CAMT Seminar

"Atmospheric-pressure plasma deposition of carboxyl-containing co-polymers: understanding complex chemistry through simple models"

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"Functional plasma polymer surfaces in quartz crystal microbalance and surface plasmon resonance immunosensing"

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Center for Atomic and Molecular Technologies (CAMT)
(A12 棟 1 階会議室)

(Host: Satoshi Hamaguchi Ext：7913)

Atmospheric-pressure Plasma Deposition of Carboxyl-containing Co-polymers: Understanding Complex Chemistry Through Simple Models

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1. Introduction

We report preparation of carboxyl-containing co-polymers by atmospheric-pressure DBD for biosensing applications. We illustrate how characterization of the films can be coupled to relatively straightforward numerical models in order to gain deeper understanding of the behaviour of each of the monomers in the plasma and their interaction.

2. Experimental

The coatings discussed in this contribution were prepared in a DBD discharge operating at frequencies in the kHz range. The discharge operates in glow-like mode in argon with small admixture (below 0.1%) of two monomers, acetylene (C_2H_2) and maleic anhydride (MA). The films are prepared either on silicon or glass with thin gold layer (SPR chips for biosensing).

The thickness of the film, which is an input to the model discussed below, was obtained from UV+Visible ellipsometry fitted by the so-called *Universal Dispersion Model*. Additionally, the relative changes in film composition under various conditions was studied by FT-IR and the changing film roughness was studied by Atomic force microscopy.

3. Bringing model and experiments together

The experiments are complemented by a numerical model of gas flow in full 3D and simplified chemistry. The chemistry model assumes each monomer to occupy one of three averaged states, consistent with the Yasuda theory (monomer, activated monomer, stable species).

Since the numerical model reduces the complex reaction scheme to a few averaged species and processes, it has to be calibrated. The calibration is done by correlating activated species' fluxes from the model with the measured film thickness. Subsequently, it is confirmed by validation experiments that the model has good predictive capabilities even at conditions outside of the calibration range.

With the help of the model, we study e.g. the rates of consumption of individual monomers or the dependence of sticking coefficients on the film composition.

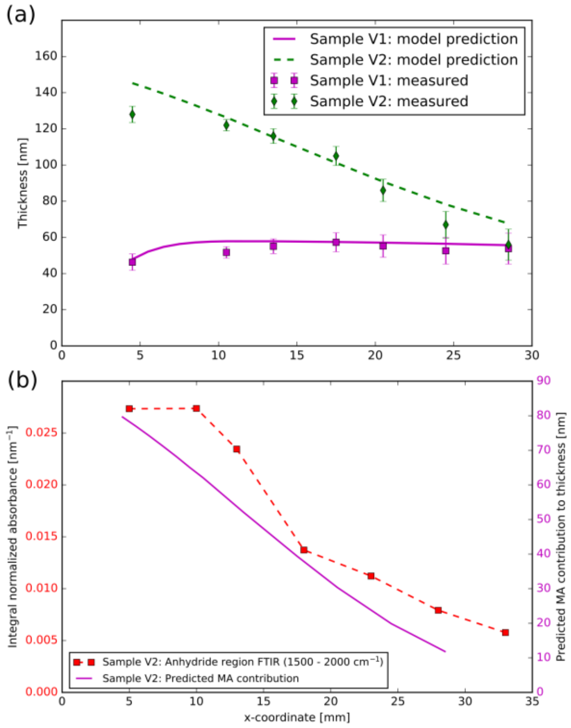

Fig 1: Illustration of the predictive capabilities of the model on validation samples

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Functional plasma polymer surfaces in quartz crystal microbalance and surface plasmon resonance immunosensing

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Biosensors have been extensively developed and applied for biomedical and environmental studies. Quartz crystal microbalance (QCM) and surface plasmon resonance (SPR) biosensors appeared to be very promising tools regarding the sensitive determination of various antigens and bacteria.

For the development of effective biosensors, the immobilization of the biorecognition biomolecules onto the sensor surface is always required. Amine- and carboxyl-rich films are of high interest for bio-applications thanks to their high reactivity allowing the formation of the covalent linkages between biomolecules and a surface. For most applications, a sufficiently high surface concentration of functional groups as well as the layer stability in different buffers is required.

Typically, the formation of self-assembled monolayers (SAMs) onto the sensor surface is utilized, but SAMs suffer from several well known drawbacks: poor stability, drift of the baseline, long time preparation, high level of noise.

In our work, stable amine and carboxyl-rich plasma polymers (PPs) were deposited onto the gold surface of QCM electrodes and SPR chips. Then the monoclonal antibody AL-01, specific to human serum albumin (HSA) was immobilized. The performance of QCM and SPR immunosensors was evaluated by the immunoassay flow test. The developed sensors performed high level of stability and provided selective and high response to the HSA antigen solutions. The limit of detection (LOD) was 1 μg/mL and 0.1 μg/mL, for the amine and carboxyl PPs, respectively. Also, the detection of *Salmonella* bacteria was carried out; the LOD of 10^5 CFU/mL was achieved in case of both PPs. The limit of sensitivity is comparable to the widely used ELISA [1] methods and other methods of label-free detection using SAMs [2]. Regeneration by 10 mM NaOH (amine PP) or by 10 mM HCl (carboxyl PP) was successfully applied, that allowed to carry out several measurements (7-9) with the single crystal or chip. The achieved results confirmed that the presented methodologies for the grafting of biomolecules on the gold surfaces have great potential for biosensing applications.

References

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[2] M. Farré, L. Kantiani, and D. Barceló, *Microfluidic Devices: Biosensors*. 2012.