ICPA-17 Summary Talks

R. Krause-Rehberg / Jerry Jean

- List will be not complete – We will be selective
- Only talks…
- I was in A sessions / Jerry in B sessions. Thus, we missed some important talk for our topics…

ICPA conferences

50 years

1965 ICPA Detroit, USA
1971 ICPA-2 Kingston, Canada
1973 ICPA-3 Otaniemi, Finland
1976 ICPA-4 Helsingor, Denmark
1979 ICPA-5 Lake Yamanaka, Japan
1982 ICPA-6 Arlington, USA
1985 ICPA-7 New Delhi, India
1988 ICPA-8 Gent, Belgium
1991 ICPA-9 Szombathely, Hungary
1994 ICPA-10 Beijing, PR China
1997 ICPA-11 Kansas City, USA
2000 ICPA-12 Munich, Germany
2003 ICPA-13 Kyoto, Japan
2006 ICPA-14 Hamilton, Canada
2009 ICPA-15 Kolkata, India
2012 ICPA-16 Bristol, UK
2015 ICPA-17 Wuhan, China

17th International Conference on Positron Annihilation (ICPA-17)

September 20-25 · 2015 Wuhan · China

187 participants from 23 countries:

- **89 China**
- 2 Argentina
- 2 Australia
- 2 Belgium
- 2 Canada
- 5 Czech Republic
- 2 Egypt
- 2 Finland
- 4 France
- **13 Germany**
- 1 Hong Kong
- 7 Italy
- **28 Japan**
- 6 Poland
- 1 Romania
- 3 Russia
- 2 Slovakia
- 1 Spain
- 2 Switzerland
- 1 Taiwan
- 2 Netherlands
- 4 UK
- 6 USA

- **4 plenary talks**
- **39 invited talks**
- **60 oral presentations**
- **91 posters**

= 194 contributions

Statistics ICPA-16 (Bristol)

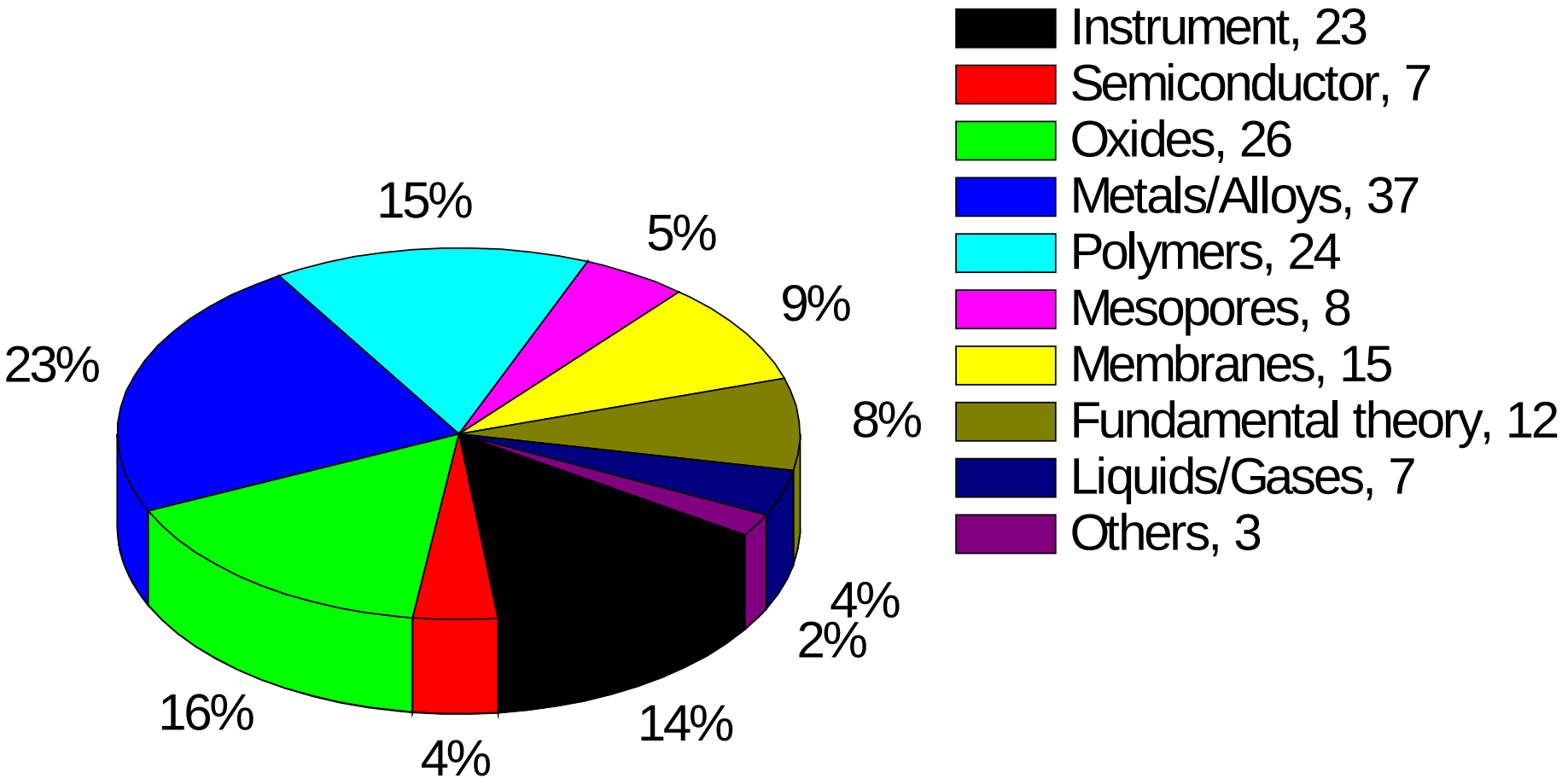
Some statistics (in red ICPA-17):

- ≈ 200 Participants (187)
- 160 contributing participants (194)
- 96 talks (103)
- among them 37 invited talks (43)
- 72 Posters (91)
- Contributions from 29 countries (23)

Fields of Contributions

Topic	Number	%	Who?
Instrumentation	23 (22)	14 %	JJ
Semiconductors	7 (8)	5 %	RKR
Oxides / Ceramics	26	18 %	RKR
Metals / Alloys / Spin Polarized Positrons	37 (16)	**20 %**	RKR
Polymers	24 (10)	15 %	JJ
Mesopores	8	10 %	JJ
Membranes	15 (8)	10 %	JJ
General Theory (incl. Anti-Hydrogen)	12 (8)	8 %	RKR
Gases / Liquids	9	5 %	JJ
Other materials	5	3 %	RKR / JJ

JJ = Jerry Jean / RKR = Reinhard Krause-Rehberg
(numbers) = ICPA-16


15%
5%
9%
8%
4%
2%
14%
4%
16%
23%
Instrument, 23
Semiconductor, 7
Oxides, 26
Metals/Alloys, 37
Polymers, 24
Mesopores, 8
Membranes, 15
Fundamental theory, 12
Liquids/Gases, 7
Others, 3

Metals / Alloys / Spin polarized e+

- Many studies of Fe and steel, often for **Fission / Fusion** purposes
  - Not a simple material, but important field
  - 1V, 2V and dislocation lifetime is very similar
  - Precipitation, voids, grains and impurities in addition
  - ODS steel shows saturated e^+ trapping without treatment
  - not more than 3…5 dpa (otherwise many gas-filled voids – nothing to see any more)
- W for Fusion: irradiation studies - much easier interpretation; e^+ are very useful tool
- Al alloys: only a few studies – Positrons can still do a lot in this field (e.g. early stages of precipitation Al-Cu and Al-Mg-Si; defects in precipitation; role of vacancies)
- Combination with other methods: atom probe
- H in metals (steel, Ti)
- Very promising: Corrosion studies
- Spin-polarized positrons: important for spintronics; could be very surface sensitive (TOF); use of ^{68}Ge allows higher polarization (70%); subjects: Ni; Heusler alloy;
- project of polarized beam: ELI-NP (Extreme Light Infrastructure) near Bucharest
- Nice study on high purity Ni(100) foils incl. XPS
- Ultra-fine grained steel
- Layers: W/Cu

Semiconductors

Small but constant number of studies

- Very nice overview by Filip
- Defects in GaN for power devices
- Defects ion ZnO
- Photovoltaic research: CIGS layers
- PbSe and CdSe quantum dots
- Sulfur-hyperdoped Si

Oxides / Ceramics

- Perovskites is an important material class: vacancy identification by combination of PALS, CDBS and theory; dopant-induced vacancies; number of defects may be very large up to 1%
- Question: positive vacancies might be visible when positive repelling potentials overlap each other ?? Oxygen vacancies are positive. But may be too small anyway?
- UO_2 defect studies
- Thermoelectric materials
- Defects in SnO_2 films produced by sol-gel process
- Ca-doping of $BiFeO_3$ ceramics
- Effect of source irradiation: α-Al_2O_3 alumina at 10K long lifetime component changes
- Sintering mechanism in fine-grained Silica

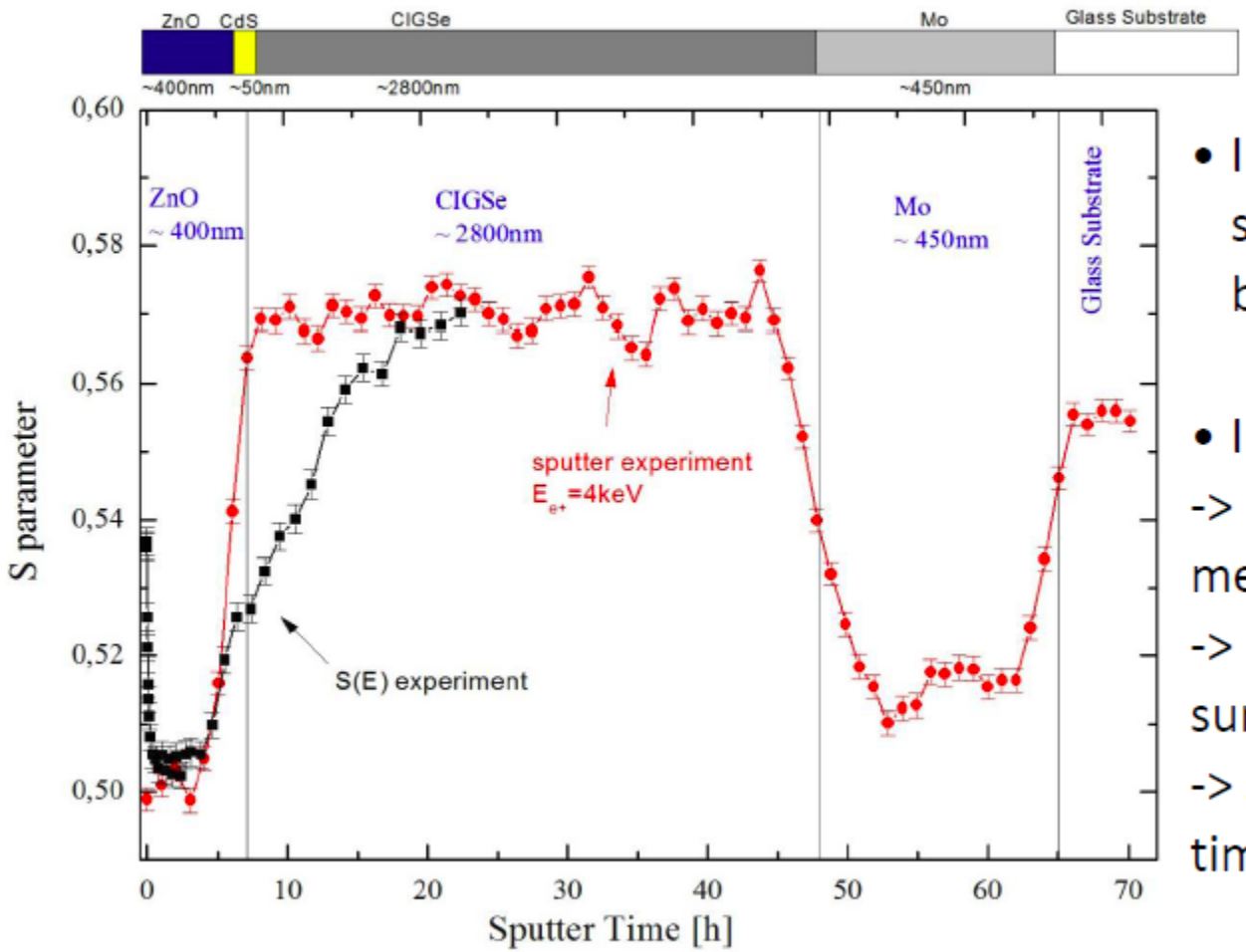
Theoretical work

- Parameter-free gradient corrections for e+ states in oxides
- High-accuracy positron lifetime calculation
- First-principle calculations of e+ and Ps states near Bi_2TE_2Se
- Vacancy identification in ZnO, In_2O_3, and SnO_2
- Positron lifetime spectra evaluation by particle swarm optimization
- Positron diffusion in strong magnetic fields
- Positron scattering and annihilation on atoms and molecules

Others

- Total-reflection high-energy Positron Diffraction (**TRHEPD**): determination of surface structure at outmost layer of surface; can clarify old puzzles of surface science -> very promising new positron technique
- Anti-Hydrogen research is continued: GBAR; ALPHA, AEgIS: resonant transitions observed between hyperfine states
- X- and Y-cut of natural quartz: stereoisomer behavior? More date required
- Study of native defects in topological insulator Bi_2Se_3 -> very hot topic

Marco John: Improvement of Depth resolution by Sputtering the sample



- Investigation of the whole solar cell, especially near the back contact

- In-situ sputtering

-> no air contact between the measurements

-> no degradation on the surface

-> shorter overall measurement time

Sputter parameters: I_B = 6 mA; U_B = 400 V

ICPA17 Summary Talk 9/25/2015

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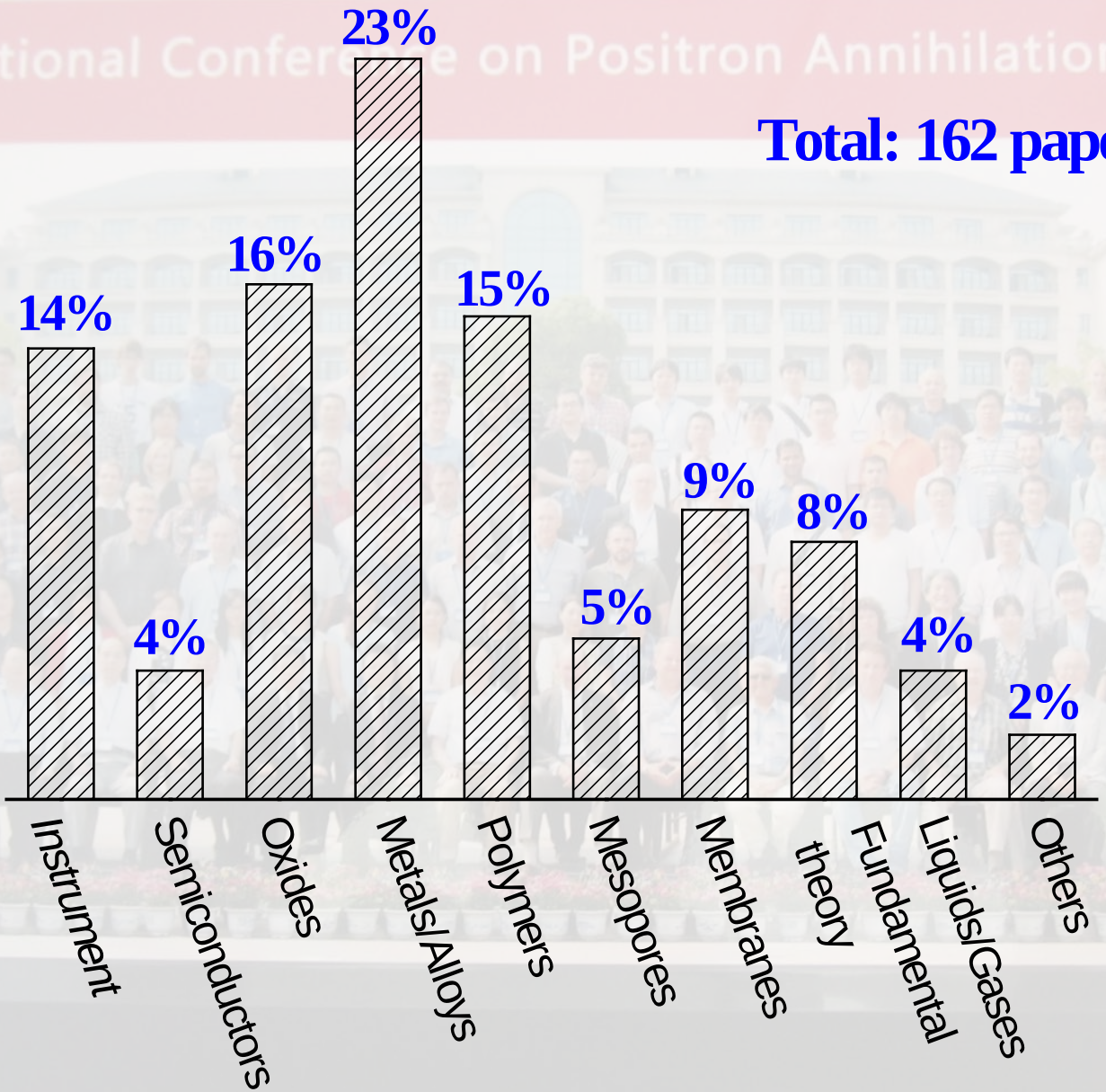
ICPA17 Papers Statistics 9/25/2015

#Papers	Topic/Materials	(paper%)	Rank	Sum Talks
37	Metals/Alloys	23	1	RK
26	Oxides	16	2	RK
24	Polymers	15	3	JJ
23	Instrument	14	4	JJ
15	Membranes	9	5	JJ
12	Fundamental /theory	8	6	RK
8	Mesopores	5	7	JJ
7	Semiconductor	4	8	RK
7	Liquids/Gases	4	8	JJ
3	Others	2	10	RK/JJ
162	Total # papers	100%		


Total: 162 papers
14%
4%
16%
23%
15%
5%
9%
8%
4%
2%
Instrument
Semiconductors
Oxides
Metals/Alloys
Polymers
Mesopores
Membranes
Fundamental theory
Liquids/Gases
Others

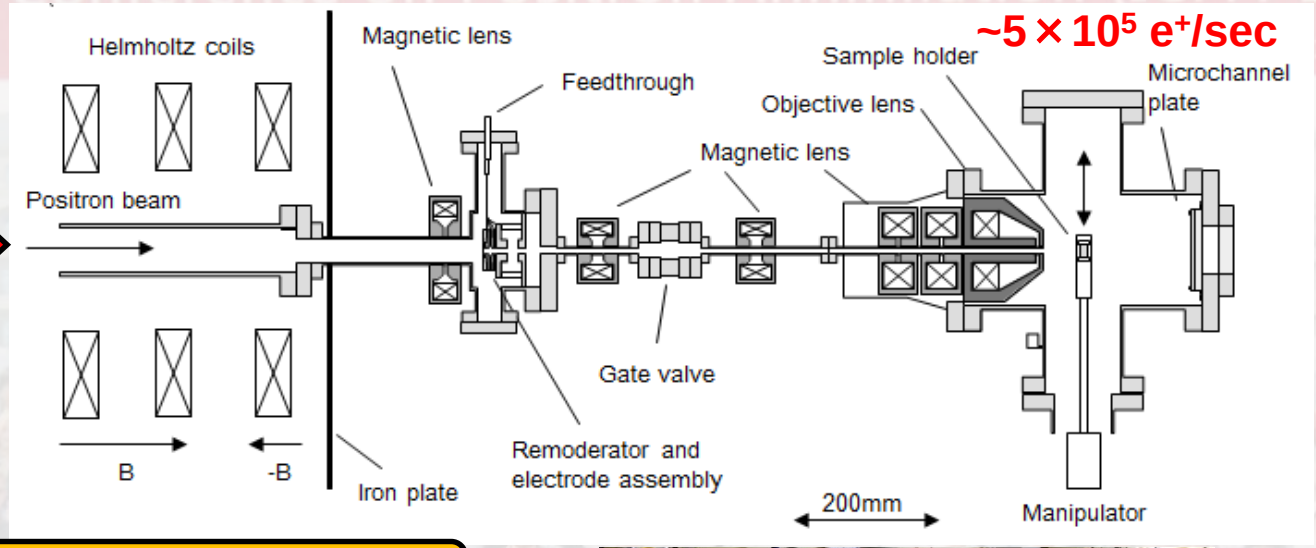
Instrumentation

- Surko's trap: 7 meV cryogenically cooled gas
- NEPOMUC: Low-energy High-Intensity $10^9 e^+/s$
- New positron beams: McMaster, UTA,ELI-NP,…
- TRHEPD Total-Reflection High-Energy Positron Diffraction
- Spin polarized positron beams
- Other techniques: PET, SEM, TEM, AFM, GPC, BET, XRD, SAXS, FTIR, EP, SIMS, UV-vis; LEED, XPS,…

Fukaya: Development of LINAC-based TRHEPD

(2010~)

5×10^7 e^+/sec



Linear accelerator (LINAC)

e-

Energy-tunable (< 35 keV)

e+

Converter/ moderator

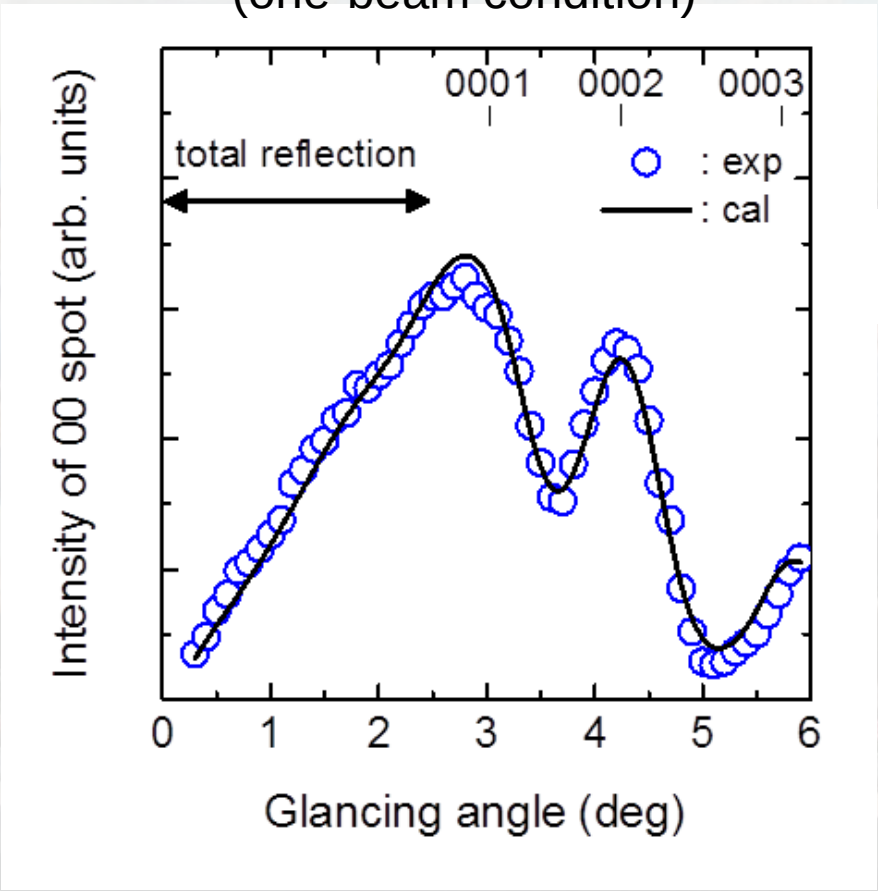
Intensity is **~100 times** larger than RI beam

Maekawa *et al.*, Euro. Phys. J. D **68**, 165 (2014).

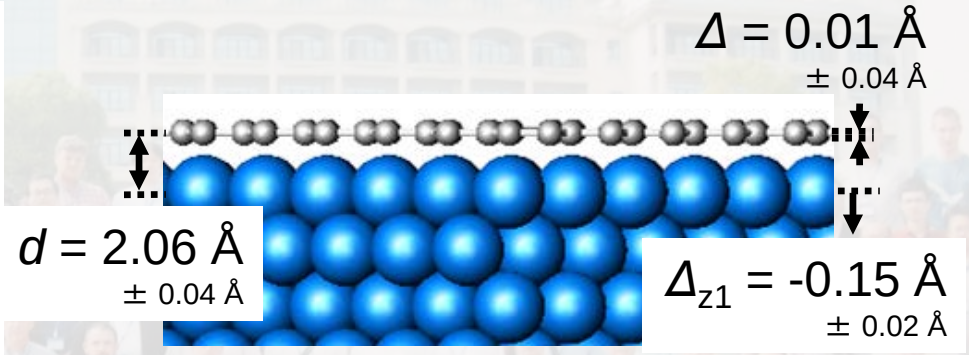
Slow Positron Facility, KEK

Structure of graphene/Co(0001)

Rocking curves for graphene on Co(0001) substrate (one-beam condition)



Optimum atomic positions



side view

***d* (Gr/Co) << *d* (graphite)**

(3.35 Å)

(Graphene on Co(0001) has no buckled structure)

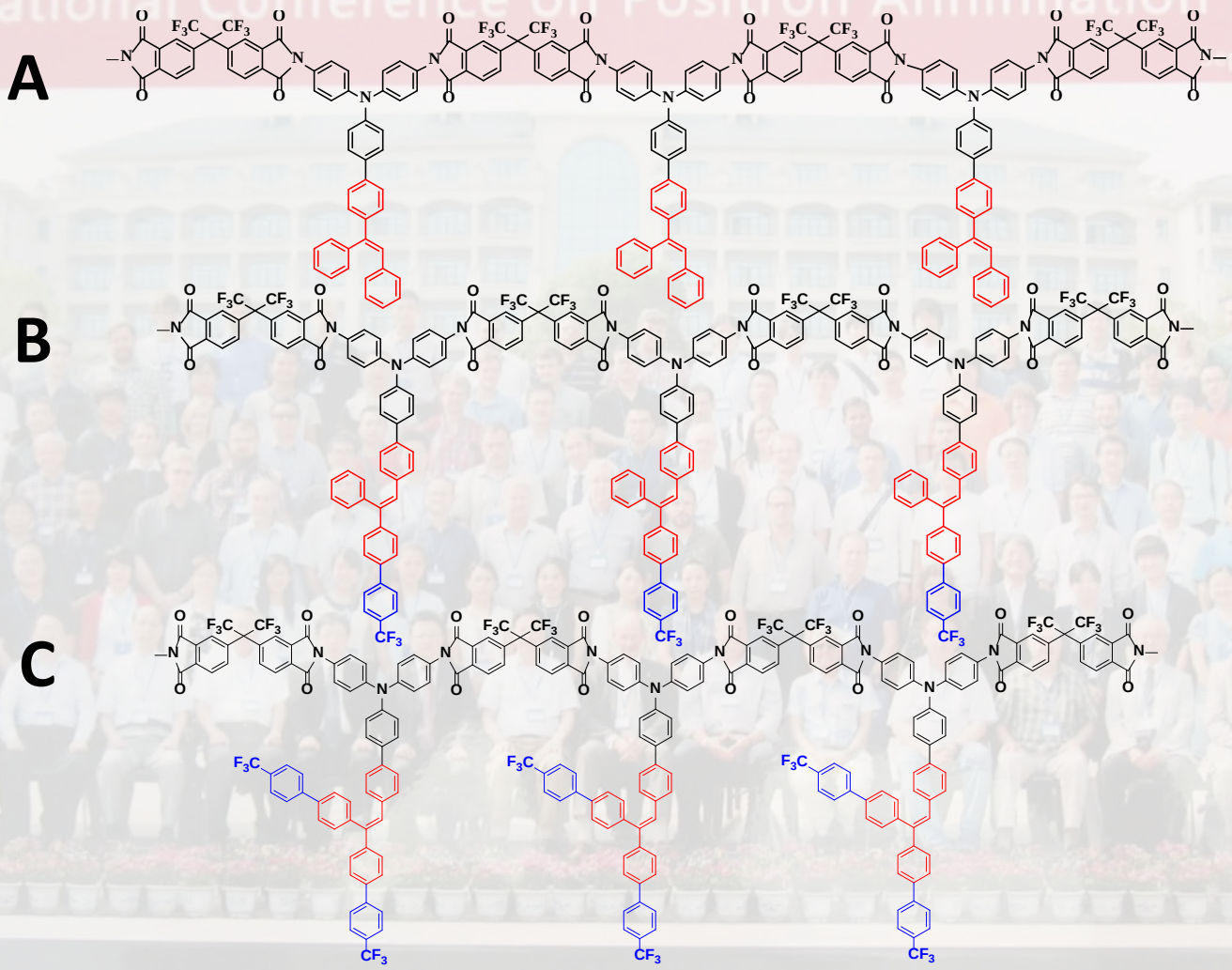
Strong interaction with substrate

Y. Fukaya *et al.*, in submission.

Polymers, Organic macromolecules

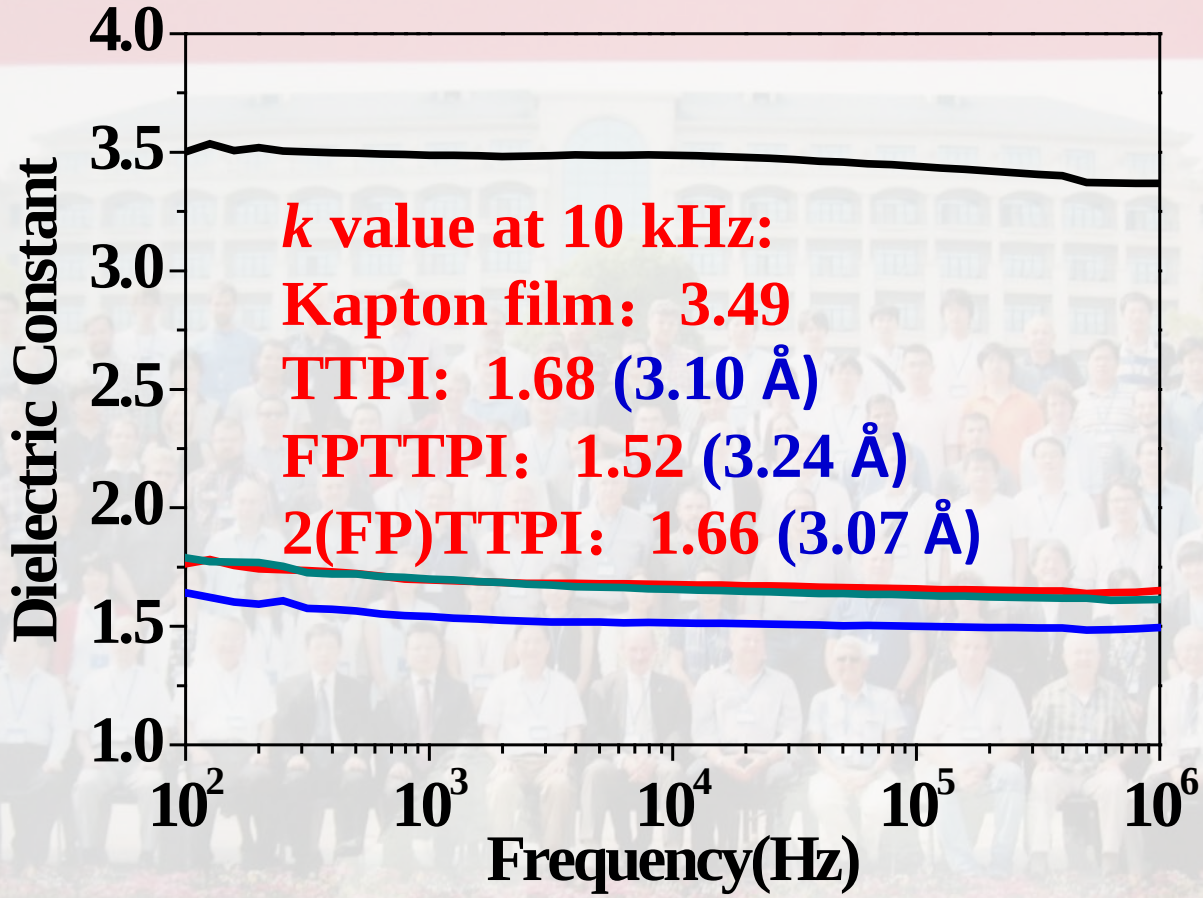
- Sub-nanometer free-volume size, fraction
- Free-volume theory and Ps-free volume
- Phase transitions
- Crystallinity and interfaces
- Molecular designs for devices
- Drug/ nutrient transport
- Radiation effects

Zhang, Yi: Recent Progress in High-Performance Intrinsic Ultralow-*k* Polyimide Films



Chemical structures of TTPI(A), FPTTPI(B) and 2(FP)TTPI(C)

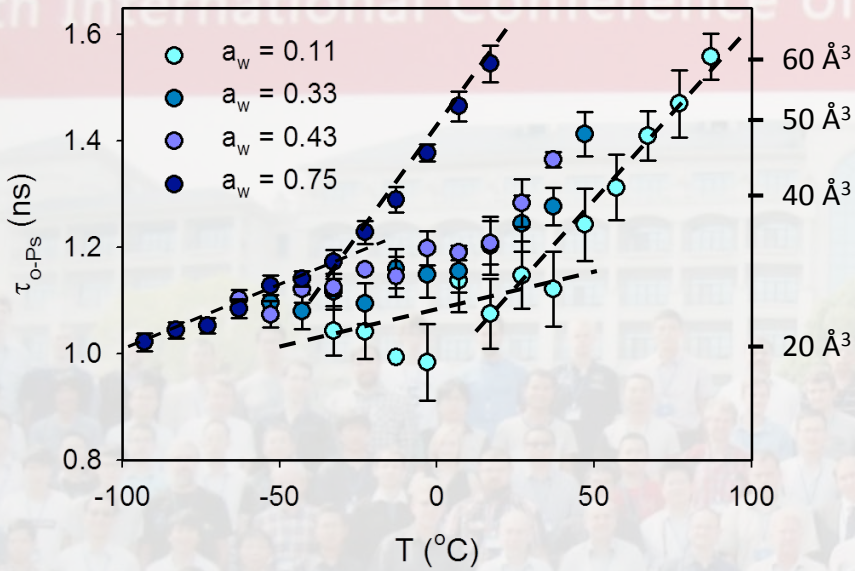
Results and Discussions

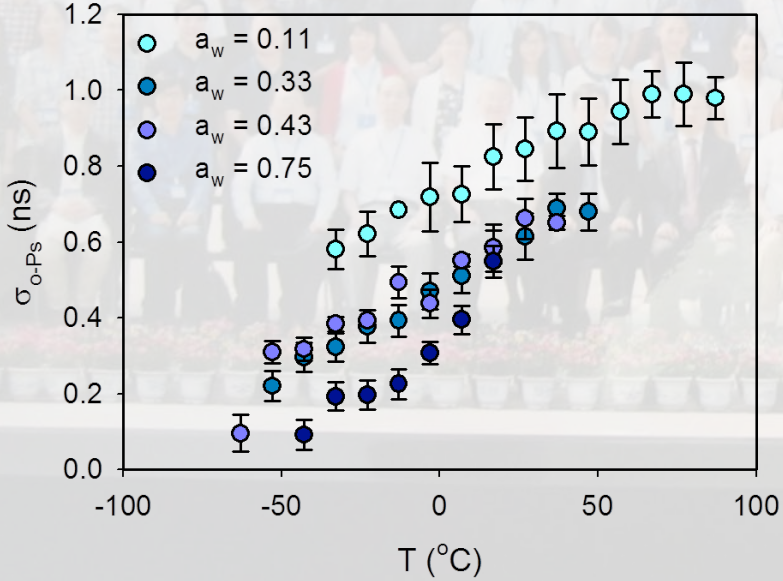


Dielectric properties of the PI films and a DuPont™ Kapton® polyimide film.

Chem. Mater. 2015, accepted

Alam, A. : Edible biopolymer + sucrose + processing biopolymer+ bioactive +water

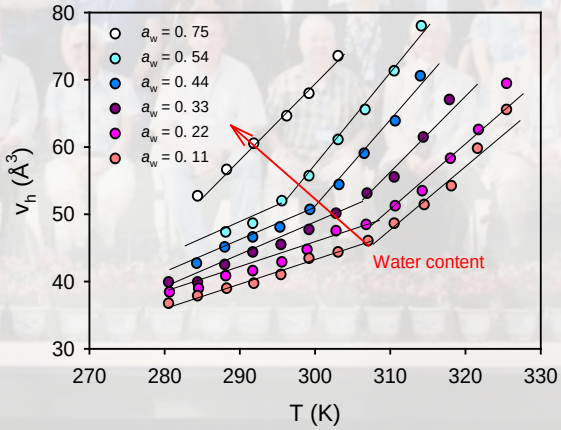




- Expected trends in hole volume with varying water content as in model systems
- Expected trends in T_g
- Expected trends in hole vol. dispersion with water activity

Complex but still managable

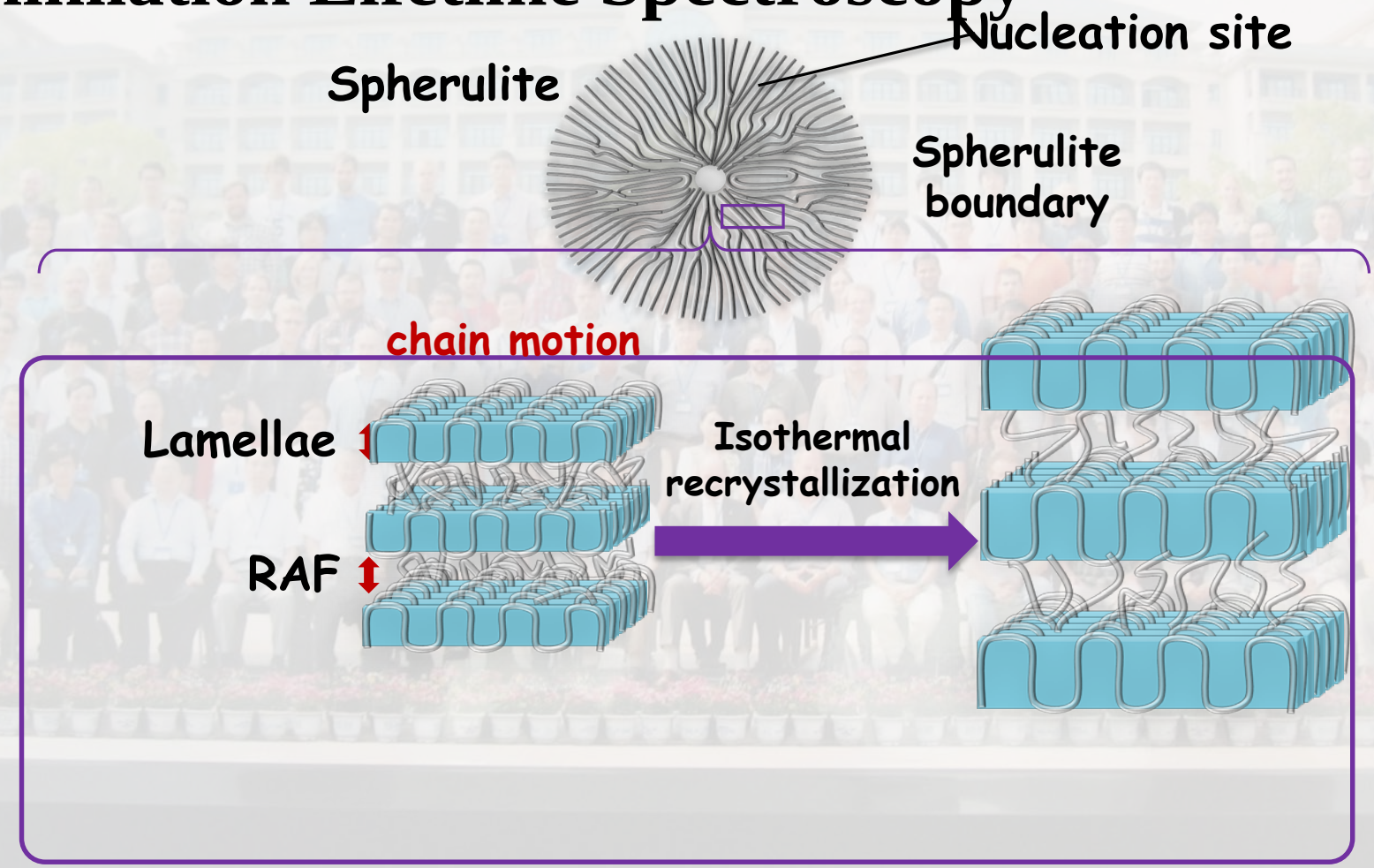
carbohydrate matrices for comparison



Membranes

- Gas transport diffusivity, permittivity, and selectivity and free-volume
- Free-volume size control transport phenomena
- Asymmetric membranes –multi-layers
- Crystallinity and interfaces
- Desalination
- Molecular designs for devices

Sun, Y.M.: Structure Behaviors of Isothermally Annealed Isotactic Poly(4-methyl-1-pentene) Membranes Characterized by Positron Annihilation Lifetime Spectroscopy

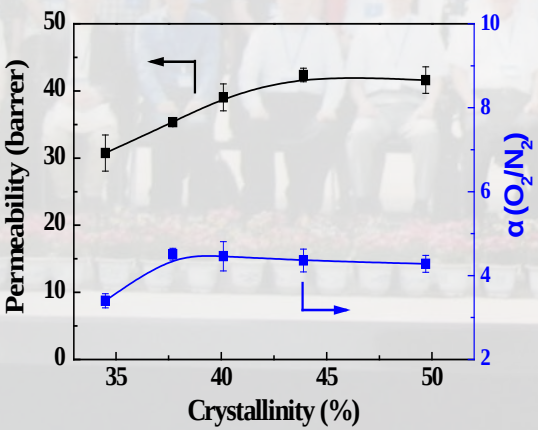


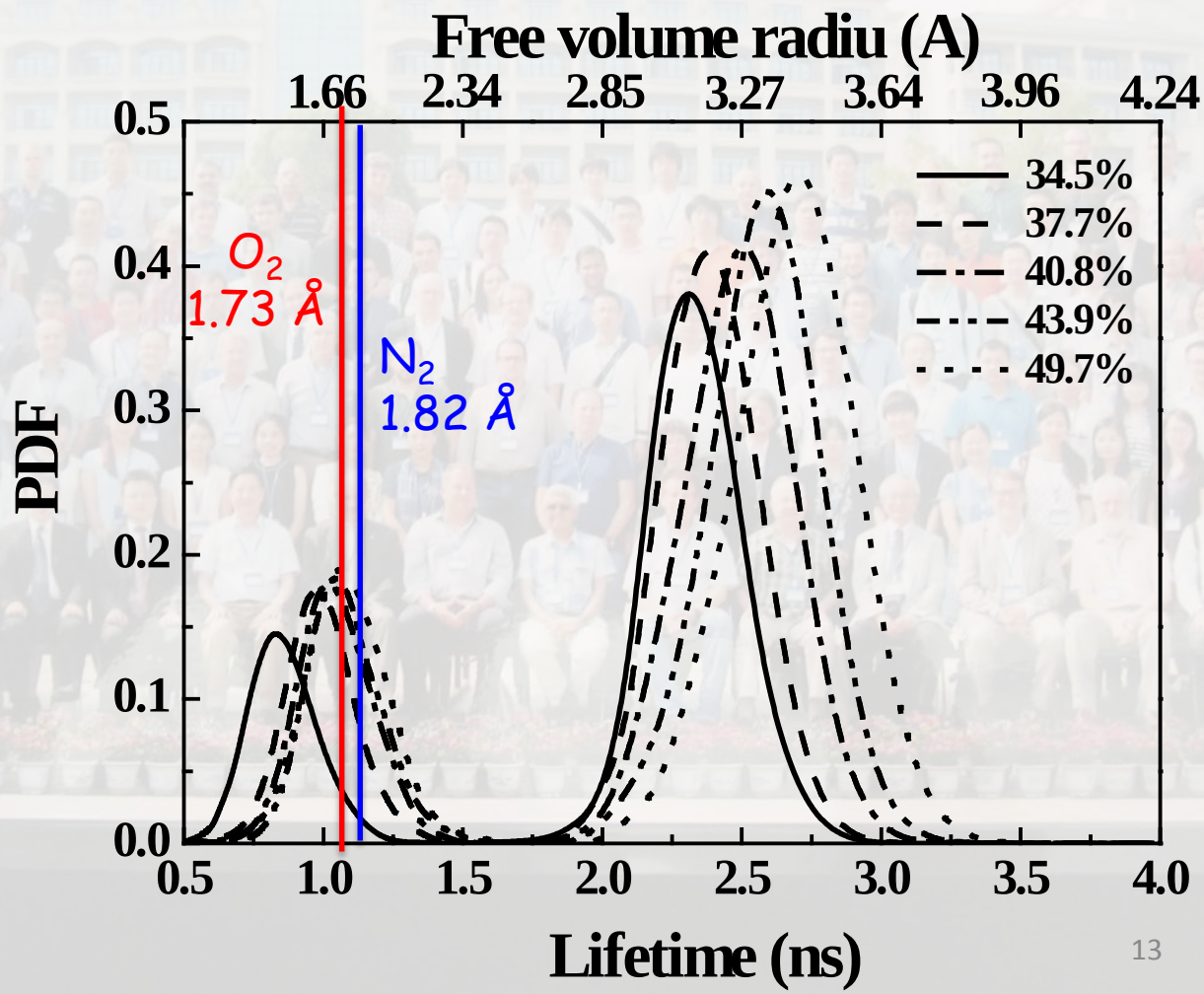
τ_{3a} and I_{3a} increase → Selectivity↑
τ_{3b} and I_{3b} increase → Permeability↑

Kinetic Molecular Diameter

O_2 3.46 Å

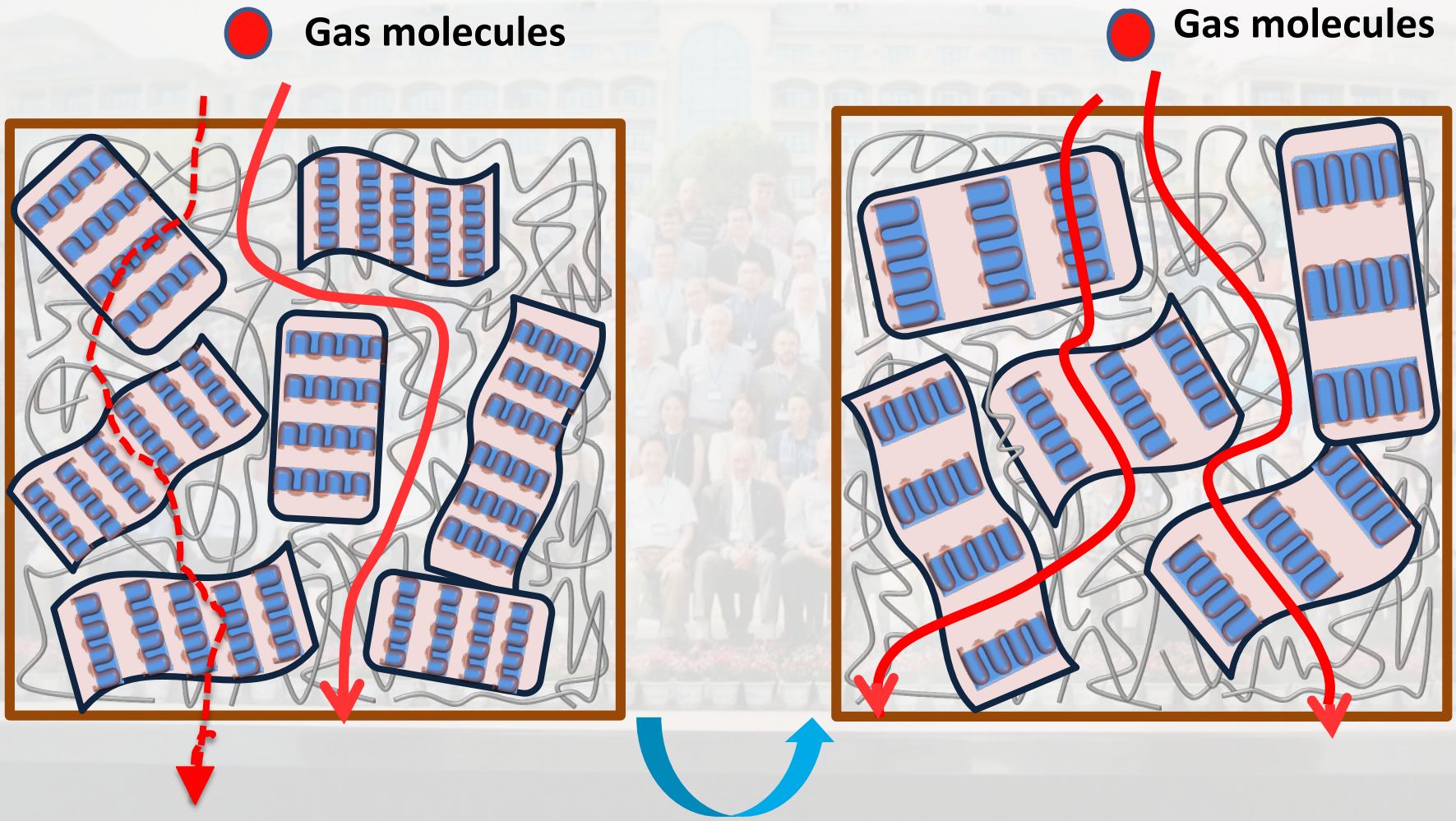
N_2 3.64 Å





Proposed Model of gas transport through *i*-PMP

Three-phase model

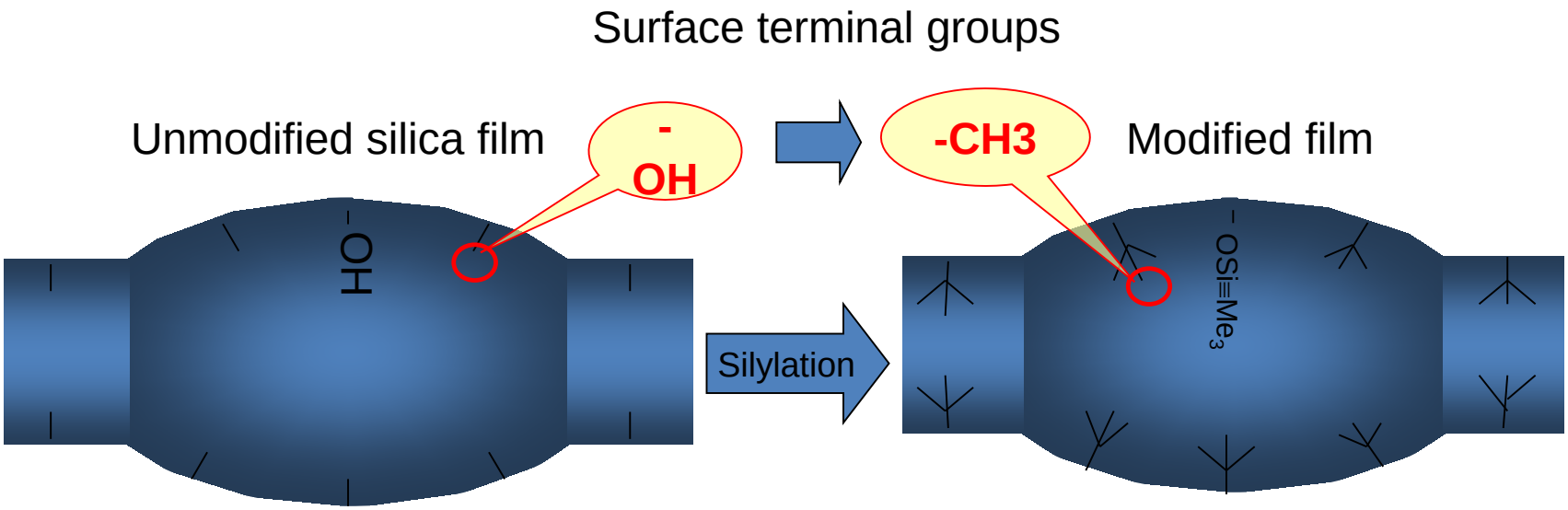


Isothermal recrystallization

Mesopores

- Ps yield/production
- Theoretical models: quantum vs classical
- Inner surface chemical modification
- Pore filling
- Molecular designs for devices

He, C.Q: surface modification of inner surafces

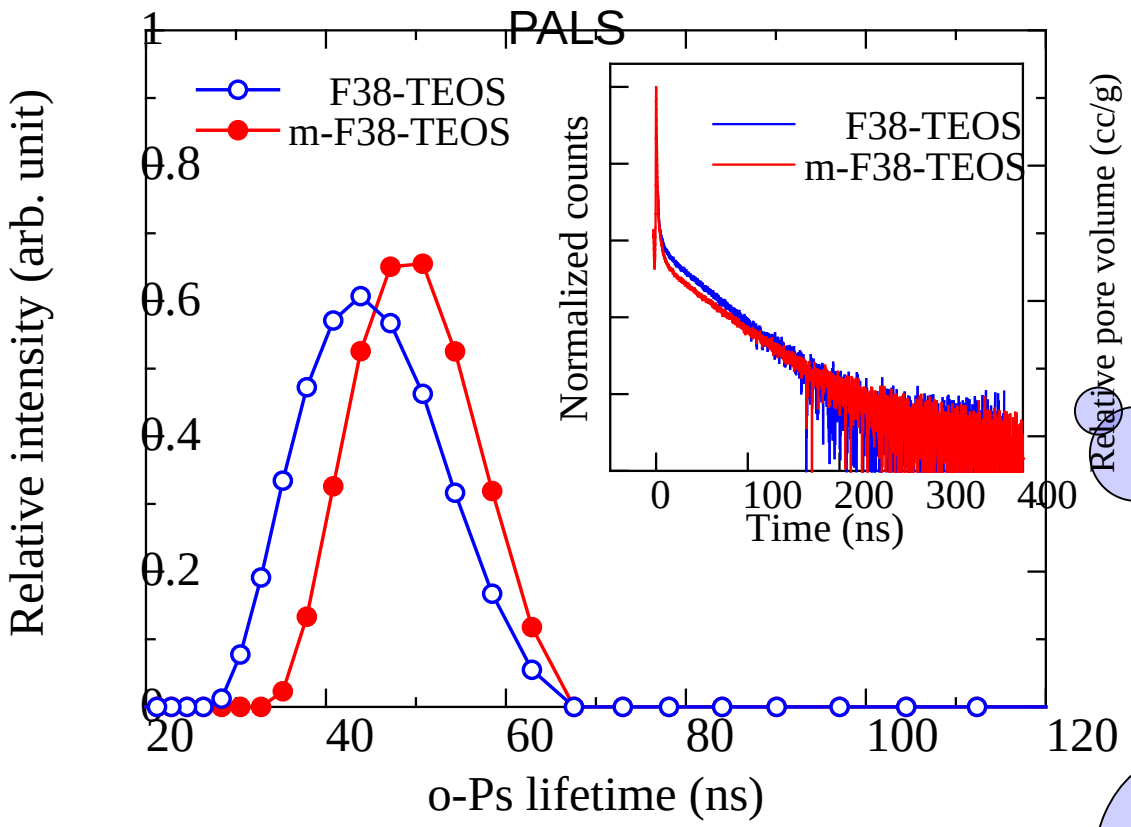


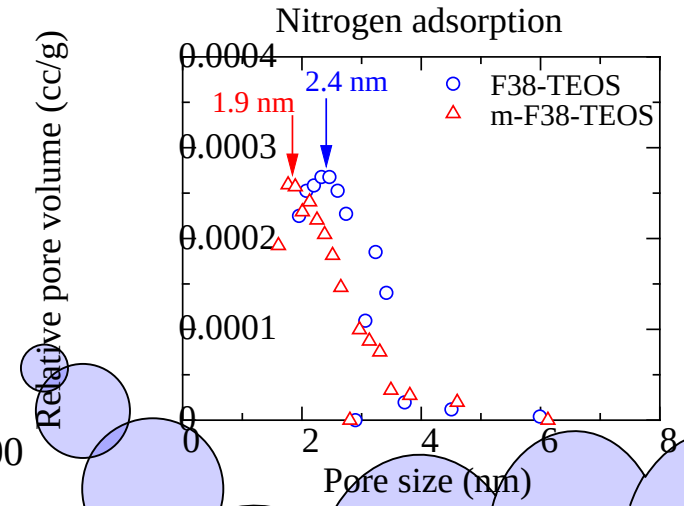
Trimethylsilylation @ ~100°C for 3 hours

$$-OH + (CH_3)_3{\equiv}Si\text{-}Cl \rightarrow -O\text{-}Si{\equiv}(CH_3)_3 + HCl$$

1. Pore architecture is unchanged;
2. Pore size becomes smaller.

Ps lifetime and pore surface chemistry



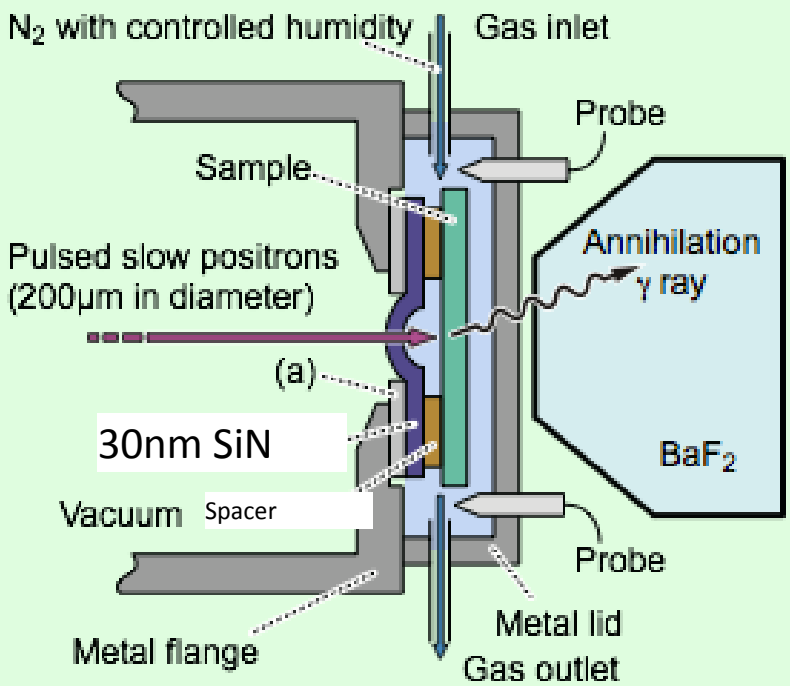


Ps-surface interaction depends on surface chemistry. (*C.He et al., PRB 75, 195404 (2007)*);

Note: pore size decreases by 0.5 nm (N_2 adsorption)!

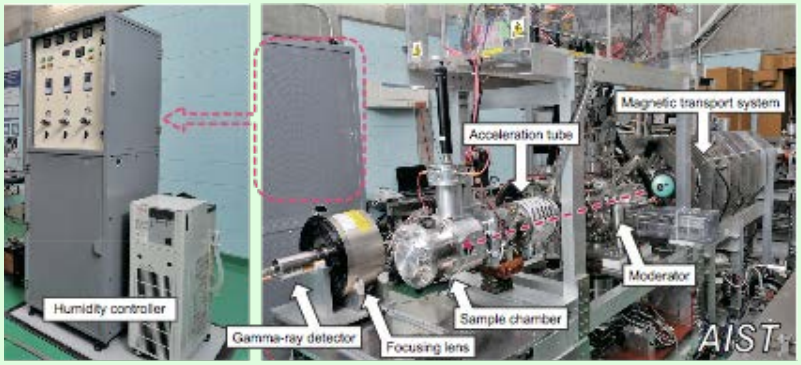
Inconsistent ?

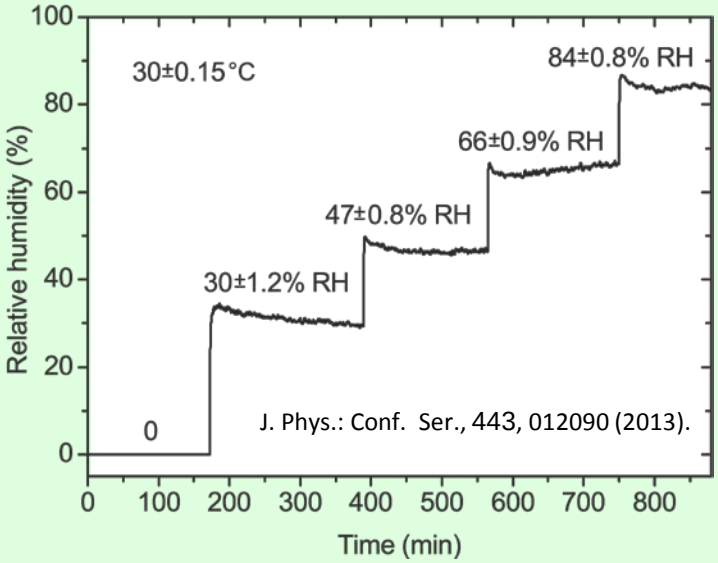
Ito, K: Atmospheric PPMA-PP with humidity controller



W. Zhou, et al., APL **101**, 014102 (2012).

Humidity-controlling chamber
with a thin vacuum window

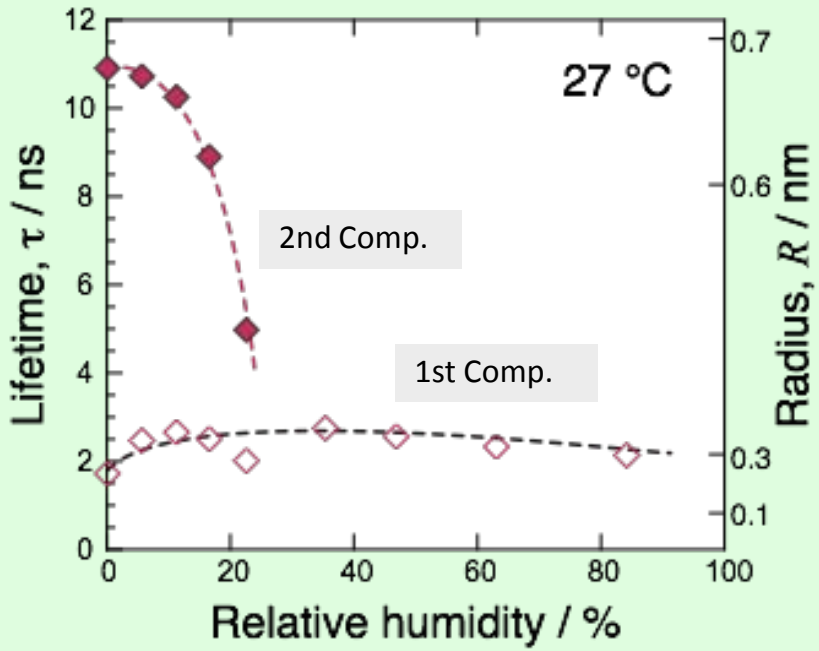




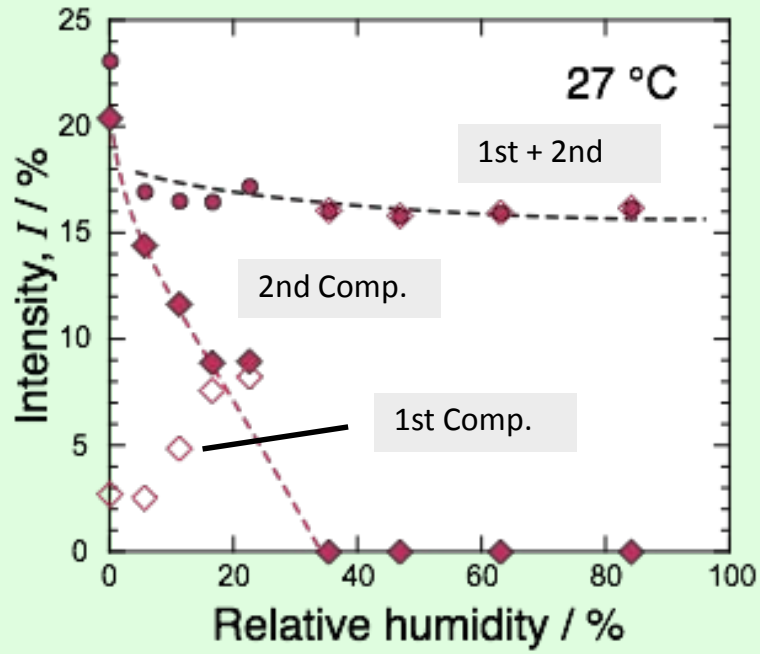
J. Phys.: Conf. Ser., 443, 012090 (2013).

Positron lifetimes were measured with different relative humidities.

RH dependence of o-Ps lifetime and intensity for



o-Ps lifetimes as a function of RH



o-Ps relative intensity as a function of RH

Subnanohole size of 2nd comp. reduces with increased RH due to water adsorption, while the smaller hoe size of 1st comp. is independent on RH.

Gases/Liquids

- Positron-atomic scattering
- Scattering theories
- Ps formation in liquids
- Ps-bubble in liquids

Others

- Zhang, R. : Study of Defects in Ferroelectric Croconic Acid Single Crystals
- J.David van Horn: chiral molecules , quartz, tartaric acids
- Zhong, J.: Graphene, and graphene oxides
- Shi, W. : Colloidal quantum dots
- Zgardzinska: Encapsuled nano polymer/alkane

Two Personal Encouragements

- Cultivate young generations to positron science
- Cooperation and collaborations *inter and intra*

Thank ICPA17 excellency,
Welcome to USA for ICPA18
God Bless You