CRF 8E (Revised Dec 08)

RGC Reference	**HKBU8/CRF/11E**
please insert ref. above	

The Research Grants Council of Hong Kong
Collaborative Research Fund Equipment Projects
Completion Report

(for completed projects only)

Part A: The Project and Investigator(s)

1. Project Title

Low-temperature, Ultrahigh-vacuum Glancing Angle Deposition (LT-UHV GLAD): Material and Morphology Engineering of Multi-dimensional Photonic Nanostructures for Fundamental and Applied Studies

2. Investigator(s) and Academic Department/Units Involved

Research Team	Name/Post	Unit/Department/Institution
Project Coordinator	Dr. Zhifeng Huang /Assoc. Prof.	HKBU/Physics
Co-investigator(s)	Prof. Kok-wai Cheah Prof. Jimmy Chai-mei Yu Prof. Mengsu Yang	HKBU/Physics CUHK/Chemistry CityU/ Biology and Chemistry
Others		

3. Project Duration

	Original	Revised	Date of RGC Approval *(must be quoted)*
Project Start Date		01-Jun-2012	
Project Completion Date		31-May-2014	
Duration (*in month*)	12	24	13-Feb-2012
Deadline for Submission of Completion Report	31-Jan-2015	31-May-2015	

Part B: Report on Project Progress

5. Project Objectives

5.1 Objectives as per original application

1. Set up a LT-UHV GLAD equipment with a multi-crucible electron beam evaporator to produce morphology-controllable multi-dimensional nanopillar arrays (mD-NPAs) made of metals and metal/dielectric composites;
2. Broaden the morphology-engineering range from semiconductors and oxides to metals and metal/dielectric composites;
3. Fully develop the GLAD-based material/structure production platform in Hong Kong;
4. Promote the fundamental studies of material/morphology-sensitive nanophotonics;
5. Explore applied researches in the emerging fields, e.g. nano-optics, environmental remediation using renewable energy and stem cell differentiation.

5.2 Revised objectives

Date of approval from the RGC: 13-Feb-2012

CRF 8E (Revised Dec 08)

Reasons for the change: polish in words, as indicated by underlining

1. Set up a LT-UHV GLAD equipment with a multi-crucible electron beam evaporator to produce morphology-controllable multi-dimensional nanopillar arrays (mD-NPAs) made of metals and metal/dielectric composites;
2. Broaden the morphology-engineering range from semiconductors and oxides to metals and metal/dielectric composites;
3. Fully develop the GLAD-based material/structure production platform in Hong Kong;
4. Promote the fundamental studies in the morphology dependence of material properties;
5. Explore applied researches in the emerging fields, e.g. nano-optics, environmental remediation using renewable energy and stem cell culture.

6. Research Outcome

6.1 Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

A LT-UHV GLAD was set up at HKBU, to generate mD-NPAs on diverse substrates (such as Si wafers, transparent and conductive substrates and flexible substrates). The mD-NPAs can be flexibly engineered in terms of materials (e.g., noble metals, semiconductors, dielectrics and metal/dielectric compounds) and morphology (e.g. shape, height, surface density, and surface orientation).

On the basis of the LT-UHV GLAD, a platform to produce functional nano materials has been developed to carry out fundamental and applied researches, by means of the collaboration with research institutes in Hong Kong, mainland of China, Taiwan and Saudi Arabia. Some collaboration projects are being studied, and some have been published. Herein, it is shown some research outcomes that have been or are going to be published.

1. Ballistic glancing angle deposition of inclined Ag nanorods limited by adatom diffusion. *Nanotechnology* 24: 465707 (2013)
Inclined Ag nanorods (AgNRs) were deposited using high vacuum low-substrate-temperature GLAD to study the NR growth orientation with deposition angle. The CE model fits very well, illustrating that the oblique deposition of Ag undergoes ballistic deposition in high vacuum, limited by temperature-dependent adatom diffusion. The CE model evaluates E_d as 0.23 eV, illuminating that the as-deposited Ag NRs are poly-crystalline with dominant (111) crystalline surfaces, as confirmed by the XRD characterization.

2. Microfluidic-based metal enhanced fluorescence for capillary electrophoresis by Ag nanorod arrays. *Nanotechnology* 25: 225502 (2014)
We have studied the solution-based metal enhanced fluorescence (MEF) of AgNR arrays in terms of their morphology, orientation, absorption, and scattering. With a nominal thickness of 2 μm, AgNRs exhibit the largest EF. Since MEF is a short-range effect and only occurs within interstitial spaces in the Ag ND layer, the EEF values are also calculated by referring to Si substrate and reported as 259 ± 92 and 494 ± 157, respectively, for the Ag NDs at T = 2000 nm and 3000 nm owing to their strong scattering. Finally, a multilayer of SiO_2 NRs/Ag NRs is integrated with a CE microdevice, and a 6.5-fold improvement in the optical detection of amino acid is observed with a separation channel depth of 10 μm.

3. Dramatic enhancement in enantioselectivity induced by three-dimensional chrioplasmonics, submitted to *Nat. Mater.*
Ag nanospirals (AgNSs) exhibit the UV and visible chiroplasmonic CD activity. The visible mode predominantly originates from the scattering loss on the helix surfaces, accompanied with the generation of optically induced electric current flowing along the coil longitudinal axis. Consequently, with an elongation of spirals, the visible surface mode tends to broaden and have a red shift in a linear manner. Molecular adsorption on the helical surfaces generally screens the visible CD, probably owing to the adsorbents that effectively reduce the helical chirality or block the chiral current flow on the surfaces. The sensitive response of the visible surface mode to molecular adsorption is used for enantioselection, leading to an enantioselection g factor on the order of 10^{-1} that has a significant increase in 2-4 orders of magnitude compared to achiral quantum dots and nanoclusters. The dramatic enhancement in enantioselectivity is mainly ascribed to the extremely high chiroptic activity of the AgNS arrays, so as to remarkably amplify the chiroplasmonic interaction with enantiomers on the helix surfaces.

6.2 Potential for further development of the research and the proposed course of action *(maximum half a page)*

In the section 5.3, it has been tabulated various collaborations which are in progress. These collaboration projects will be continuously carried after the completion of this CRF project. Furthermore, there are some researches that will be explored, including surface enhanced Raman optical activity, surface enhanced vibrational circular dichroism, and the application in the trace detection of environment, food production, agriculture and health.

7. The Layman's Summary

(describe in layman's language the nature, significance and values of the research project, in no more than 200 words)

This CRF-equipment project set up a material-fabrication equipment, low-temperature, ultrahigh-vacuum glancing angle physical vapour deposition. The facility enables one to generate nano/micro-scale thin films looking like a forest, and to flexibly engineer the shape, structure and material of trees in the forest. On the basis of the facility, it was set up a platform to produce functional nano materials in Hong Kong. A wide range of collaborations has been operated with research institutes in Hong Kong, mainland of China, Taiwan and Saudi Arabia, in the field of cell culture, biological sensor, green energy, semiconductor electronics, chemical synthesis induced by light, optical function coating. The setup of the platform will promote the material-related fundamental and applied research in Hong Kong, and enhance the contribution of Hong Kong to the field of material-related science and technology.

CRF 8E (Revised Dec 08)

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s) *(denote the corresponding author with an asterisk*)*	Title and Journal/Book *(with the volume, pages and other necessary publishing details specified)*	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of RGC *(Yes or No)*
Year of publication	Year of Acceptance (For paper accepted but not yet published)	Under Review	Under Preparation (optional)					
2013				F. Bai, W. K. To, and Z. F. Huang,*	Porosification-induced back-bond weakening in chemical etching of n-Si(111), *J. Phys. Chem. C*, 117: 2203-2209 (2013).	No	Yes	Yes
2013				W. F. Lau, F. Bai, and Z. F. Huang,*	Ballistic glancing angle deposition of inclined Ag nanorods limited by adatom diffusion, *Nanotechnology* 24: 465707 (2013)	Yes (2013)	Yes	Yes
2014				Z. F. Huang* and F. Bai	Wafer-scale, Three-Dimensional Helical Porous Thin Films Deposited at a Glancing Angle, *Nanoscale* 6:9401 (2014).	No	Yes	Yes

			✓	F. Bai, J. H. Deng, W. F. Lau, M. S. Yang, T. F. Ng, and Z. F. Huang*	Dramatic Enhancement in Enantioselectivity Induced by Three-Dimensional Chiroplasmonics, under preparation for submitting to *Nature Mater.*	No	No	Yes
			✓	W. F. Lau, L. Cheng, N. P. Lui, K. L. Yung,* and Z. F. Huang*	Physically induced differentiation of neuron stem cells on porous thin films	No	No	Yes

9. **Recognized international conference(s) in which paper(s) related to this research project was/were delivered** *(Please attach a copy of each conference abstract)*

Month/Year/ Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of RGC *(Yes or No)*
Dec/2014/Hong Kong	Engineering of chiroplasmon and investigation in the molecule-chiroplasmon Interaction (invited talk)	The 11th Cross-Strait Workshop on Nano Science and Technology	No	Yes	No
Dec/2014/Hong Kong	Noble metal nanospirals: 3D chiral nanoplasmonics and potential applications in enantioselection (invited talk)	2014 International Conference on Small Science	No	Yes	No
Nov/2014/ Wuhan, China	Noble metal nanospirals: 3D chiral nanoplasmonics and potential applications in enantioselection (Keynote talk)	the 6th National Molecular Chirality Congress of Chinese Chemical Society	No	Yes	Yes

Oct/2014/Hsinchu, Taiwan	3D chiral nanoplasmonics on noble metal nanospirals (invited talk)	the 7th Vacuum and Surface Science Conference of Asia and Australia	No	Yes	Yes
Nov/2013/Beijing, China	Silver nanospirals: 3D chiral metamaterials (invited talk)	Asia Communications and Photonics Conference (ACP) 2013	No	Yes	No

10. Student(s) trained *(please attach a copy of the title page of the thesis)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Mr. Fan, Bai	PhD	01-Jan-2013	NA

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*

For the collaboration, please refer to 5.3.