Report on Visit to Ruhr-University Bochum by International Training Program

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This report is about a research project organized by International Training Program I was attending from 27th, January 2012 to 26th, March 2012 in Ruhr-university Bochum.

Introduction of Ruhr-university Bochum

Ruhr-University Bochum is located on the southern hills of central Ruhr area Bochum, was founded in 1962 and is the first new public university in Germany after World War II. The Ruhr-University Bochum is one of the largest universities in Germany and part of the Deutsche Forschungsgemeinschaft, the most important German research funding organization. Unlike a number of traditional universities, the buildings of Ruhr University are all centralized on one campus, except for the Faculty of Medicine, which also includes some hospitals in Bochum and the Ruhr area. Although the university is notorious for its monotonous 1960s architecture, mainly consisting of 14 almost identical high-rise buildings, its location at the edge of a green belt on top of the Ruhr valley is rather scenic.

Laboratory introduction

The plasma process technology plays a big role about the major industry such as a display and a solar battery, the semiconductor supporting a country. And the plasma technology has been applied to the field of application because it was applied to production widely while it was developed fast. The development of the plasma technology is carried out now in U.S.A. and Europe and Japan. At first the plasma technology is applied to many advanced fields and I am very likely to be the application and am expected. I was dispatched in Electrical engineering and plasma technology (AEPT) of the German RUHR University and moved a study. I study vapor deposition in the applied technology, etching, and the surface treatment while excellent studies moving a plasma study gather in AEPT, and being based on plasma fundamental researches.

Plasma sterilization: Removing germs and pathogens from thermo labile plastics used for medical instruments, surgical implants, wrappings or food packaging is a crucial process step in the medical and food industry. For the plasma sterilization process only non-toxic gases are needed. In this field research on : Basic studies of sterilization mechanisms, by UV radiation, ions or reactive species are carried out using a RF driven double ICP source. Development of a prototype of an easy to use and stable sterilization chamber (VHF-CCP). A combined decontamination and barrier coating process of PET-bottles for aseptic filling.

Plasma Coating and Sputtering: We encounter functional coatings which improve material's properties almost everywhere in our everyday life. Many of these thin films on nanometer scale are produced by different plasma deposition techniques such as plasma enhanced chemical vapor deposition (PECVD) or physical vapor deposition (PVD). In this field research on: Quartz-like SiOx barrier coatings on PET foils and inside bottles. Hard and wear resistant layers on mechanical tools improve their durability and therefore lower the costs and down time of machines. Ferromagnetic films, which form the basis for magnetic random access memory (MRAM), which are developed for up-to-date microelectronics.

Plasma Diagnostics and Simulation: The development of novel processes in plasma technology requires a deep insight into fundamentals of different discharges. To optimize plasma source's applications the fluxes of photons and chemically active particles to the surface of treated objects must be determined, i.e. measured or calculated.

Automatic Langmuir Probe System: This tool enables the measurement of electron energy distribution function and other parameters, like electron density or plasma potential. A retractable probe tip enables the application of APS in reactive, coating or corrosive plasmas. Even complex measurements can be performed automatically, controlled and instantly evaluated by special software.

Multiple Resonance Probe (MRP): The aim is to create a tool, which enables a calibration-free, spatial resolved, local determination of central plasma parameters by using universal plasma characteristics. A reliable evaluation of the measured data is implemented by using multiple expansion of the equivalent circuit diagram.

Optical Emission Spectroscopy: Optical emission spectra of plasmas are an important value for many applications. These measurements are performed using absolutely calibrated broadband image spectrometers.

Atmospheric Plasma: Determination of the electrical and plasma parameters, fluxes of photons and chemically active species produced in the plasma. Optimization of the plasma source by tailoring these parameters for effective application. Plasma irradiation on the substrate by simulation of spatial and temporal distribution of chemically active species in the active plasma zone and in the afterglow.

HID-Lamps: Due to their high efficacy HID-lamps are applied e.g. in automotive lighting, video projectors and high power exterior lighting. The temperature of their tungsten electrodes limits the lamp performance. Thus, actual HID-lamp research at AEPT deals with the interactions between the electrodes, their plasma boundaries and the arc discharge. The "Bochum model lamp" is used as a flexible system to study fundamental electrode phenomena under dc-, ac- and hf-operation.

Research theme

I studied relative and absolute intensity calibrations it for the modern of broadband echelle analyzer used for a diagnosis of the low temperature plasma. The scheme of a modern broadband echelle spectrometer is presented in figure 1. It is detector array with an image intensifier enables measuring very weak light sources as well as short light pulses. One single standard source of light is necessary for the relative proofreading work of the echelle spectrometer system earlier. I used it for this in the ratio of the share period of a standard tungsten ribbon lamp and NO and the release spectrum of N_2 molecules and revised echelle spectrometer by the adjustment association of tungsten-deuterium lamps. To determine the true intensity distribution of this source we used the following procedure:

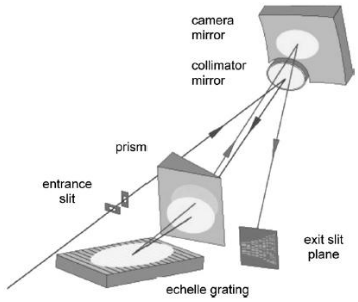

Figure 1 Scheme of the broadband echelle spectrometer

1) In a first step we stored as the 'true intensity distribution' of our composite lamp a constant value over the entire spectral region 200 nm~800 nm in the respective memory and performed the calibration procedure of the spectrometer with this premise. In this way we obtained an uncalibrated 'correction function'.

2) Then we measured the well-known spectra of the tungsten-ribbon lamp and the following molecular spectra emitted by an RF discharge: The NO ($A^2\Sigma^+ - X^2\Pi$)-system, the N_2 ($C^3\ \Pi_u - B^3\Pi_g$) 'second positive' system. We 'corrected' these spectra by the correction function $\varepsilon(\lambda)$ obtained in step 1). (Figure 2)

3) We compared the intensity distributions of the spectra obtained in step 2) with the well known spectra of these radiation sources and determined correction factors linked by the overlapping spectral regions. So, we corrected the 'true intensity distribution' assumed in step 1) by the correction factors and repeated the calibration procedure with the originally measured spectrum of the composite lamp and this new standard spectrum. In this way we obtained the final correction function $\varepsilon(\lambda)$. By using $\varepsilon(\lambda)$ to correct the unprocessed spectrum of figure 2 we obtained also the correct spectrum of the 'composite' light source of figure 3.

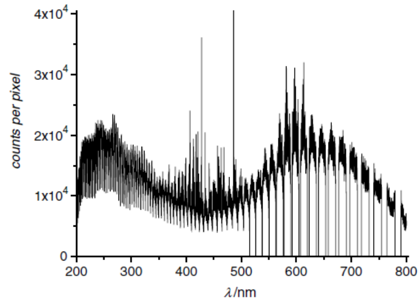

Figure 2 The uncorrected spectrum of the light source.

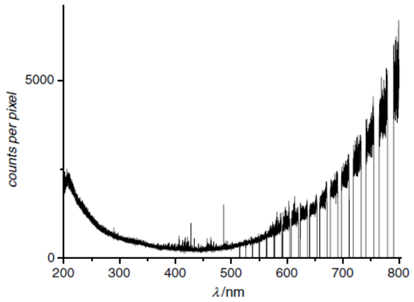

Figure 3　The spectrum of figure 2 corrected by ε(λ).

To demonstrate the potential of the echelle spectrometer for plasma diagnostics we report some results from a continuously pumped low pressure 13.56 MHz ICP-discharge running in nitrogen at about 1500 W absorbed RF power. Parts of the measured nitrogen spectra are presented in figures 4 and 5. Above 11 eV electron kinetic energy the electron temperature can be determined by means of the intensity ratios of the N_2(C—B) and N_2^+(B—X) transitions. In the range 1.5 eV~4.5 eV the electron temperature can be determined from the N_2(C—B) vibration band. The average electron density can be evaluated from absolute intensities of measured molecular bands. Under ICP discharge conditions the rotational distribution of the nitrogen molecules corresponds to the gas temperature despite the low gas pressure and can be determined from the emission spectrum by fitting calculated intensity distributions to measured ones; see figure 5.

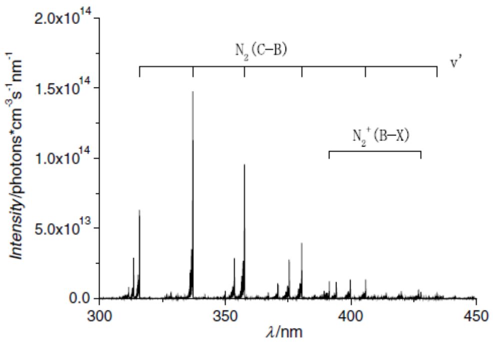

Figure 4　Part of a corrected experimental spectrum of an ICP discharge in nitrogen　(p =10 Pa, f =13.56 MHz, P=1500 W).

We have relatively and absolutely calibrated an echelle spectrometer by means of an adjustable combination of a tungsten-ribbon and a deuterium lamp, using as standard a tungsten ribbon lamp and the branching ratios in the emission spectra of NO and N_2 molecules. Emission spectra can be measured with spatial and temporal resolution. The well-resolved rotational structures of molecular emission bands give information on the gas temperature under discharge conditions. The electron distribution function can be determined from of the electronic and vibration intensity distributions of the spectra of two-atom molecules.

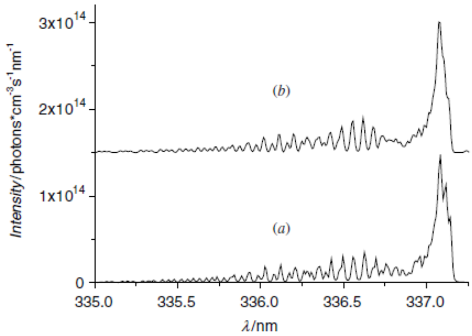

Figure 5. Corrected experimental (a) and calculated (b) rotational band of the N_2(C—B) emission demonstrating the high resolution of the echelle spectrometer.

About the life in Germany

In university, we had lunch in Menza every day. There are too many menus that we can try different food longer than one month. If you could show your student ID, they also could give you discount, so every meal just cost you below 4 euro. For dinner, we bought food from supermarket near to the university, beer, sausage and pizza from many countries, there is too much choice to decide what we eat in evening.

In holiday, I travel to the most eastern city of Germany "Essen".

The new home of the Ruhr Museum could hardly be more spectacular. The Zollverein Coal Mine, Pit XII, is the unique architectural expression of the industrial modernism of the 20th Century. It was built by the architects Fritz Schupp and Martin Kremmer on behalf of the "United Steel Works" in the style of pure functionalism 1928 to 1932. The capacity of the mine was 12,000 tons of coal a day. She was so over the decades the most powerful underground coal mine in the world. The Zollverein has been closed down in 1986 and was listed in 2001, including the Zollverein as a "representative example of the development of heavy industry in Europe" in the UNESCO list of world (cultural) heritage included. For a museum that has the Ruhr region on the topic, there is no more attractive place. For several years, the Zollverein area by EU, the North Rhine-Westphalia and the city of Essen as a center for art, design, culture and history is being rebuilt. The Zollverein Foundation manages the overall site, organizes cultural events and offers in addition to the rental of meeting rooms, a wide range of tours, most notably technically and historically significant monument guides that explain the "coal route" from the promotion to the removal. (Figure 6)

Figure 6　Welterbe Zollverein

This is my first time to Europe, I travelled every weekend to find different to Asia. Talked to people from different country, it was very helpful for me to practice my English and open my mind. This experience will also meaningful in my future work.

At last, I would like appreciate Prof. Awakowicz give me a chance to known the Germany style work, all staff and students they help me so much, without them I can’t do anything. I also appreciate Prof. Hori, Prof. Sekine, Prof. Toyoda, secretary of ITP office, without their support I can’t finish this project.