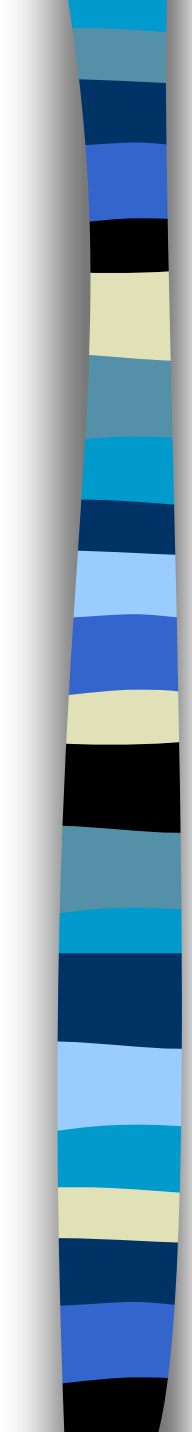


Etching and structure changes of polystyrene at PIII



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Federal project: Ion Implantation of polymer materials for biomedical and aerospace applications, 2005-2008

- Principles of structure modification of polymers
- Protein and cell interactions with modified polymer surface
- Protective coating on polymer materials

Layer structure of polymer at ion beam

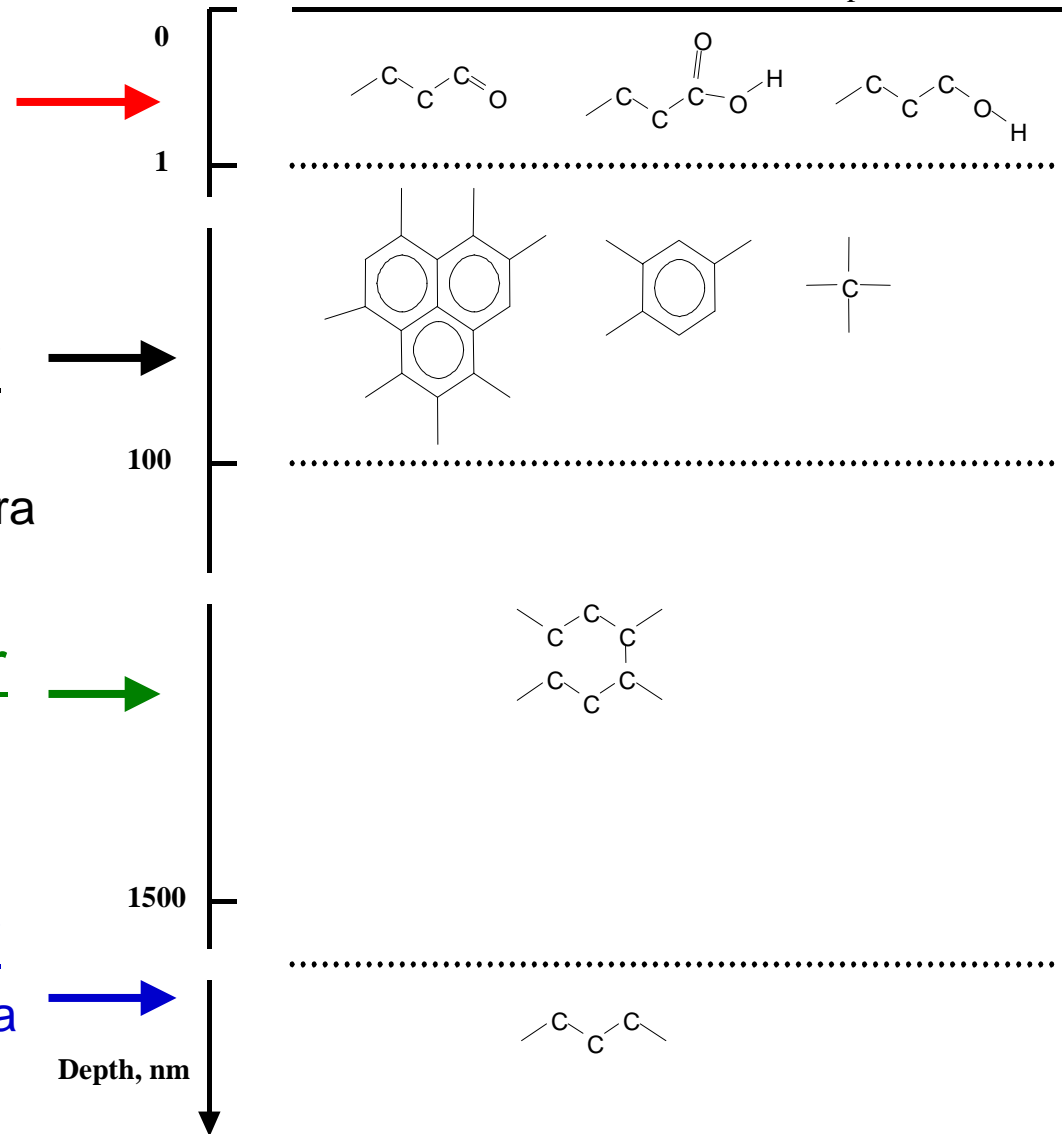
- Oxidized layer
- Wetting angle
- UV reflection spectra
- XPS spectra

- Carbonised layer
- FTIR ATR spectra
- UV transmission spectra

- Crosslinked layer
- Gel-fraction
- Mechanical properties

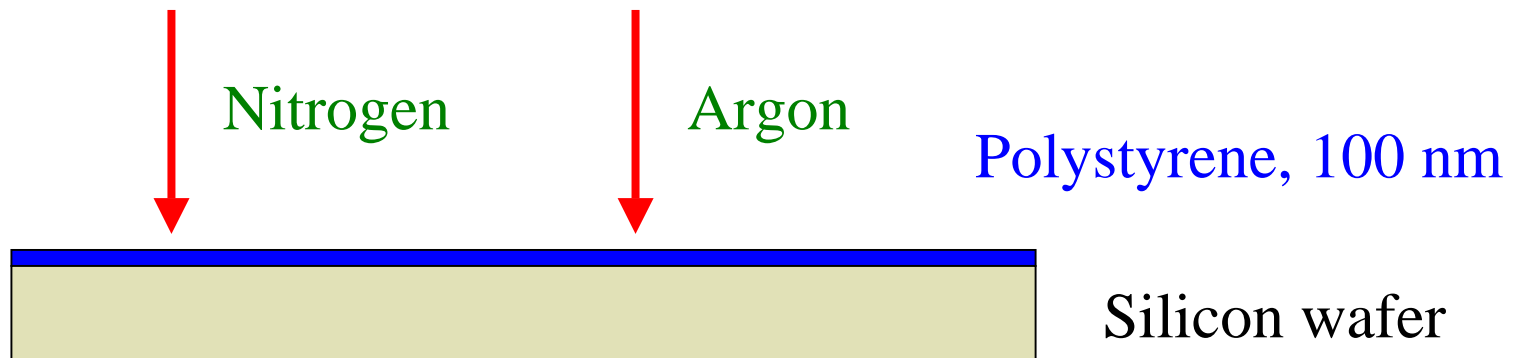
- Unchanged layer
- IR transmission spectra

For example, PE, N⁺, 20 keV, d_p=100 nm



Goals of research

- **Structure changes in polymer:**
- Oxidation, carbonization
- **Etching kinetics:**
- Thickness kinetics, rate of etching

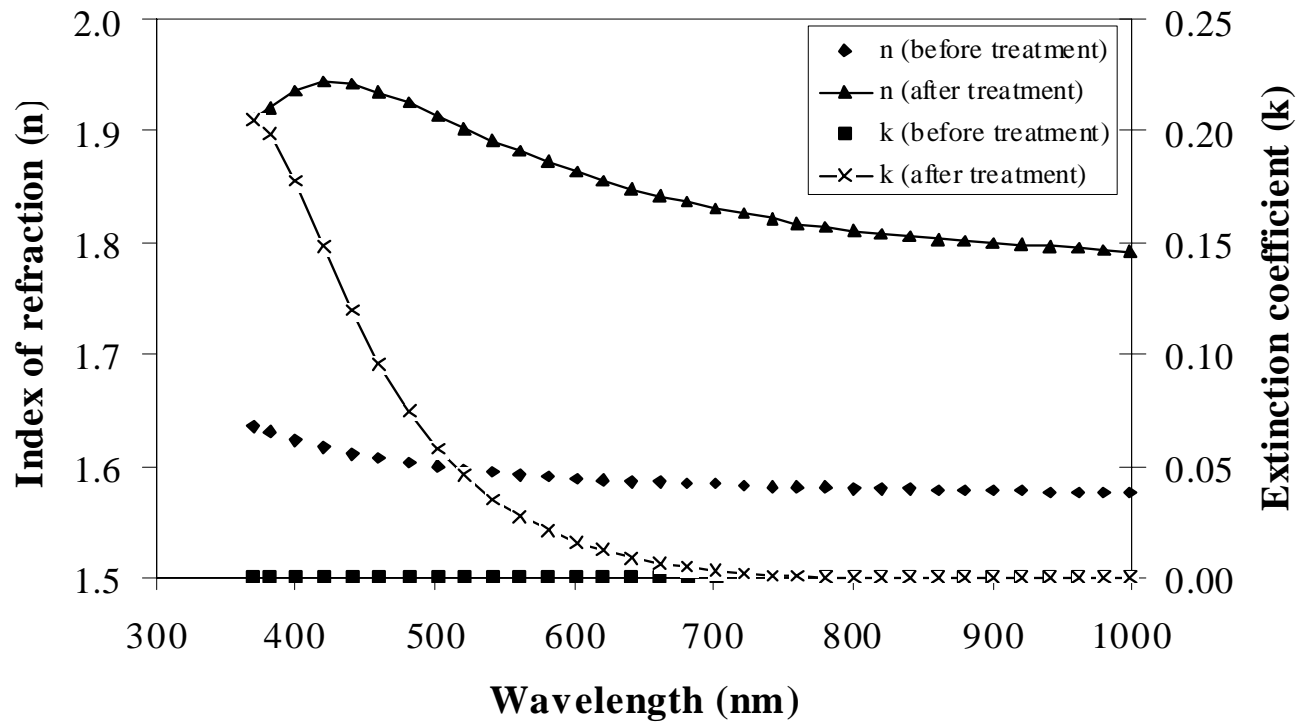
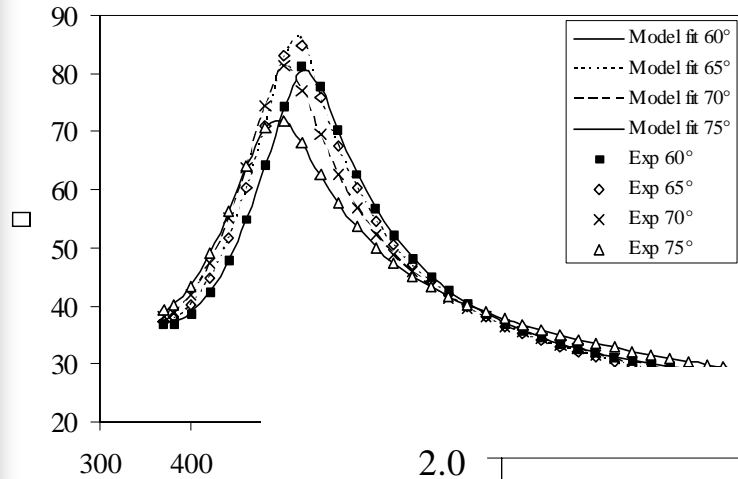




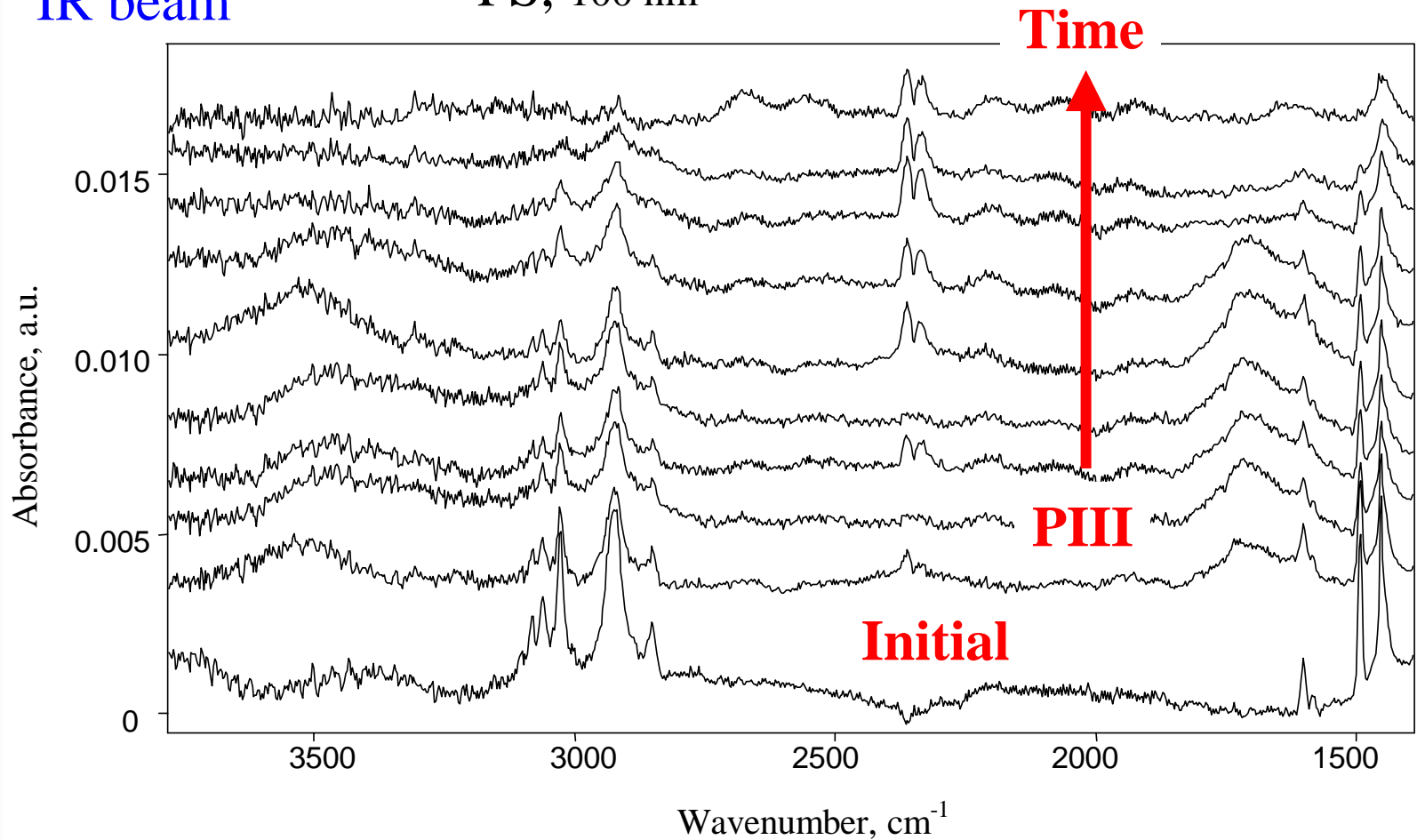
Material and equipment

- **Polystyrene** film spincoated on Silicon wafer, thickness of 100 nm
- **Plasma Immersion Ion Implantator**
 - RF-Plasma of N₂ and Ar, 100 W, 0.3-2 mTorr
 - High voltage pulse: 5-20 keV, 5 μS
- **FTIR transmission, Ellipsometry (UV-vis and FTIR), AFM, electron and optical microscopy, wetting angle**

Ellipsometry of PS

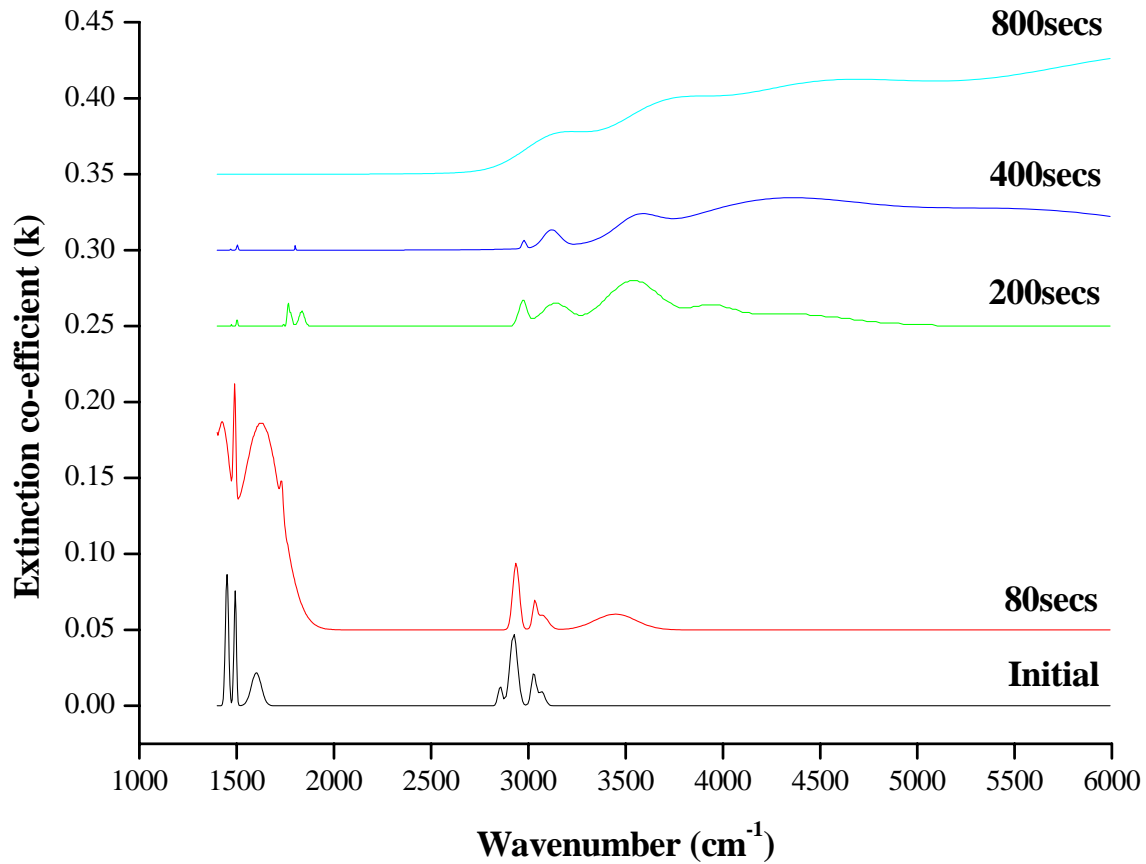


FTIR transmission spectra

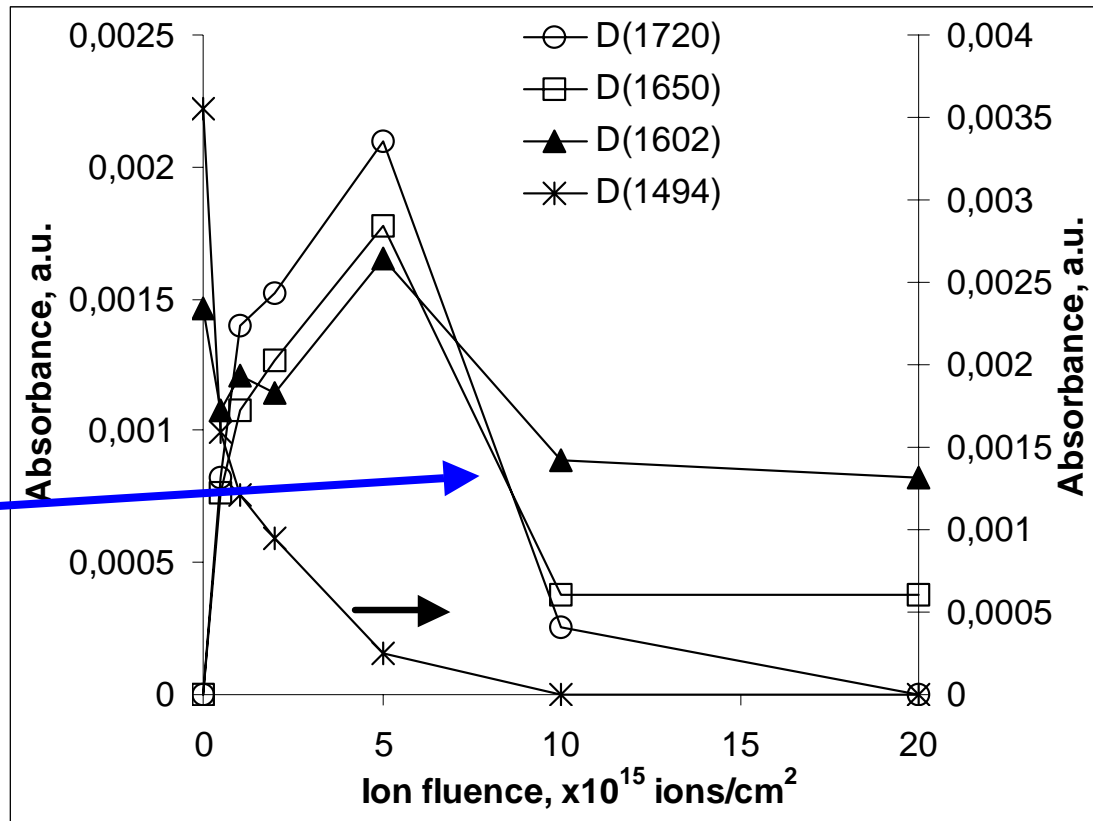
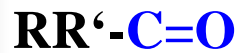


FTIR-ellipsometry data

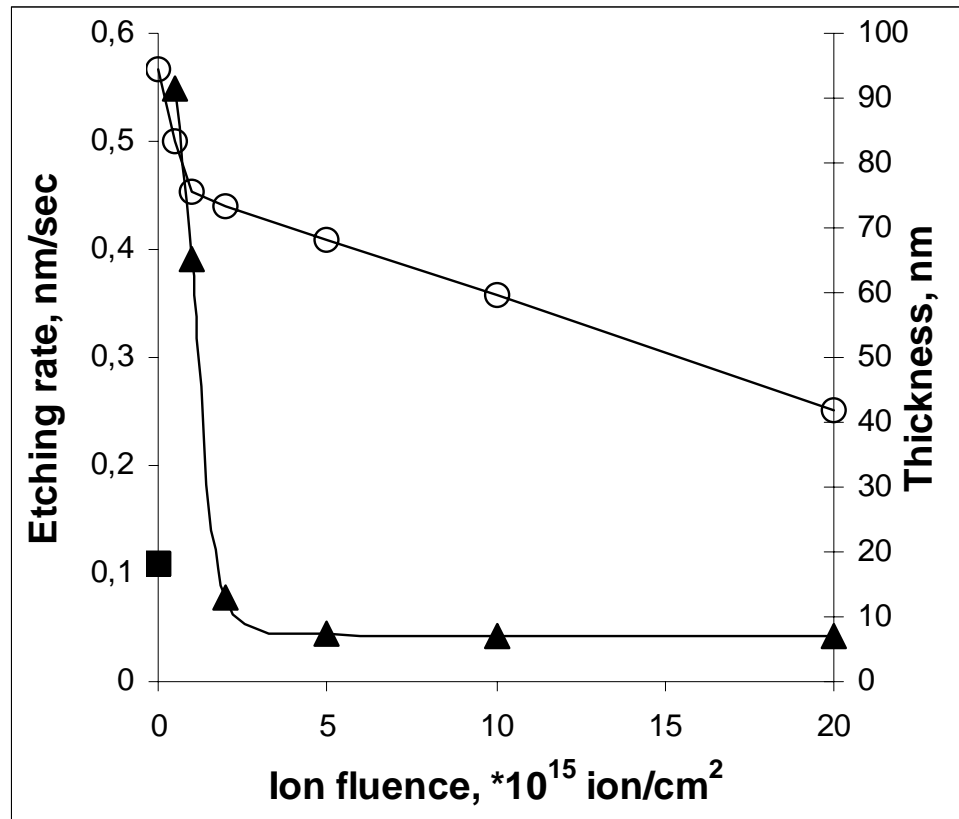
PS on Si: 0.33mT Argon 20kV



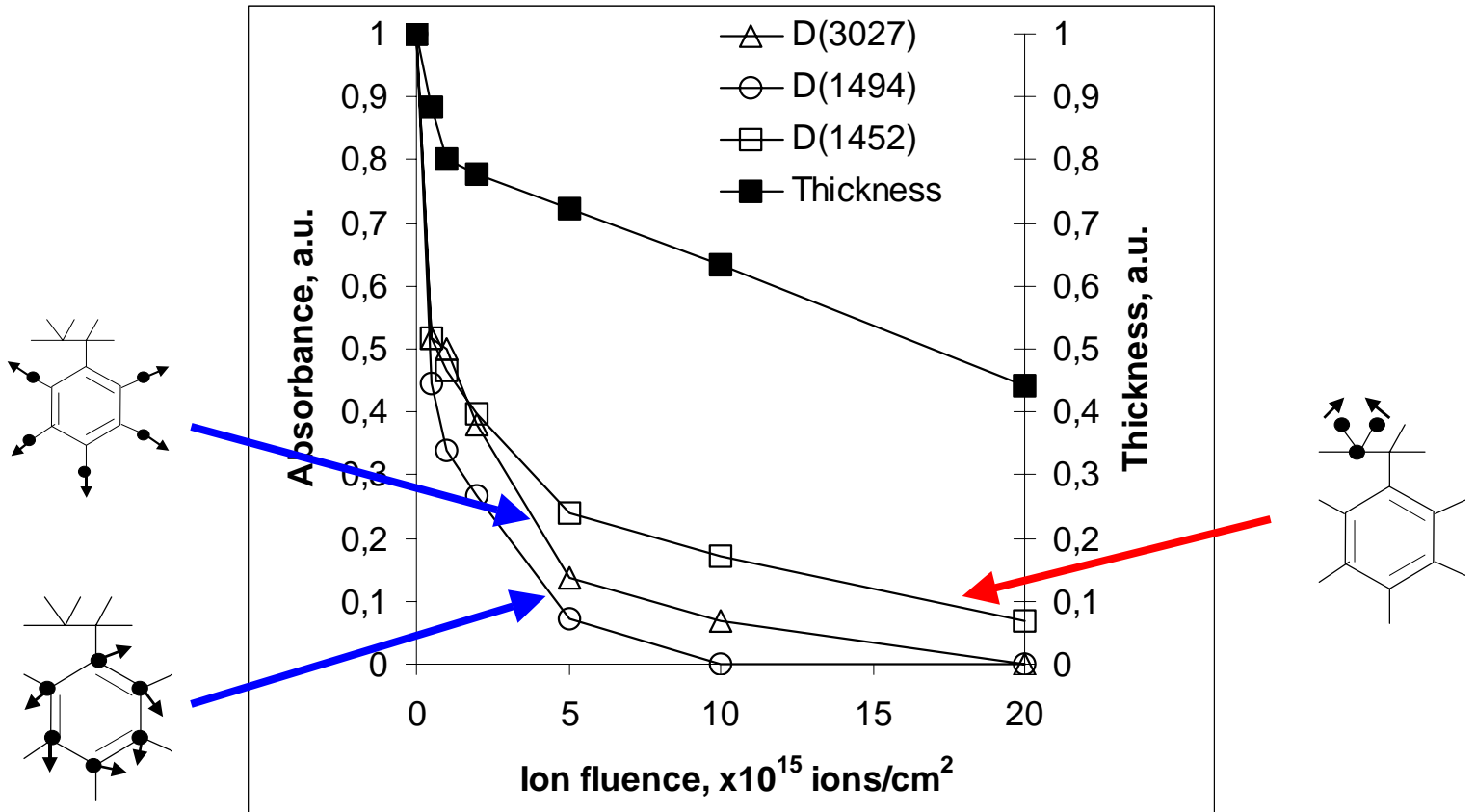
Structure of PS at Nitrogen PIII



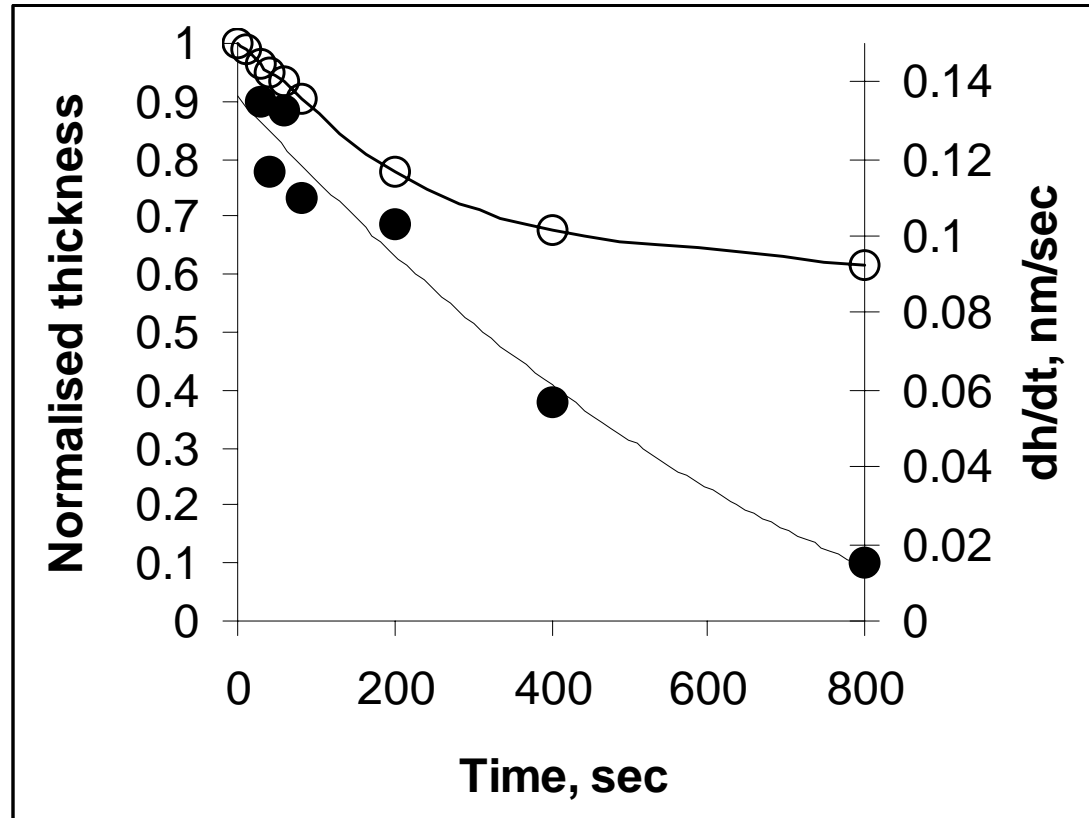
Etching kinetics in Nitrogen PIII



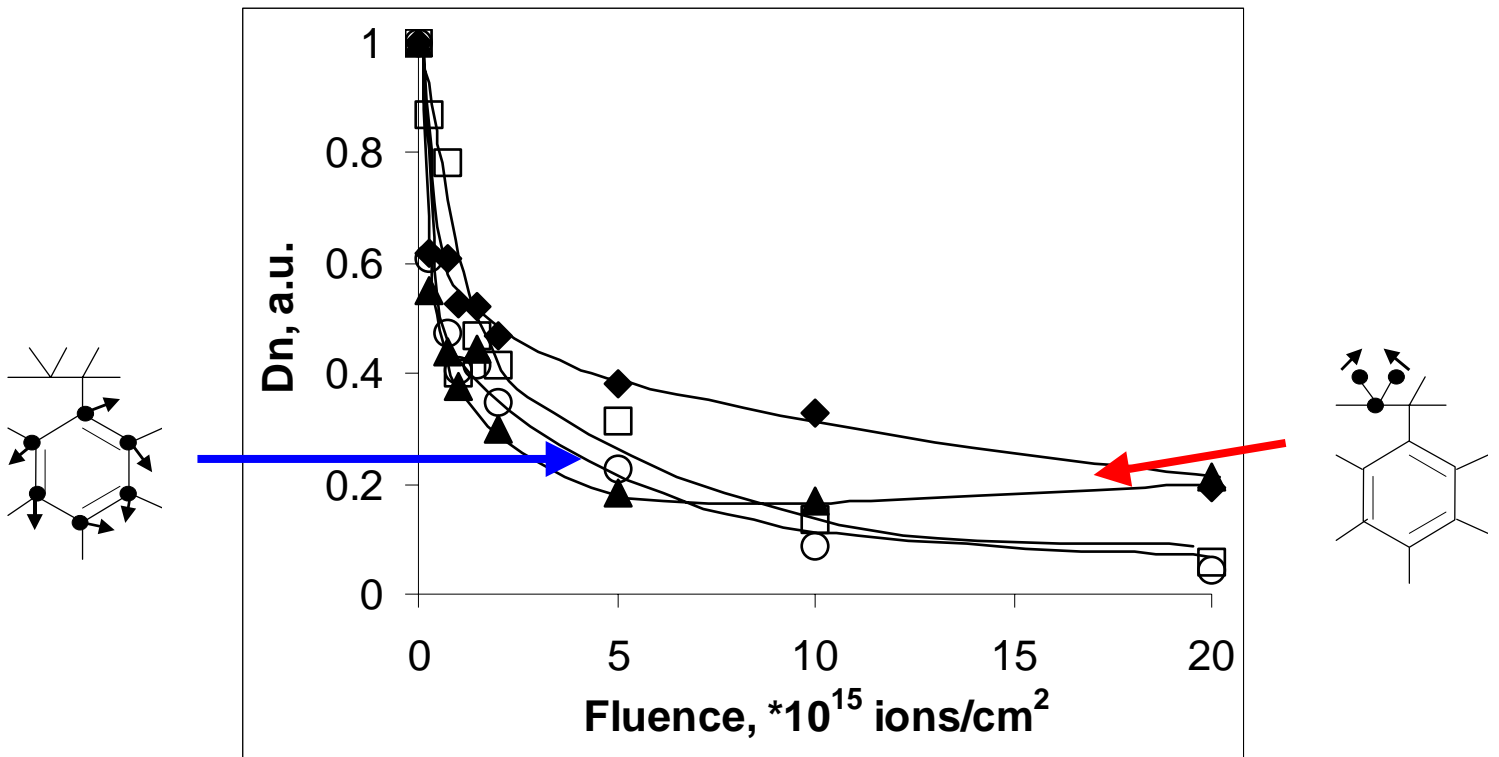
Structure of PS at Nitrogen PIII



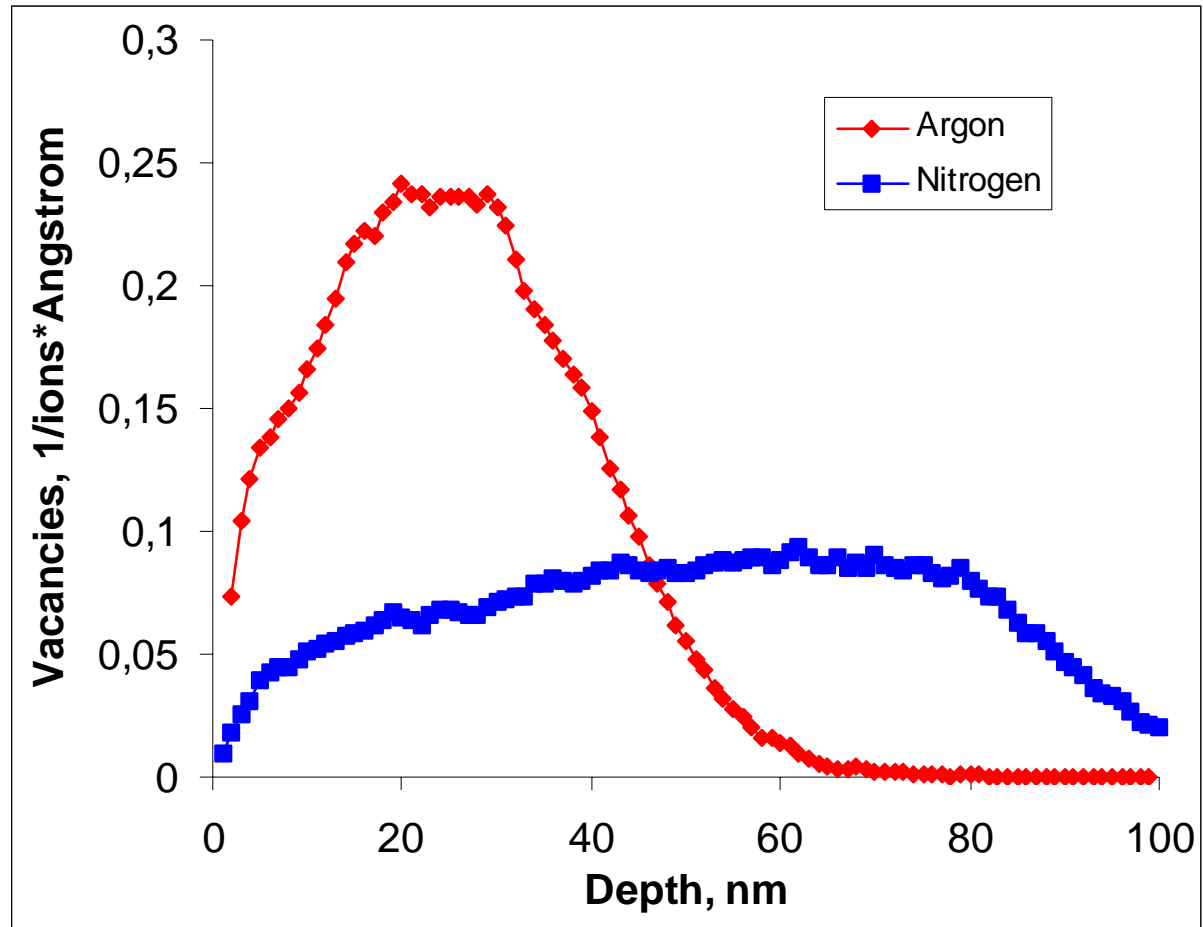
Etching kinetic at Argon PIII



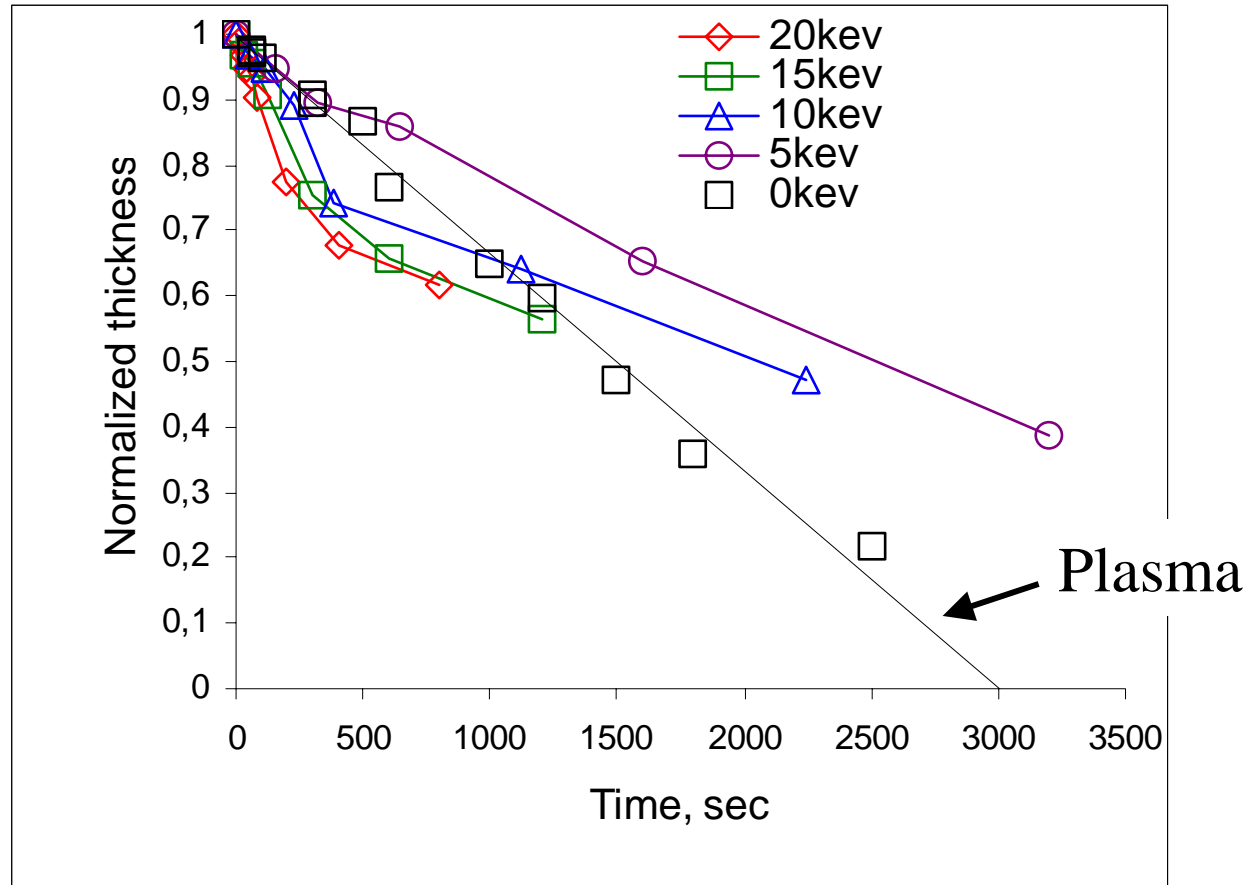
Structure of PS at Argon PIII



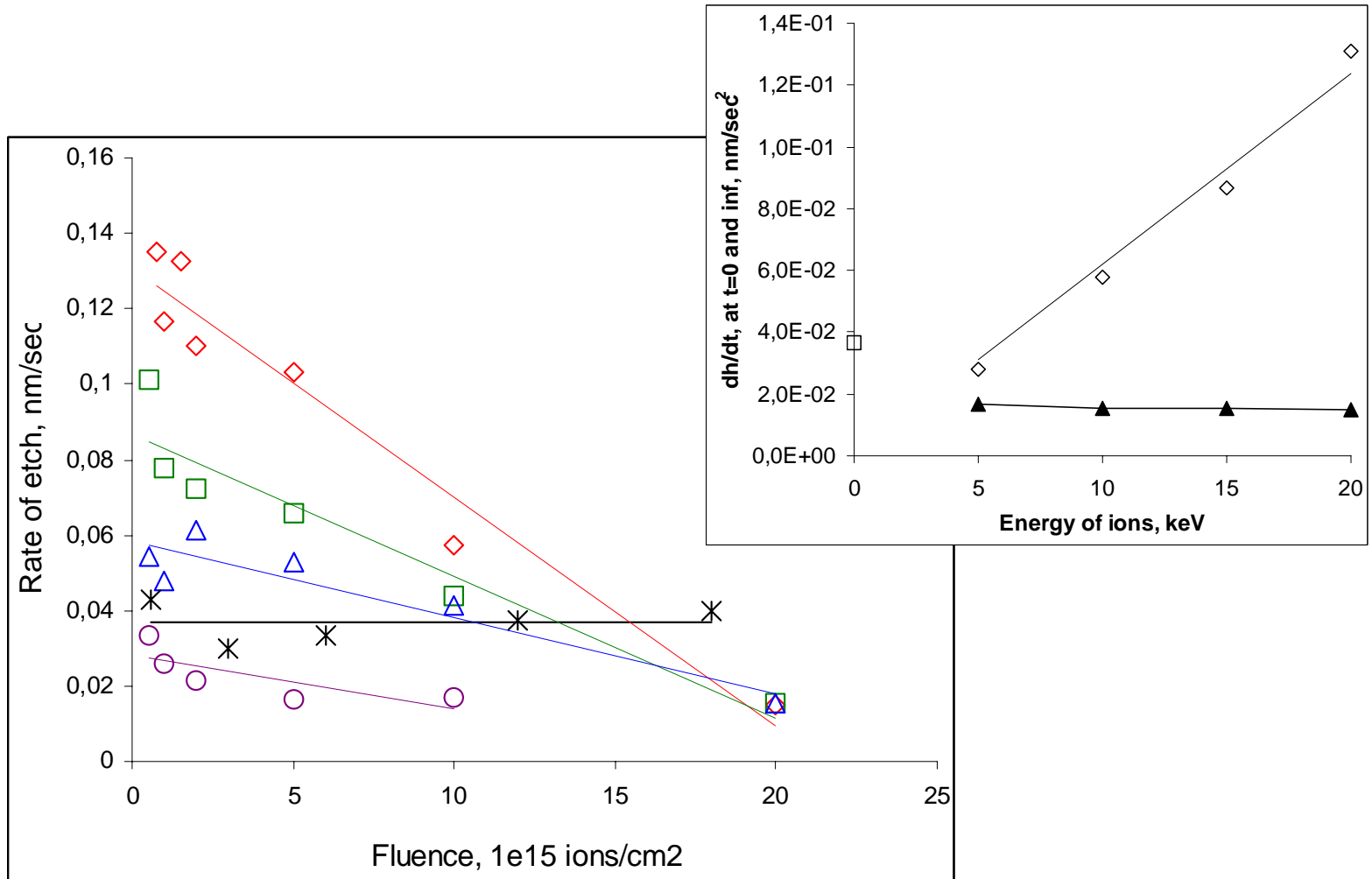
TRIM calculations



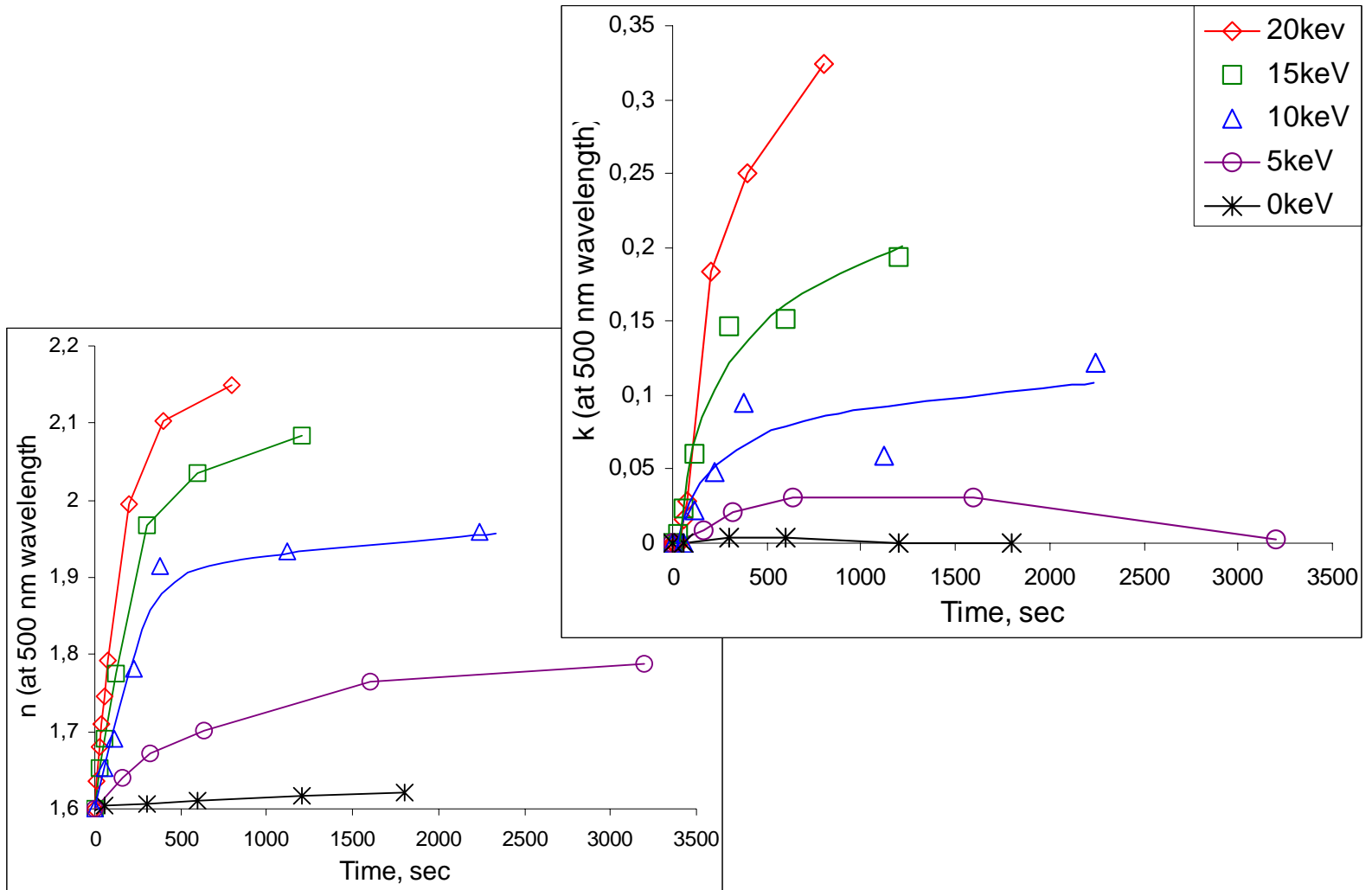
Etching of PS at Argon PIII



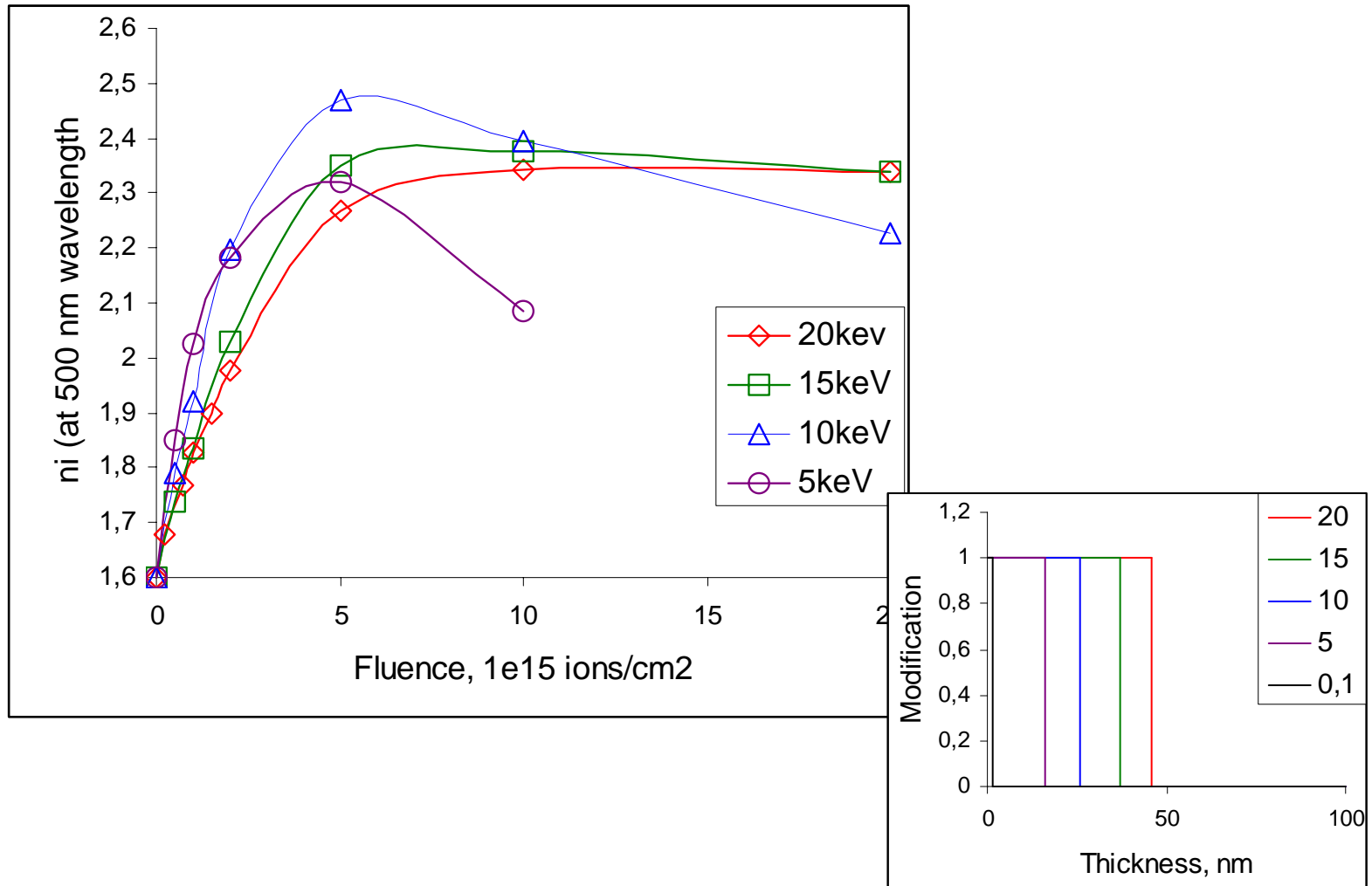
Etching of PS in Argon PIII



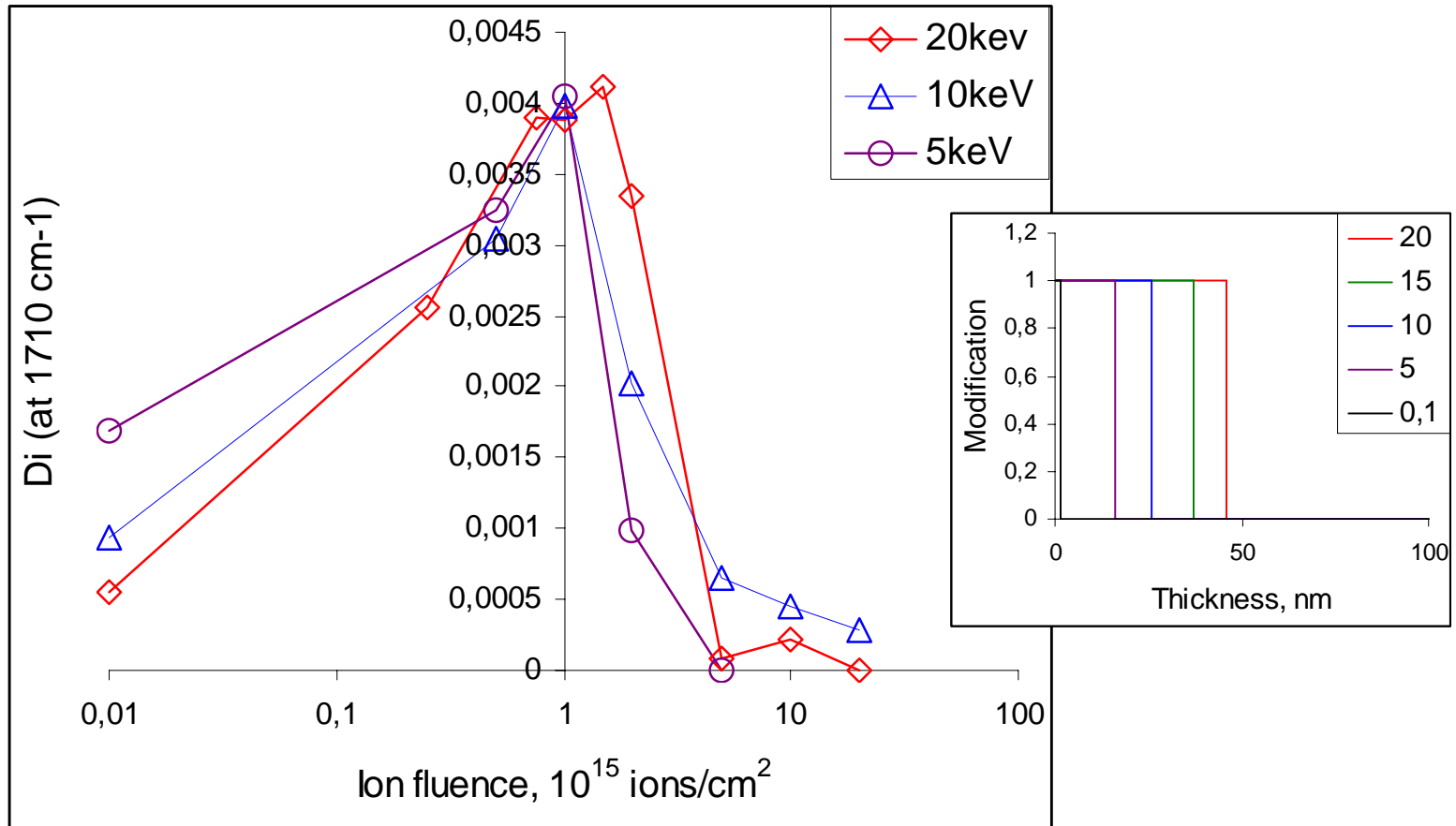
Optical constants of PS at Ar PIII



Optical constants of PS at Ar PIII



Structure of PS at Ar PIII



Chemical model of carbonisation, oxidation and etching

$$C_{defect}(x) = [vacancy_distribution]$$

$$\frac{\partial h}{\partial t} = -k_{PS} \cdot C_{PS}^n - k_{carbon} \cdot C_{carbon}^n$$

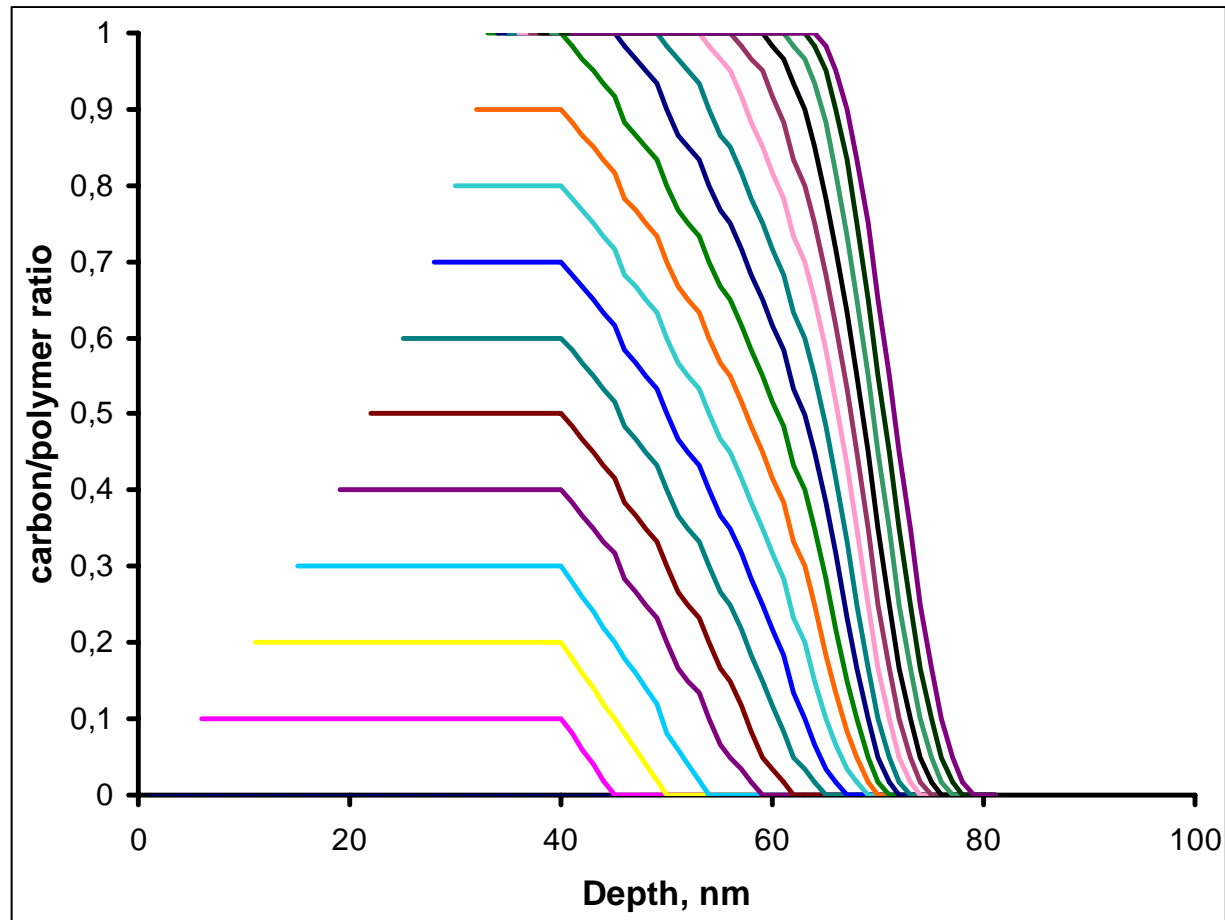
$$\frac{\partial C_{PS}(x)}{\partial t} = -C_{defect}(x)$$

$$\frac{\partial C_{carbon}(x)}{\partial t} = C_{defect}(x)$$

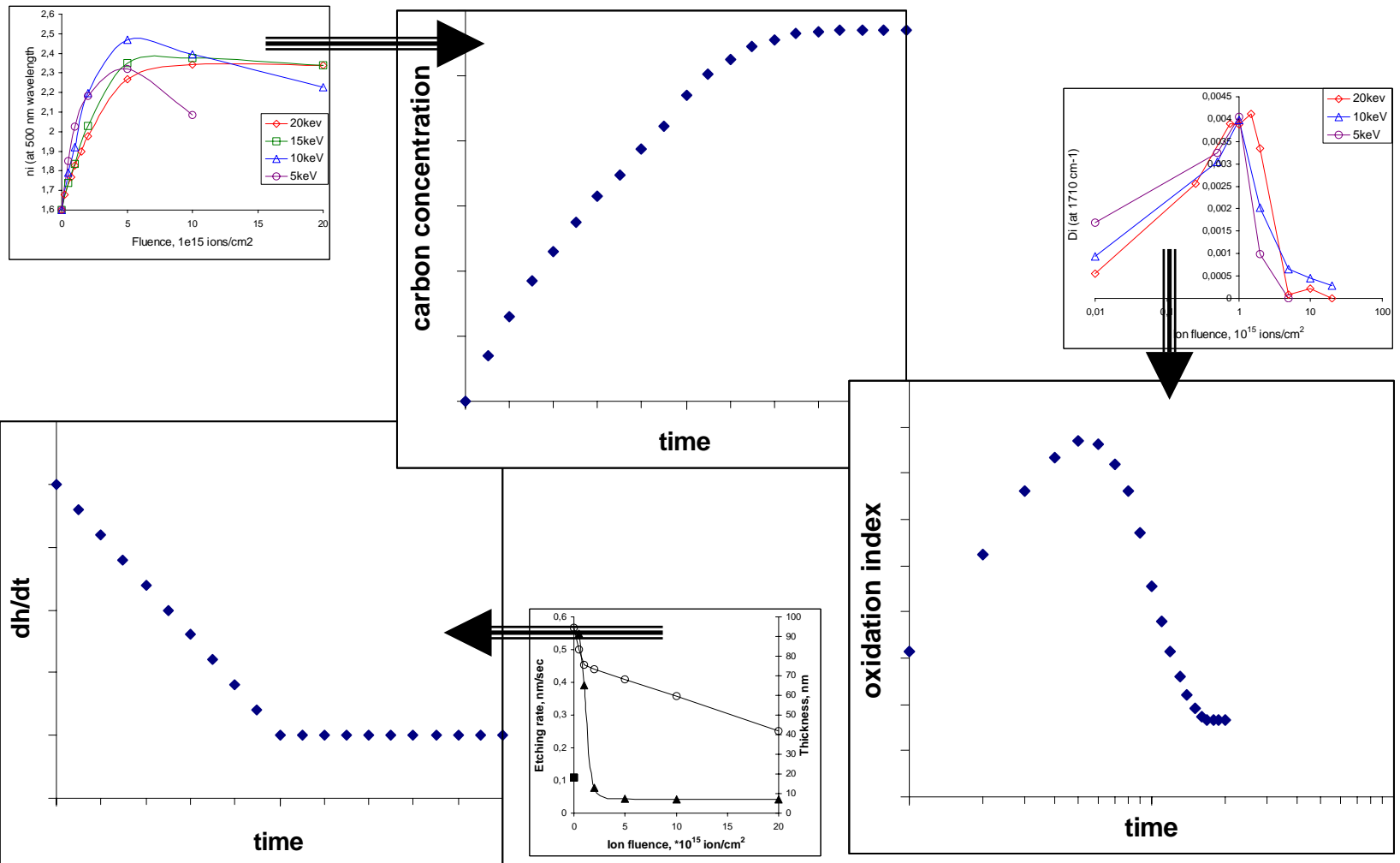
$$C_{oxidation}(t) = \int_{x=0}^{x=h} C_{PS}(x, t) \cdot C_{defect}(x) \cdot dx$$

$$C_{PS}(0, x) = 1$$

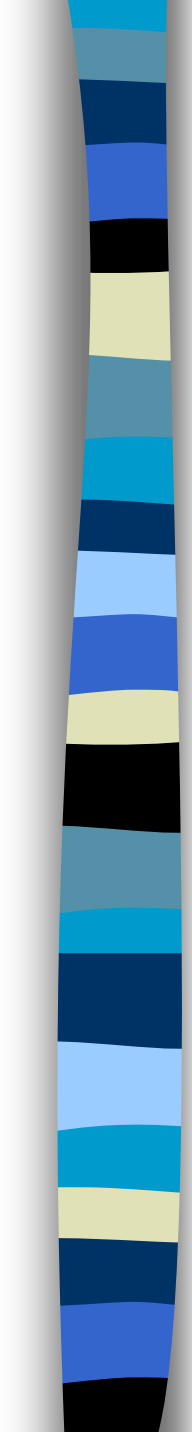
Chemical model of carbonisation, oxidation and etching



Chemical model of carbonisation, oxidation and etching



Conclusions

- 
- **Structure changes of polystyrene at PIII:**
 - Collection of structure defects – oxidation as result of contact with oxygen;
 - Carbonisation at high fluence – PIII into carbon
 - **Qualitative model of PIII structure changes in polymer surface layer**