VIBRATING NANONEEDLE AND LAB-ON-CHIP MICROFLUIDICS SYSTEM FOR SINGLE CELL MECHANICS

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MARCH 2015

Specially dedicated to my beloved parents and lovely wife Nusrat Jahan.

Also for those who want to be researchers.

ACKNOWLEDGEMENT

By the name of Allah, the most merciful, the most benevolent. First and foremost, I would like to express my heartiest gratitude to my supervisor Dr. Mohd Ridzuan bin Ahmad. I am very lucky to have a great mentor like him as he is the best in his nature. His careful guidance, kindness, friendly & positive behaviour and his undying spirit continuously motivate me to keep focus on research work. Indeed, he has taught me to be diligent and steadfast in my work. I am truly grateful.

I am greatly indebted to the examiners of this thesis: Prof. Dr. Shabudin bin Mohamed Ali (UKM) and Dr. Leow Pei Ling (UTM) for their valuable time and efforts to evaluate this thesis. Their constructive comments and suggestions improved this work significantly. I am thankful to Professor Yasuhisa Hasegawa and Professor Toshio Fukuda of Nagoya University (NU), Japan for providing me the micronano fabrications & clean room facility. I also had the privileged to work with Associate Prof. Dr. Masahiro Nakajima and Dr. Takeuchi Masaru (NU). Indeed, their priceless suggestions and comments to the fabrication works created huge difference in this research. My appreciations also go to Dr. Naznin Sultan and Dr. M. Abu Naser (UTM) for their suggestions on single cell culturing and also for the valuable discussions from biological points of view.

I really appreciate the kind efforts of Sarder Mohammad Yahya and Dr. Pei Song Chee (UTM) to enhance my understanding to develop the relationship between drag force and motion of the particle inside microfluidics channel. Their suggestions also improved the thesis presentation and reduced typos. My heartiest appreciations go to my research group Micronano Mechatronics System Engineering, UTM specially Abdul Hafiz Mat Sulaiman, Amelia Ahmad Khalili, Salma Abdullah, Mostafa Sayahkarajy, Ida Laila, Bashir Bala Muhammad and Siti Nadia for their sincere guidance, constructive comments, valuable suggestions and endless supports.

I am also thankful to my senior research fellows specially Sazzad Hossain (MIMOS, Malaysia), Mir Hossain (Chittagong University, Bangladesh), Akhtaruzzaman Adnan (UAP, Bangladesh) for their sincere guidance in developing my research career. In addition, Dr. Md. Liakat Ali (LSU, USA), Dr. Mohammad Abdur Razzaque (Trinity College Dublin, Ireland), Dr. Mahmud Anwar (Curtin University, Malaysia) & Dr. Shafiqul Islam (UTM) for their encouragements in research.

I have to say, there are many more people were involved in this research work especially Bangladeshi students from Universiti Teknologi Malaysia. My appreciations go to my helpful friends, sincere fellows and lovely juniors specially Tahsin Morshed, Ananya Raka Chakraborty, S. K. Sakif Saad, Sohel Rana, Mohammad ul Haq, Jubaer Ahmed, Mhm Mubasshir, Shamim Hasan Sarkar, Md. Tareq Rahman, Md. Sabbir Ahamed, Raian Zafar Khan, Sharful Hossain Rafee, Saidus Salehin and Shamur Rahman Akash for keeping my life cherished. It is really hard to mention all the names here in this limited space. If I forgot your name please forgive me as you always did before.

Again, I am greatly indebted to my parents for teaching me the value of integrity, patience and hard work in life. My family especially my wife Nusrat Jahan sacrifices a lot during my study, yet inspiring me with smile and care. Thanks for being with me always in ups and downs of my life. Foremost, thanks for your unconditional love.

Last but not least, I would like to take the opportunity to express my appreciation towards Ministry of Higher Education Malaysia (MOHE) grant no. 4L038 (ERGS) and Universiti Teknologi Malaysia grant nos. 02H34 and 03H80 (GUP) for funding this project and for their endless support.

Johor Bahru, March, 2015

Md. Habibur Rahman

ABSTRACT

Single cell mechanics is a vital part of single cell analysis. It has attracted great interest among scientists as cell mechanics can be linked to early diagnosis of diseases. To date, several great findings have been achieved in the study of single cell mechanics. Nevertheless, more work are required to enable the technology to be pushed to the frontier of single cell mechanics. Considering this objective, this work focuses on the technological development of two major parameters of single cell mechanics: Single Cell Wall (SCW) cutting operations (Phase 01) and Single Cell Mass (SCM) measurement (Phase 02). A *saccharomyces cerevisiae* yeast cell was used as a sample cell. In phase 01, a vibrating nanoneedle (tungsten) integrated with lead zirconate titanate piezoelectric actuator was used for SCW cutting operation. Two different frequencies of vibrating nanoneedle were used for cell wall cutting operation: 1 Hz and 10 Hz. For a constant penetration depth of 1.2 µm, the obtained cell nanoneedle's velocities were 7 µm/s and 24 µm/s. Results show that faster nanoneedle causes less damage to the cell surface. In phase 02, a Lab-On-Chip microfluidics system was used for SCM measurement. SCM result was extracted from the relation between drag force applied on cell and Newton's law of motion. Drag force on the cell has been generated by a pressure driven syringe micropump. This approach of measuring SCM was calibrated using a known mass (73.5 pico gram) of polystyrene particle of 5.2 µm diameter. Different sizes (2-7 µm diameter) of yeast cells were cultured in our laboratory. Mass of 4.4 µm diameter of yeast cell was measured as 2.12 pg. In addition, results show that single yeast cell mass increases exponentially with the increase of cell size. It is envisaged that this work i.e. combination of single cell cutting operation and single cell mass measurement system will add a significant contribution to the knowledge of cell mechanics and single cell analysis.

ABSTRAK

Mekanik sel tunggal adalah penting dalam analisis sel tunggal. Ia telah menarik minat yang tinggi di kalangan ahli sains kerana mekanik sel boleh dikaitkan dengan diagnosis awal penyakit. Setakat ini, beberapa penemuan besar telah dicapai dalam mengkaji mekanik sel tunggal. Walau bagaimanapun, banyak perkara perlu dilakukan untuk membolehkan teknologi ini dibawa ke tahap paling tinggi dalam analisis mekanik sel tunggal. Bagi mencapai objektif ini, tumpuan diberikan kepada pembangunan teknologi bagi dua parameter utama mekanik sel iaitu operasi memotong Dinding Sel Tunggal (SCW) (Fasa 01) dan pengukuran Jisim Sel Tunggal (SCM) (Fasa 02). Sel yis *saccharomyces cerevisiae* digunakan sebagai sel sampel. Dalam fasa 01, jarum nano bergetar (tungsten) disepadukan dengan penggerak piezoelektrik pelambam zirkonat titanat telah digunakan untuk operasi memotong SCW. Dua frekuensi jarum nano bergetar yang berbeza telah digunakan untuk operasi pemotongan dinding sel: 1 Hz dan 10 Hz. Bagi mendapat kedalaman penembusan berterusan sebanyak 1.2 μm, halaju penembusan dinding sel yang didapati adalah sebanyak 7 μm/s dan 24 μm/s. Keputusan menunjukkan bahawa jarum nano yang lebih laju dapat mengurangkan kerosakan pada permukaan sel. Dalam fasa 02, satu sistem mikrobendalir *Lab-On-Chip* telah digunakan bagi pengukuran SCM. Jisim sel tunggal dikira melalui daya seretan yang dikenakan kepada sel yang dikaitkan dengan hukum gerakan Newton. Kuasa seretan pada sel telah dijanakan oleh picagari pam mikro dipandukan tekanan. Sistem ini dikalibrasi menggunakan jisim zarah polistirena (73.5 pico gram) berdiameter 5.2 μm. Sel yis bagi saiz yang berbeza (2-7 μm diameter) telah dikultur di makmal. Jisim sel yis tunggal bagi saiz diameter 4.4 μm telah diukur sebagai 2.12 pg. Di samping itu, keputusan menunjukkan bahawa jisim sel yis tunggal mengalami peningkatan secara eksponens dengan peningkatan saiz sel. Adalah dijangka bahawa kerja ini iaitu gabungan pemotongan sel dan sistem pengukuran jisim sel tunggal akan menambah nilai yang besar terhadap bidang mekanik sel dan analisis sel tunggal.