2． 項目簡介

(*項目所屬科學技術領域、主要技術內容、授權專利情況、技術經濟指標及應用推廣情況*)

Automated micromanipulation systems are demanding and peering devices for modern precision engineering applications in micro/nano manufacturing, biomedical engineering, IC packaging, etc. As technology breakthroughs, microinjectors and microgrippers are frontier equipments to enable the automation of micromanipulation process. In modern biotech industry, there are extensive needs for advanced micromanipulation equipments with microforce sensing and control capabilities. The invention of force-sensing microinjectors and microgrippers enable extensive applications involving biological field with guaranteed safety and accuracy of advanced robotic manipulation.

In line with the development trend of robotics and biomedical S&T, the objective of this project is to lead innovative technologies for developing force-sensing microinjector and microgripper equipments towards automated operation at the micro and nanometer scales. The invented technologies and equipments make the following breakthroughs.

(1) Development technologies of microinjector with microforce sensor are proposed to invent novel force-sensing piezo-driven microinjector for reliable and effective microinjection of batch biological cells with high survival rate.

(2) Development technologies of force-sensing microgripper are created to generate novel microgrippers for safe manipulation of living biological cells. Novel MEMS microgrippers with one force sensor for dual-axial force sensing are invented with simple structure.

(3) Development technologies of constant-force microinjector and microgripper are designed to eliminate the dependence on force feedback control. Novel constant-force equipments are applied to enable reliable micromanipulation with system cost reduction.

(4) Novel control technologies are focused and conducted to enable precise and robust motion/force control for the micromanipulation equipments dedicated to automated micromanipulation.

Technology transfer of the invented innovative technologies leads to cost reduction of product, and the project results have significant impacts on academic community. The impacted outcomes have been well recognized and appraised by world renowned experts in related field.

During 5-year execution, the project has trained/under training 3 PhD, 14 MSc, and 18 BSc students, and led to 65 publications including 1 monograph by Springer Nature publisher, 30 SCI journal papers, and 34 EI conference papers. Among them, 15 papers are published in prestigious IEEE/ASME journals including IEEE Trans. on Industrial Electronics (Rank 1/60 in AUTOMATION & CONTROL SYSTEMS), IEEE/ASME Trans. on Mechatronics (Rank 1/44 in ENGINEERING, MANUFACTURING), IEEE Trans. on Industrial Informatics (Rank 1/44 in ENGINEERING, INDUSTRIAL), IEEE Trans. on Robotics, etc. The publications have been cited by 282 times in Google Scholar, where the PI has the H-index of 37. The involved students have been nurtured successfully. Even BSc students, after a training of less than one year with their hard work in final-year projects, received Toshio Fukuda Best Paper Award in Mechatronics in 2016 IEEE Int. Conf. on Advanced Robotics and Mechatronics (ARM).

Owing to the novelty and utility of the invented technologies, 4 China Patents have been authorized or under review. The first monograph on biological micromanipulation from Macau has been published. The invented technologies and equipments of automated micromanipulation have demonstrated extensive applications in biomedical engineering, gene engineering, disease diagnosis, and drug development, etc. Considering the superiority of the invented equipments over existing commercial products, they have attracted great interests from both academia and industry. Commercialization of the invented technologies will be conducted in near future. The outcomes of the project have substantially contributed to the advancement of S&T and industry field in Macau and beyond.

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