Growth mechanism of a-C:H(O) Functional Plasma Polymers by macroscopic kinetics

-Report on Visit to Ruhr-University Bochum under International Training Program (ITP)
2010.10.1~11.30

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Outline

- Introduction of Ruhr-University Bochum and Prof. Keudell’s group
- Activities
- Motivation of research project
- Experimental setup
- Result and conclusion
- Work shop
- Life in Germany
- Conclusion

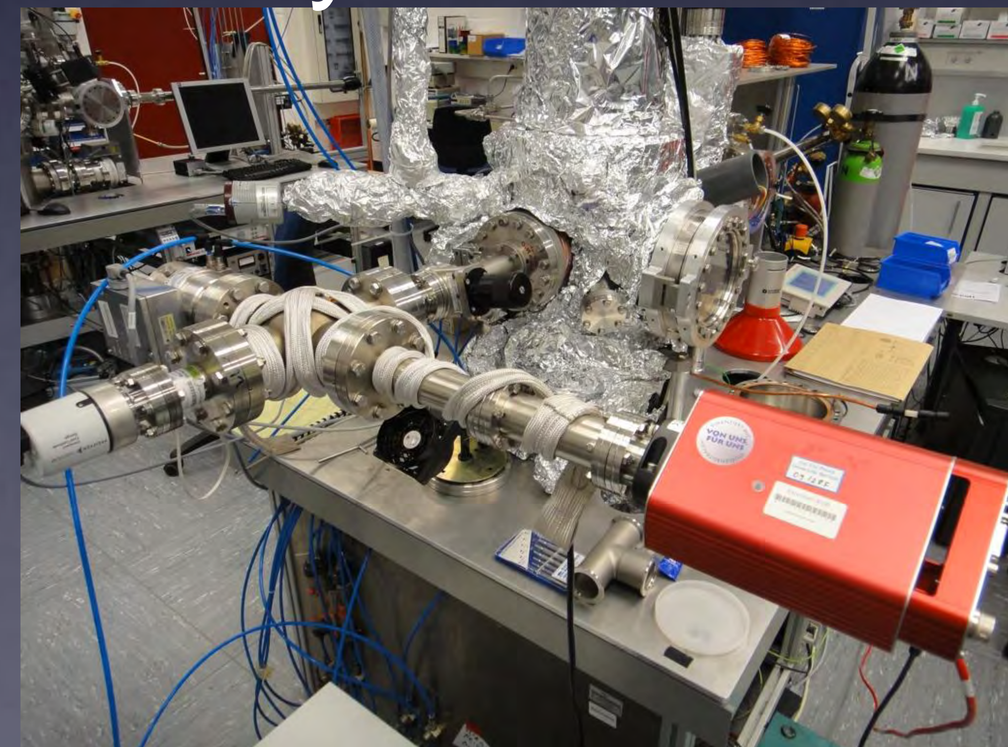
Ruhr-University Bochum

Hall

Office

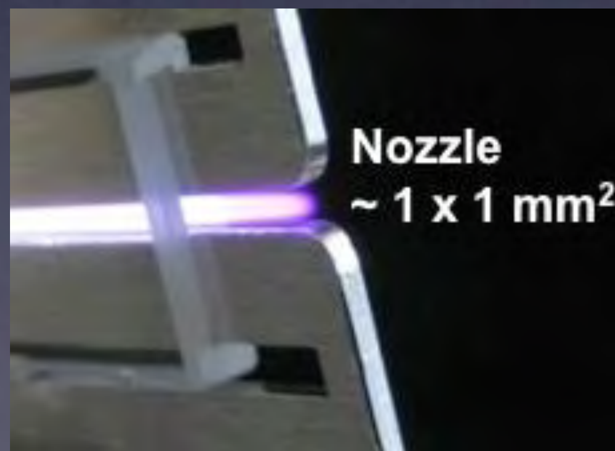
Laboratory

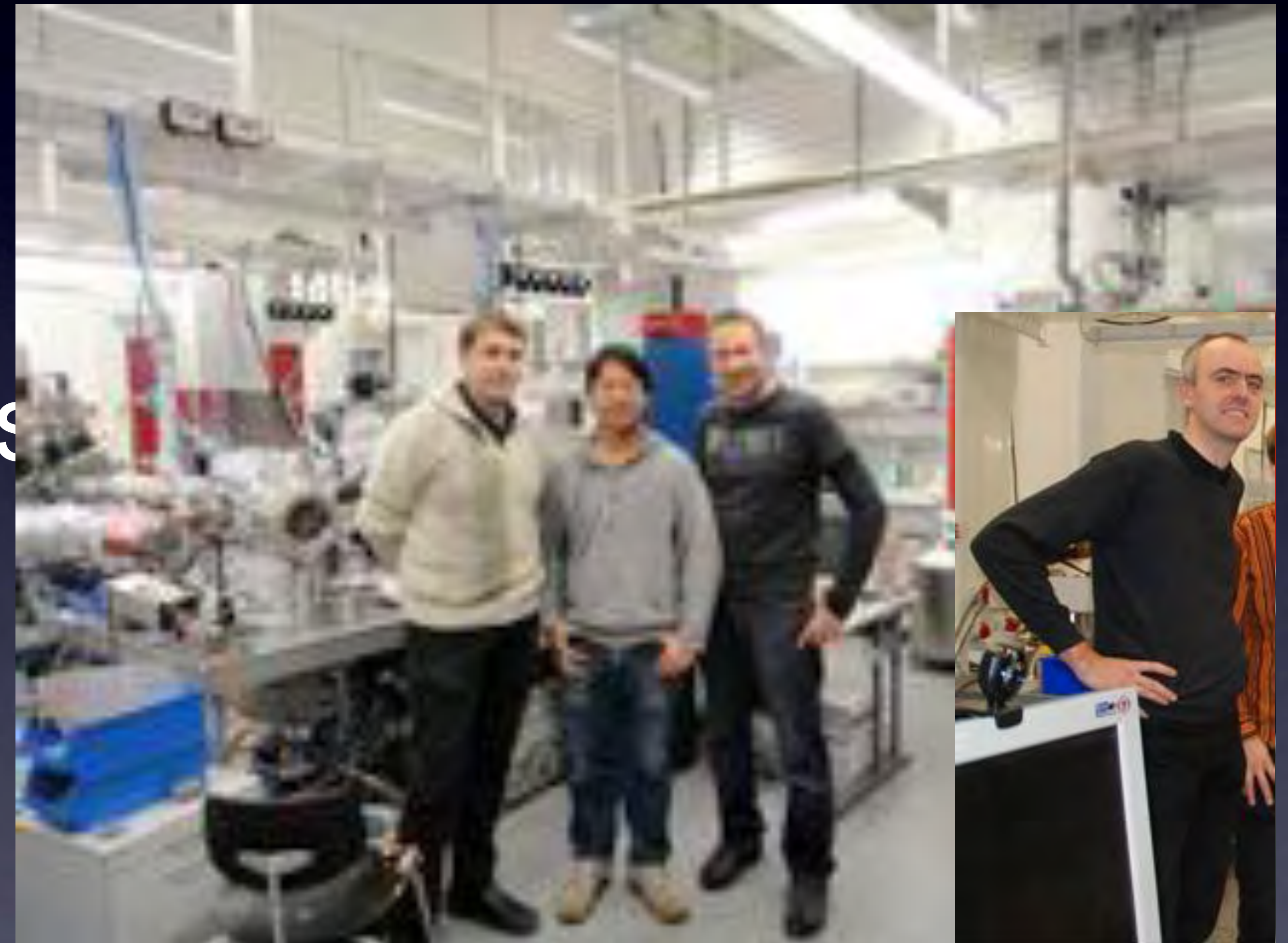
Facility



Prof. Keudell's group

- Plasma chemistry
- Plasma Sterilization
- Magnetized Plasmas
- Micro plasma jet





Prof. Benedikt (left), me, Dr. Hegemann (Swiss Federal Laboratories for Materials Testing and Research), and Prof. Keudell

Activities

- Experimental setup (QMS and Ellipsometer)
- Try to build a *in-situ* Ellipsometer model for a-C:H(O) film
- QMS measurement for C_2H_4 plasma
- FTIR evaluation of a-C:H(O) film
- Attending a work shop held in Netherlands with all student of Prof. Keudell’s group

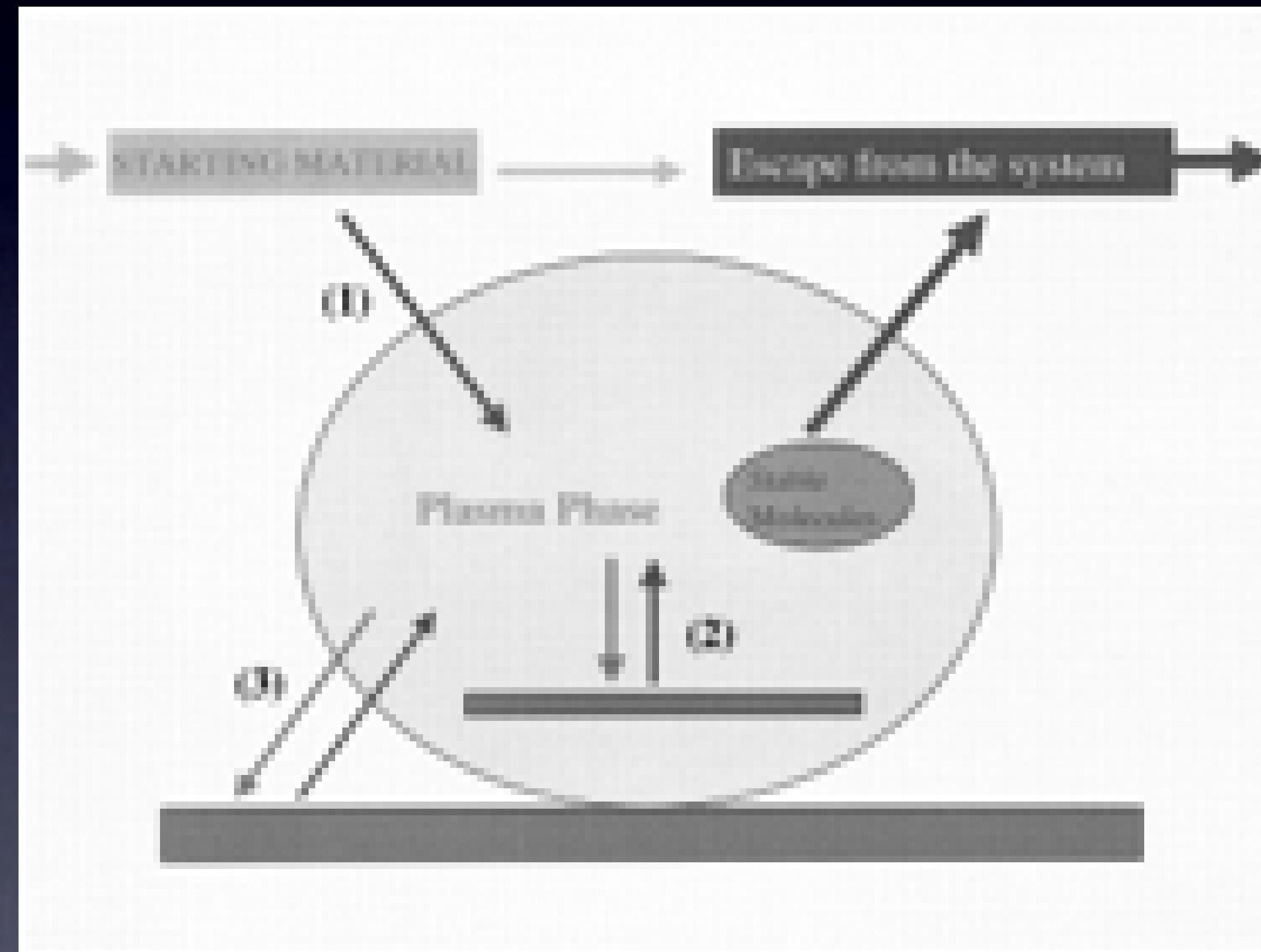
Motivation

- a-C:H(O) functional plasma polymers gain increasing interest in applications where the stability of the coatings during storage.
- Hydrocarbon monomers show a complex behavior of the deposition rate as a function of the energy input, where often a drop in deposition rate.

Object & Procedure

- Understanding the nature of various deposition/growth mechanisms though gas phase process and surface process

- CO_2/C_2H_4 plasma diagnostic and a-C:H(O) film evaluation based on Macroscopic kinetic.



Competitive ablation and polymerization (CAP) principle.

Macroscopic kinetics[1]

Advantage:

No simulator
Easy to analysis and process

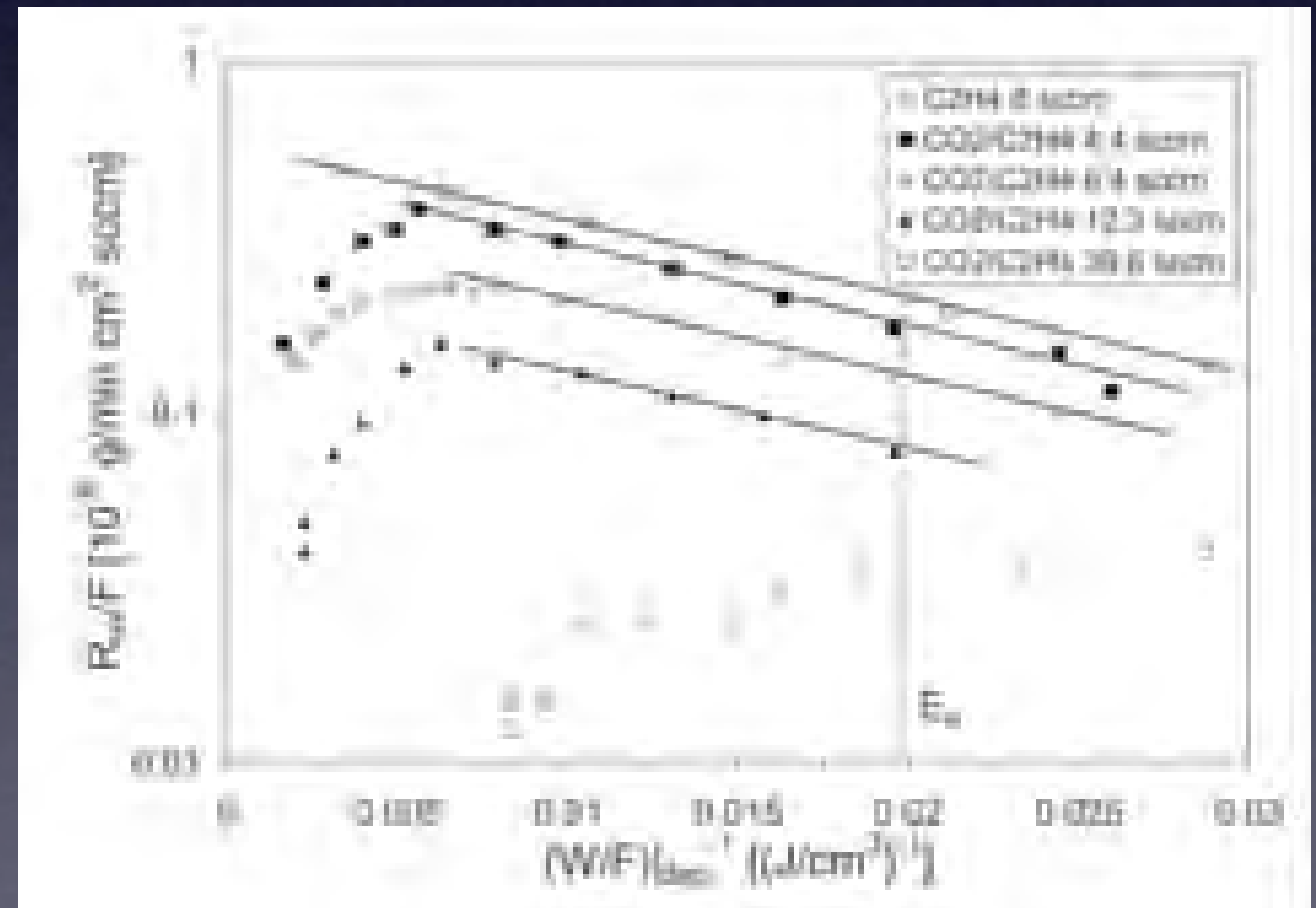
Hypothesis:

- Electron density proportional to the power input
- Both ion flux and ion energies, only depends on power input W for a fixed pressure

quasi-Arrhenius equation:

$$\frac{R_m}{F} = G\exp\left(-\frac{E_a}{W/F}\right)$$

Rm, the deposition rate (in [nm/s]); Thus expresses the deposited mass per area out of the plasma volume (in [g/cm5]) as a function of the specific energy input W/F (in [J/cm3]), while G is a reactor and process depending factor, Ea the apparent activation barrier.

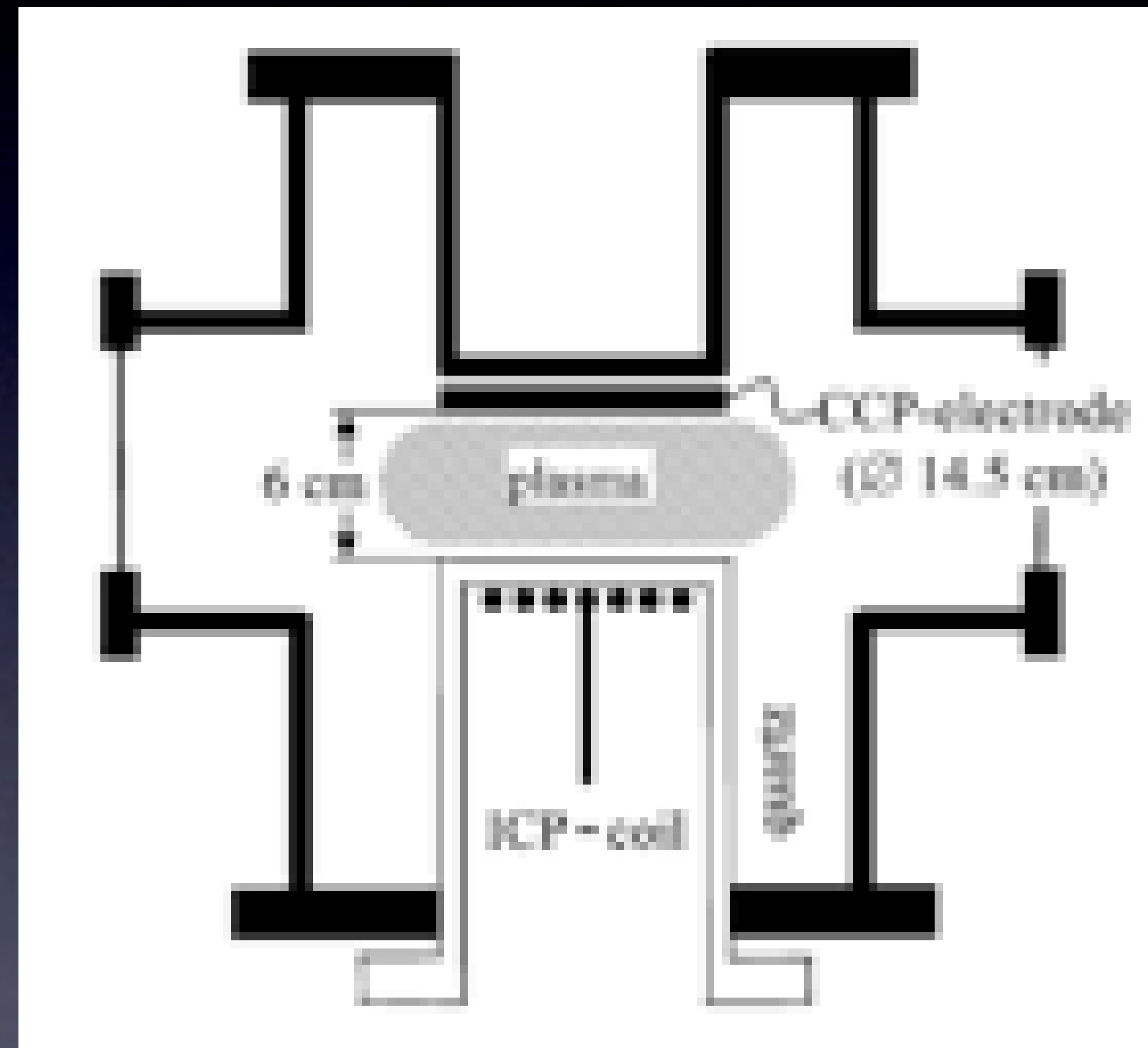


[1] D. Hegemann et.al., Proc. 53rd SVC Ann. Tech. Conf., Orlando, FL, April 17-22, 2010.

Experimental setup

Condition during film growth:

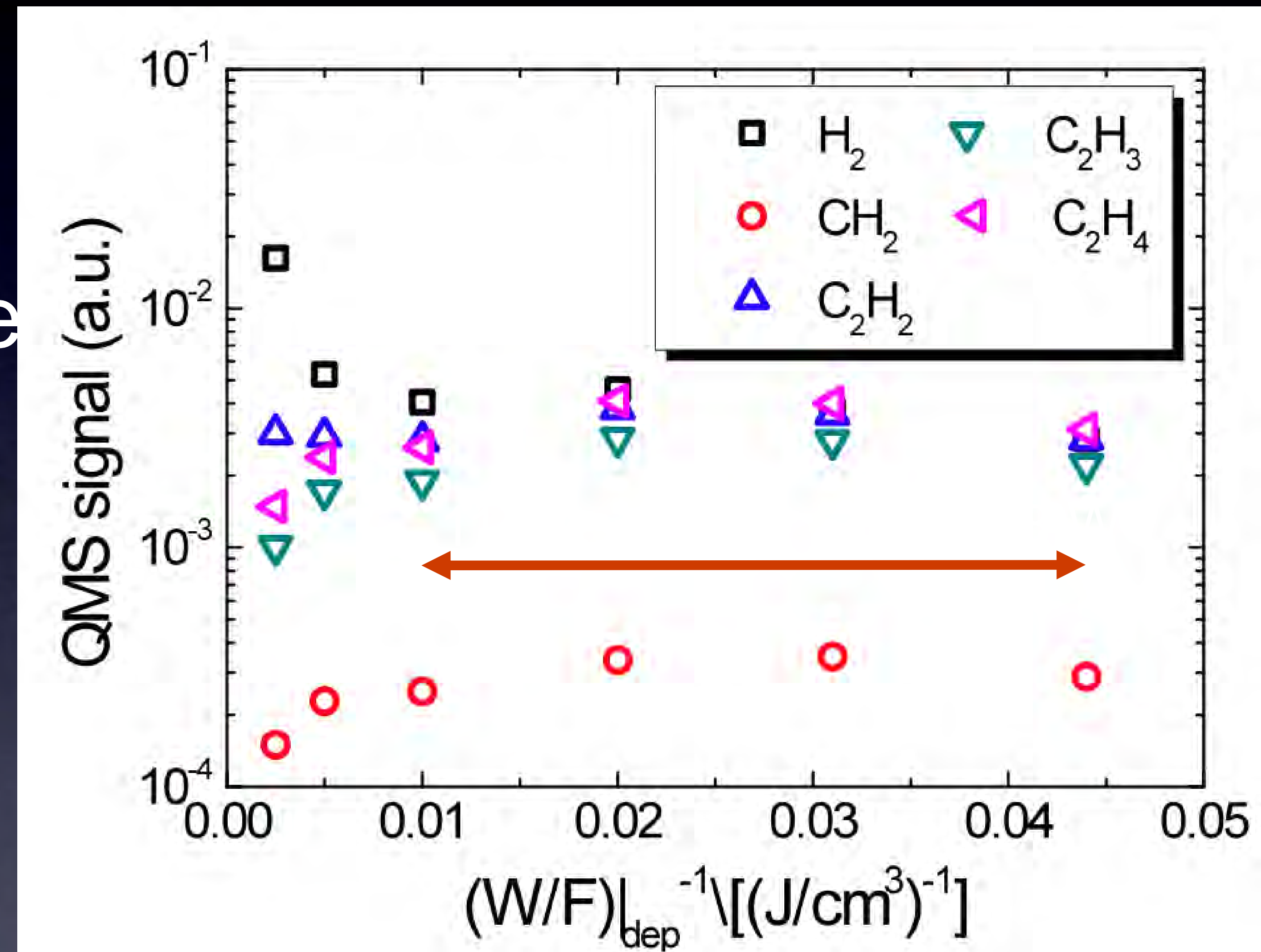
Pressure: 5 Pa
Gas flow rate: 8 sccm
DC bias: -10 V
RF power: 5~132 W
Substrate temperature: <80ºC
Growth time: 1min



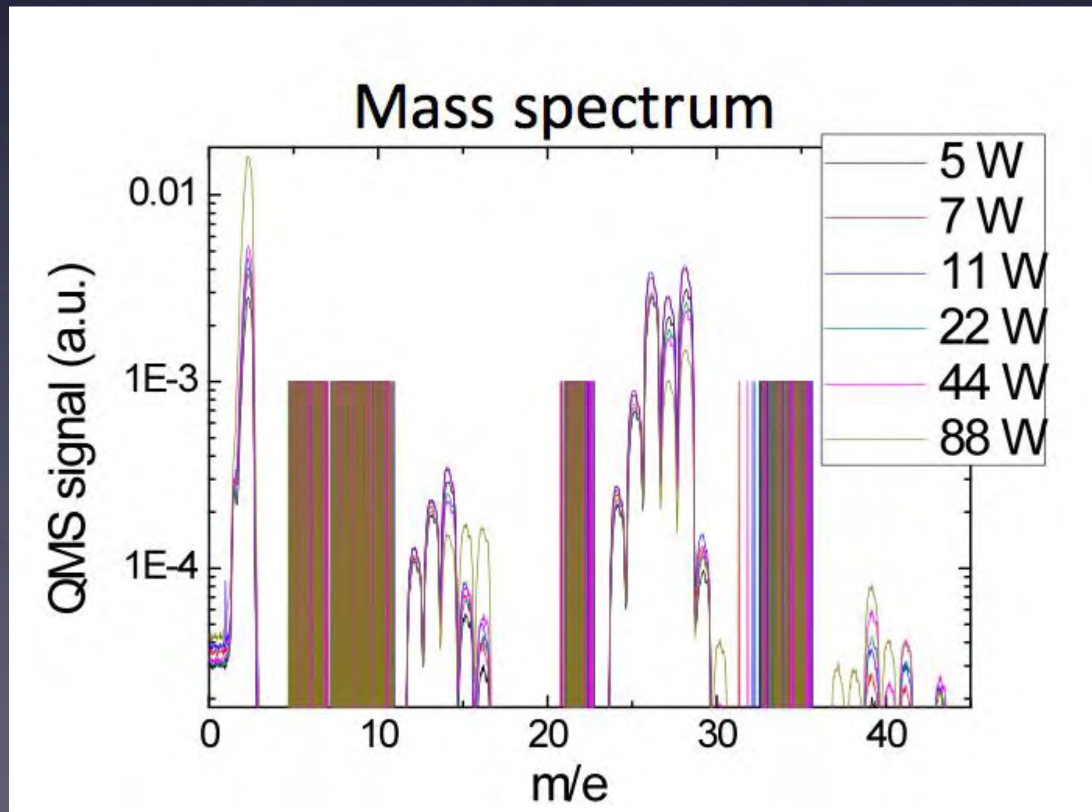
Adjust of in-situ ellipsometery was failed, because the films was changed with changing plasma condition and laser was not stability.

QMS

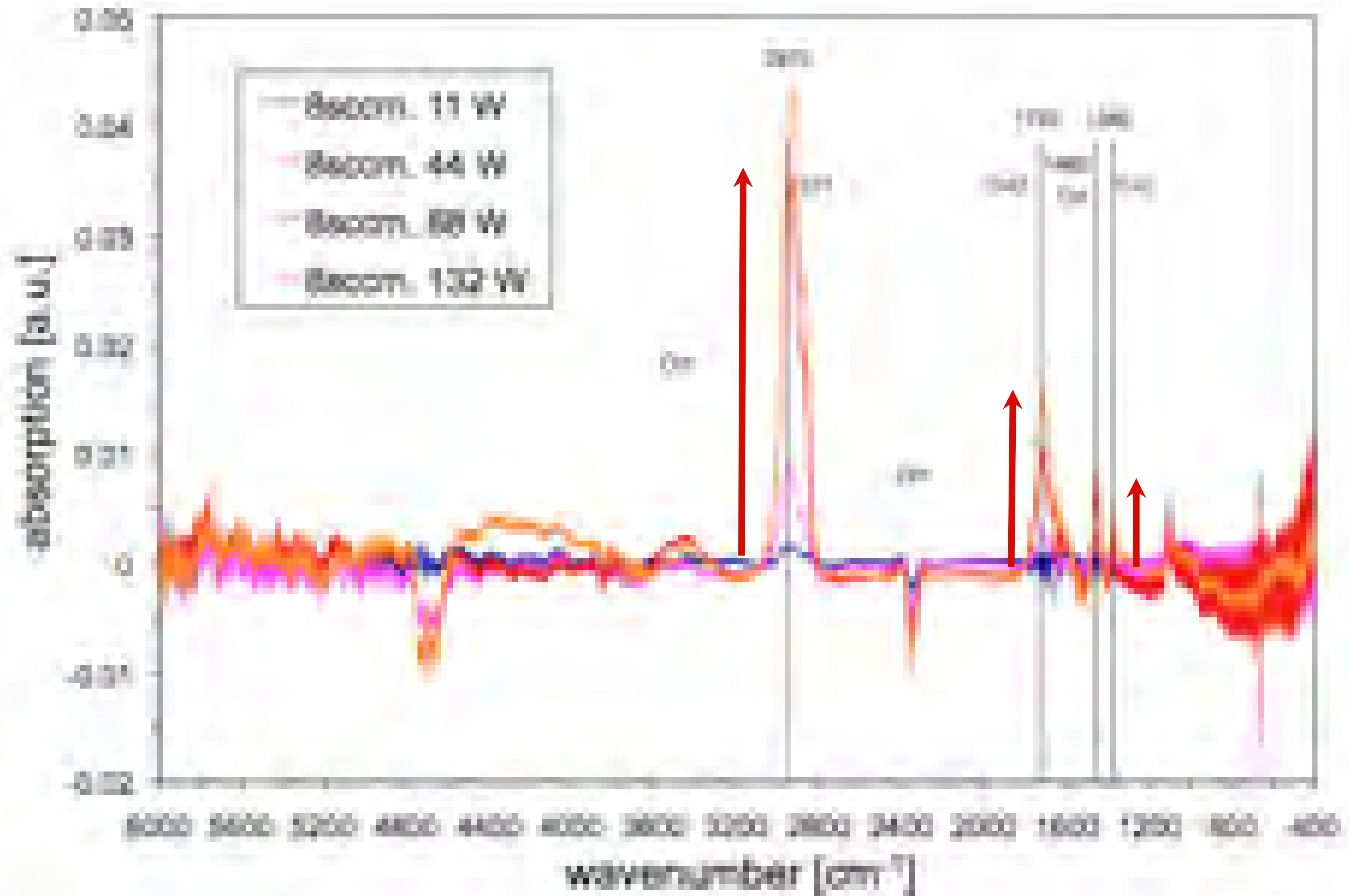
RF power: from 5 to 88 WPre



Macro kinetic parameter W/F as a function of QMS signal intensity.



FTIR (C_2H_4 plasma)



Conclusion

- A new proposal in order to understand the plasma surface reaction was investigated.
- With macro kinetics that is convenient to characteristic analysis the complex reaction.
- It was developmental experience for me to continue the future work on plasma etching which also involve gas phase and surface process.

Work shop

The 13th Workshop on the Exploration of Low Temperature Plasma Physics (WELTPP-13) held in Kerkrade, Netherlands.

Life

Thank you for your attention

I would like appreciate Prof. Keudell give me a chance to known the Germany style work, all staff and students they help me so much, without them I cant do anything.

I also appreciate Prof. Hori, Prof. Sekine, Prof. Toyoda, secretary of ITP office, without their support I cant finish this project.