Younger Scientists

Hiroyuki Fujiwara

The JSAPI would like to introduce Dr. Hiroyuki Fujiwara who is one of the 38 recent recipients of the Young Investigator Award of the 1998 Japan Society of Applied Physics Spring Meeting, for his outstanding research while at Pennsylvania State University. Currently, he is a research associate at the Electrotechnical Laboratory (ETL) in Japan, where he specialises in the real time monitoring of thin film growth using spectroscopic ellipsometry and infrared spectroscopy.

I was honoured to receive the Young Investigator Award from the Japanese Society for Applied Physics for my research into the application of real time spectroscopic ellipsometry (RTSE) to the depth-profiling of graded amorphous silicon alloy (a-Si_xC_{1-x}:H). The research was carried out in the laboratory of Drs. Collins and Wronski at Pennsylvania State University, where I was a research fellow of the Japan Society for the Promotion of Science (JSPS) and, later, a postdoctoral researcher.

It was after finishing my Doctor of Engineering Degree at Tokyo Institute of Technology in 1996 that I decided to go to the laboratory of Dr. Collins., Dr. Collins has been perfecting real time spectroscopic ellipsometry instrumentation and data analysis procedures for the last decade. RTSE is a unique film characterisation method in which the structures of thin films, including surface roughness, layer thickness, bulk layer thickness and optical properties during deposition, are characterised by utilising white light as a probe.

My motivation for joining that particular laboratory lay in my expectation that the monitoring of thin film growth in real time would become an important technique for the characterisation of many different thin film fabrications, since the structure of devices had become increasingly complicated in recent years. A good collaboration between Drs. Collins, Wronski and Prof. I. Shimizu, who had been my advisor throughout my post-graduate studies, also encouraged me in my decision to join Dr. Collins' laboratory.

During my two years as a research associate at Pennsylvania State University, I focused mainly on the application of RTSE to alloy compositions in compositionally-graded a-Si_xC_{1-x}:H thin films fabricated by plasma-enhanced chemical vapour deposition. Such characterisation is technologically important in, for example,the optimisation of a-Si:H-based solar cells because the introduction of a-Si_xC_{1-x} graded layers at the p/i interface in a p-i-n solar cell structure is known to improve solar cell performance.

Since RTSE alone cannot be used to determine C-content, the first task was to parameterise the optical response (dielectric function) of the a-Si_xC_{1-x}:H layer as a function of C-content. [1] I then determined alloy compositions in the graded film structure from the data set obtained during a-Si_xC_{1-x}:H graded layer deposition by applying the parameterised optical constant as a database. This demonstrated that the application of RTSE to the characterisation of a a-Si_xC_{1-x} graded layer was destined to be a powerful tool, since it made it possible to provide details, simultaneously and during deposition, of the time-evolution of alloy composition, the instantaneous deposition rate and the surface roughness layer thickness. Furthermore, the depth-profile on an atomic scale could readily be obtained by integrating the instantaneous deposition rate against the known time of deposition. [2]

These results represent just one example of the real time monitoring techniques that are now being developed in order to fill the need for a better understanding of thin film growth phenomena in layered structures. At this stage of the work, however, a broader database of optical functions for a wide variety of films is necessary if RTSE is to reach its full potential as a tool for the analysis of more complicated film structures and for the achievement of real time process control.

I am now engaged in a study of hydrogenated amorphous and microcrystalline silicon thin films using real time spectroscopic ellipsometry and infrared spectroscopy in the laboratory of Dr. Matsuda at the Electrotechnical Laboratory. In this research, twin measurements using spectroscopic ellipsometry and infrared spectroscopy are performed simultaneously in real time in order to find a correlation between the evolution of film structure as investigated by RTSE and the local bonding states of Si-H_n (n = 1~3) as characterised by infrared spectroscopy. I hope that this real time film- growth monitoring will give us a deeper insight into the fundamental mechanism of thin film growth. The understanding gained should then allow us to modify film and device structures more effectively and in new ways.

References

1) H. Fujiwara, Joohyun Koh, C. R. Wronski, R. W. Collins, and J. S. Burnham, J. Non-Cryst. Solids **227**, 460 (1998).
2) H. Fujiwara, Joohyun Koh, C. R. Wronski, R. W. Collins, and J. S. Burnham, Appl. Phys. Lett. **74**, 2993 (1998).

Hiroyuki Fujiwara received his BS degree in applied chemistry from Waseda University and his Doctor of Engineering Degree in electronic chemistry from Tokyo Institute of Technology. He was awarded a fellowship from the Japan Society for the Promotion of Science in 1996. He was a visiting scientist and a post-doc at the Pennsylvania State University prior to joining Electrotechnical Laboratory in 1998.