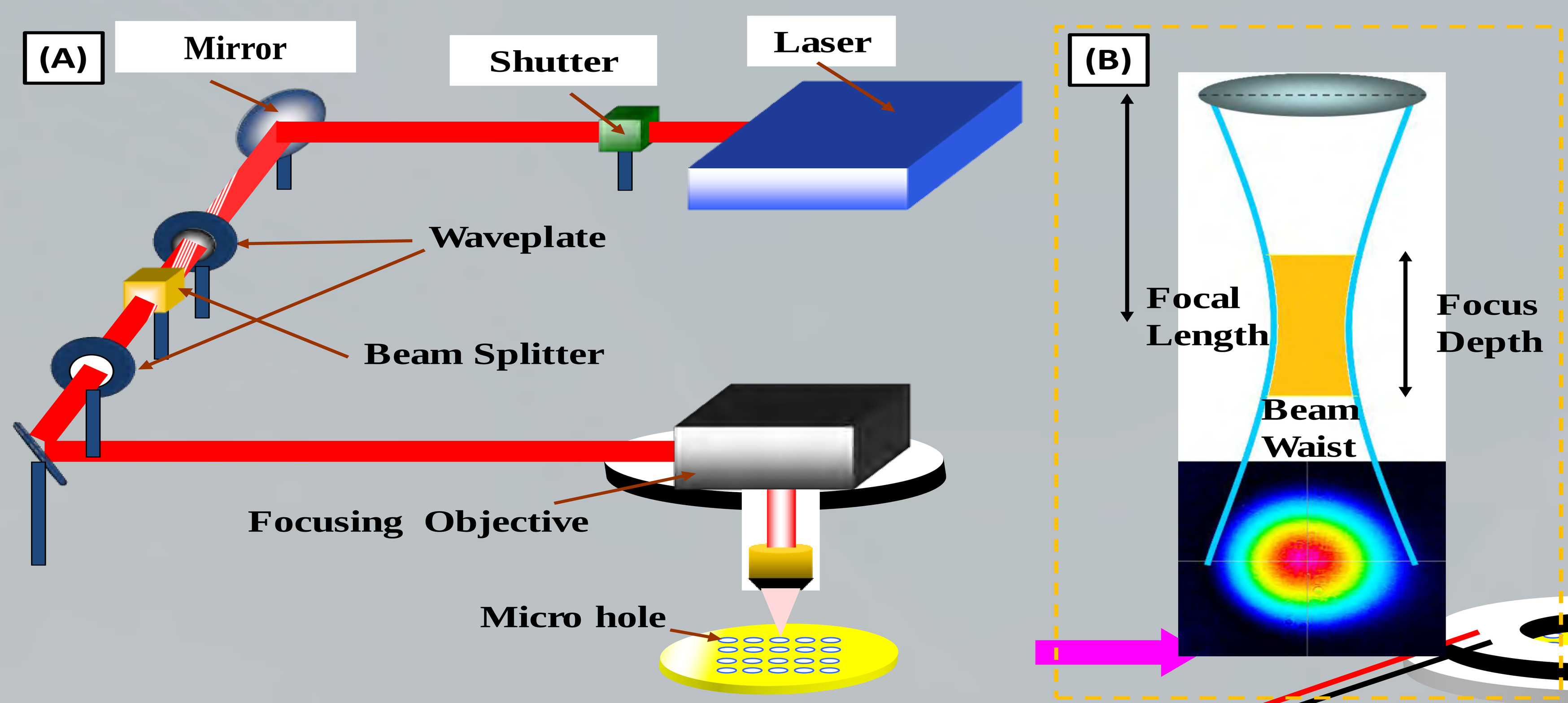


Fig.1 Schematic diagram of the Excimer laser micro-machining system


Fig.2 Experimental equipment:
(A) NGI (B)BRS (C) HPLC

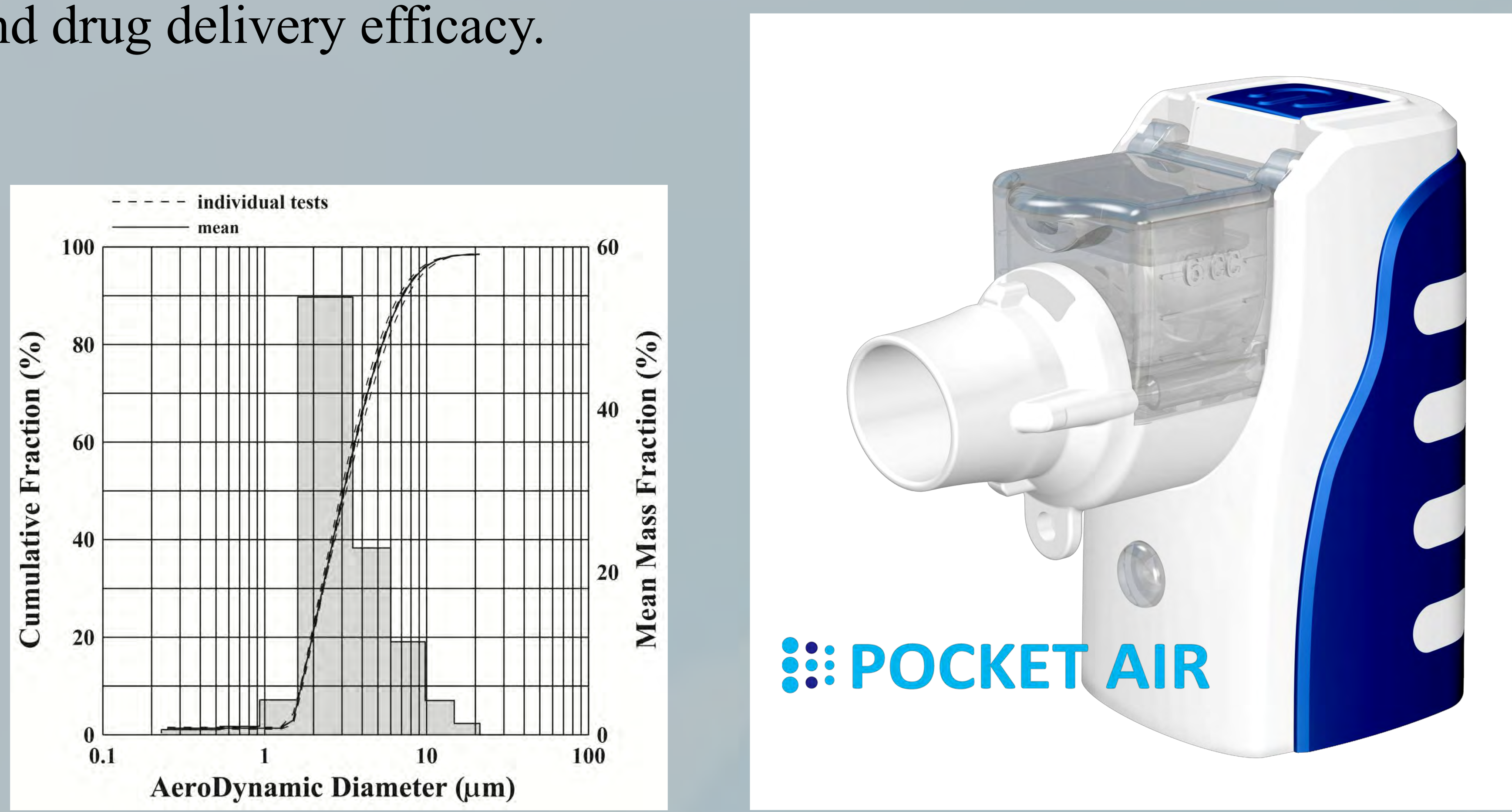


Fig.4 MicroBase nebulizer (Pocket Air) and AeroDynamic Diameter

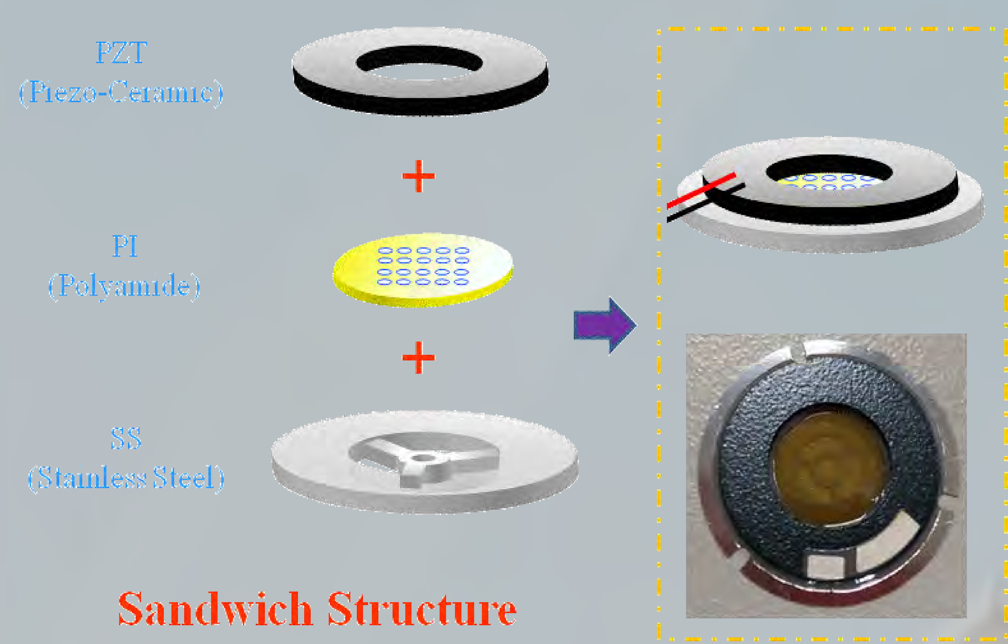


Fig.3 MicroBase nebulization module

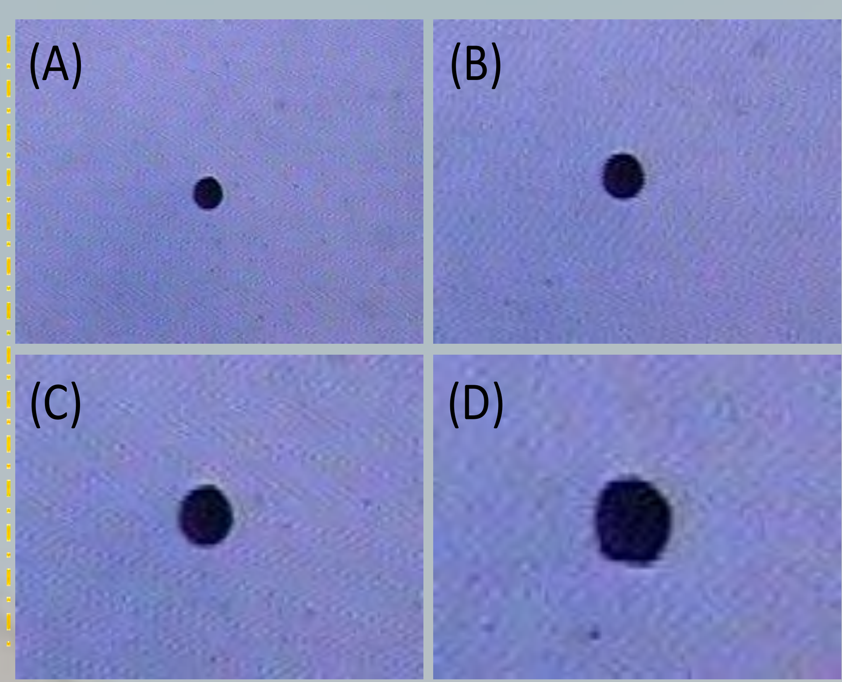


Fig.5 Typical OM image of laser microfabrication for PI

| Device | NGI | | | Breathing Simulator | | |
|---|---|---|---|---|---|---|
| | | MMAD (um) | GSD | | Total Delivered | Treatment time |
| [illegible]base | 5°C 15L/min | 5.164 | 1.797 | Adult | 41.86% | 5m10s |
| Omron | 5°C 15L/min | 5.988 | 1.917 | Adult | 38.73% | 14m17s |

Fig.6 Table of comparison

## Conclusion

In summary, current investigation yielded critical evidence revealing that our special excimer laser-etching technology can create polymer-based nebulizing meshes that has surpassed the capacity and replaced conventional metal-alloy meshes. Our new method provides a more economical and safer approach to manufacture vibrating mesh nebulizers and at the same time delivers drug more efficiently than a world leading brand. Through continuous efforts in research and development, we aim to develop novel inhalation therapeutic devices to improve patient compliance and clinical efficacy.

## Reference

[1] 沈聖智、王郁仁、程榮勝、鄧吉雄、葉建賢、李聰瑞、蔡明杰, 微機電式霧化器之研發與應用, 機械工業雜誌, 46-49( 2006)。
[2] 沈聖智、王郁仁、吳泰鋒、陳易呈、李聰瑞, 微機電技術應用於吸入式霧化器之研發, 機械工業雜誌, 77-88(2005)。
[3] S.C. Shen, "Design and fabrication of medical micro-nebulizer," Sensors and Actuators, vol. 144, pp.135-143(2008).
[4] R. Williams, S. Richard and Muller, "Etch Rate for Micromachining Processing," Journal of Microelectromechanical Systems, vol. 5, no. 4, pp. 256-269(1996).
[5] Y.R. Jeng, C.C.Su, G.H.Feng, Y.Y.Peng, "An investigation into a piezoelectrically actuated nebulizer with μEDM-made micronozzle array," Experimental Thermal and Fluid Science, vol. 31,pp.1147-1156(2007).
[6] M. Kurata-Nishimura, T. Kobayashi, Y. Matsuo, T. Motobayashi, Y. Hayashizaki, and J. Kawai, "Dynamics of ablation plasma induced by a femtosecond laser pulse in electric fields," Applied Surface Science, 255 (2009).
[7] Z. Li, P. Li, Jinqing Fan, R. Fang, and D. Zhang, "Energy accumulation effect and parameter optimization for fabricating of high-uniform and large-area period surface structures induced by femtosecond pulsed laser," Optics and Lasers in Engineering, 48 (2010).
[8] Bäuerle, D. Laser Processing and Chemistry, 3rd Ed., Springer-Verlag, Berlin, Deutschland (2000).
[9] T. K. Tsai, T. L. Chang, Y. H. Kuo, T. H. Chou, and J. Huang, " Study of femtosecond laser scribing for thin-film solar cells process,"14th Nano Engineering and Micro Systems Technology Conference (2010).
[10] J. S. Yahng, J. R. Nam, and S. C. Jeoung, "The influence of substrate temperature on femtosecond laser micro-processing of silicon, stainless steel and glass," Optics and Lasers in Engineering, 47 (2009).