

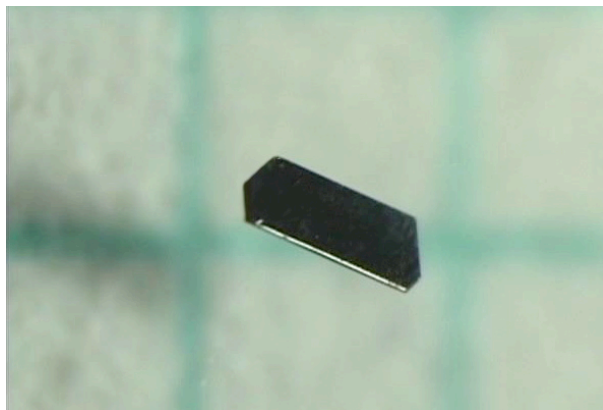


Expanding Possibilities of π electrons in Molecular Conductors

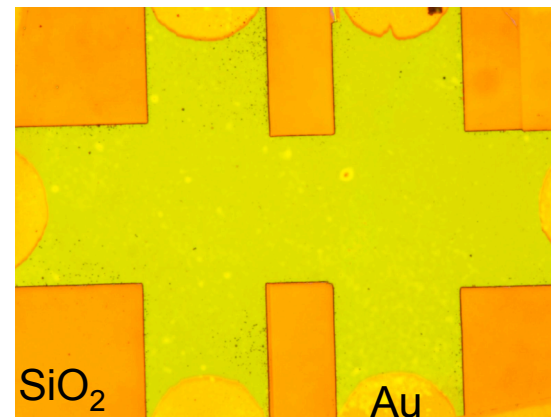
Reizo KATO (RIKEN)

Molecular p-systems: Clean, Soft, Clear

- Small in Quantity and Size, Fragile
- High Quality Measurements: Sensitivity, Accuracy, Resolution
- Multiple Extreme Conditions:
Strong Magnetic Field, High Pressure, Low Temperature



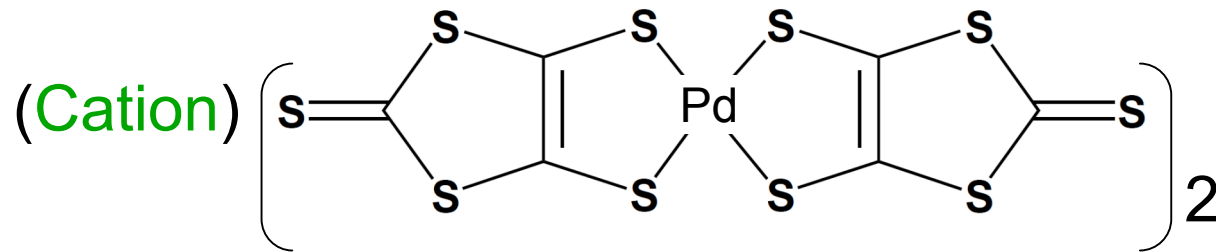
p-frustration system
($\text{EtMe}_3\text{P}[\text{Pd}(\text{dmit})_2]_2$)



p-FET
($k\text{-(ET)}_2\text{Cu}[\text{N}(\text{CN})_2]\text{Br} / \text{SiO}_2$)

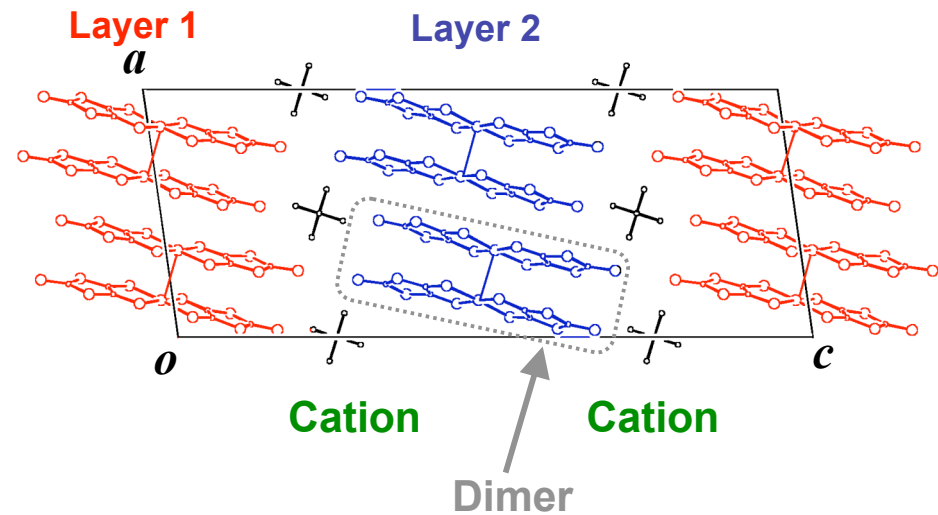
Exotic Properties of p Electrons

Based on Various Degrees of Freedom in a Mott system with a quasi-triangular lattice



Cation

Me ₄ N	EtMe ₃ N	Et ₂ Me ₂ N
Me ₄ P	EtMe ₃ P	Et ₂ Me ₂ P
Me ₄ As	EtMe ₃ As	Et ₂ Me ₂ As
Me ₄ Sb	EtMe ₃ Sb	Et ₂ Me ₂ Sb

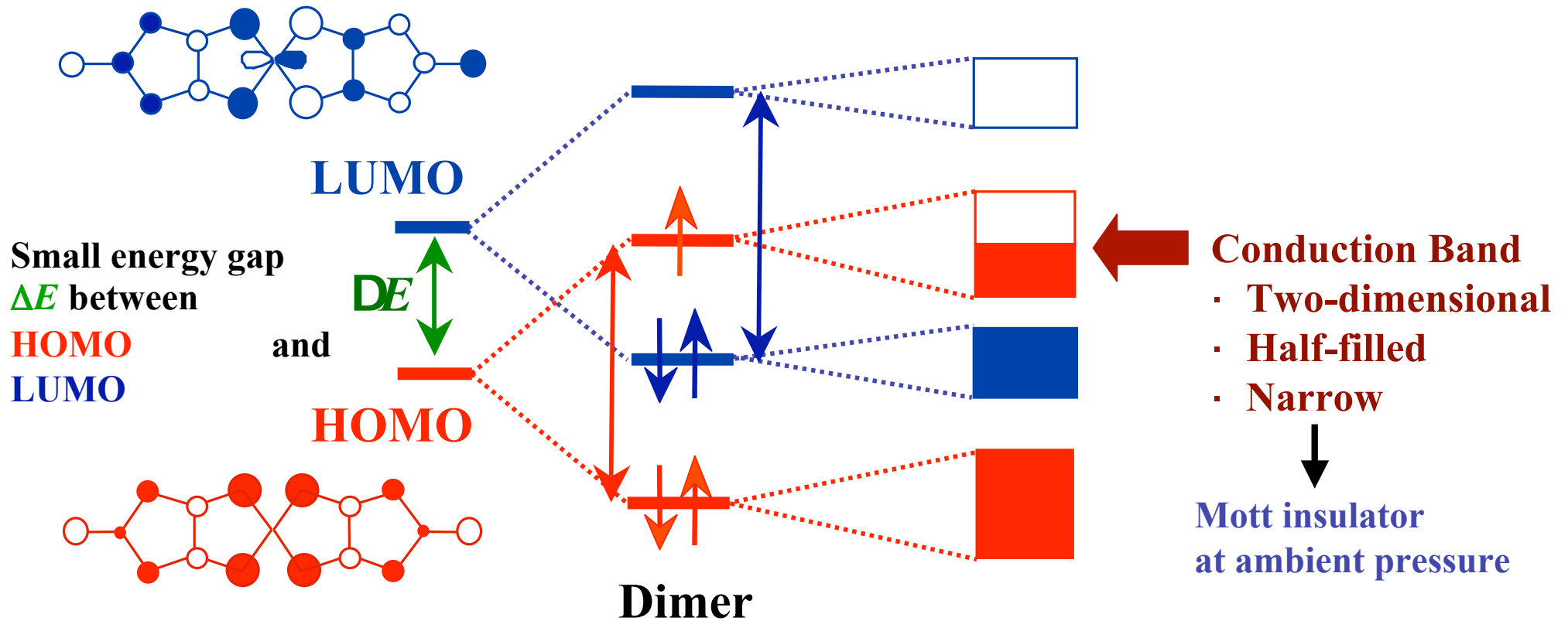


- Spin
- Orbital (HOMO-LUMO interplay)

- Charge
- Lattice

HOMO-LUMO Level Crossing in the $[\text{Pd}(\text{dmit})_2]_2$ Dimer

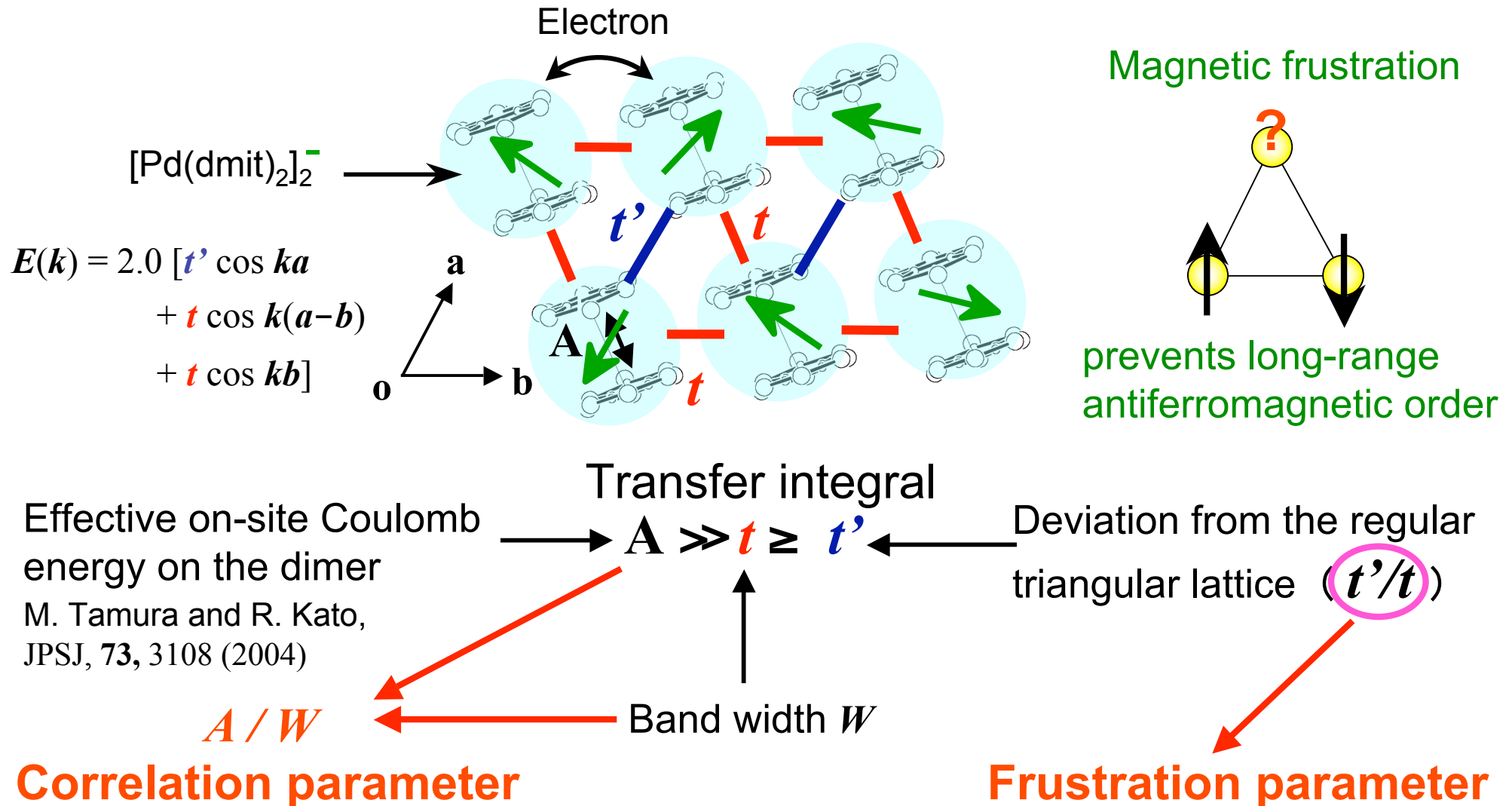
Strong dimerization: $[\text{Pd}(\text{dmit})_2]_2^-$



The stronger dimerization provides the larger gap.

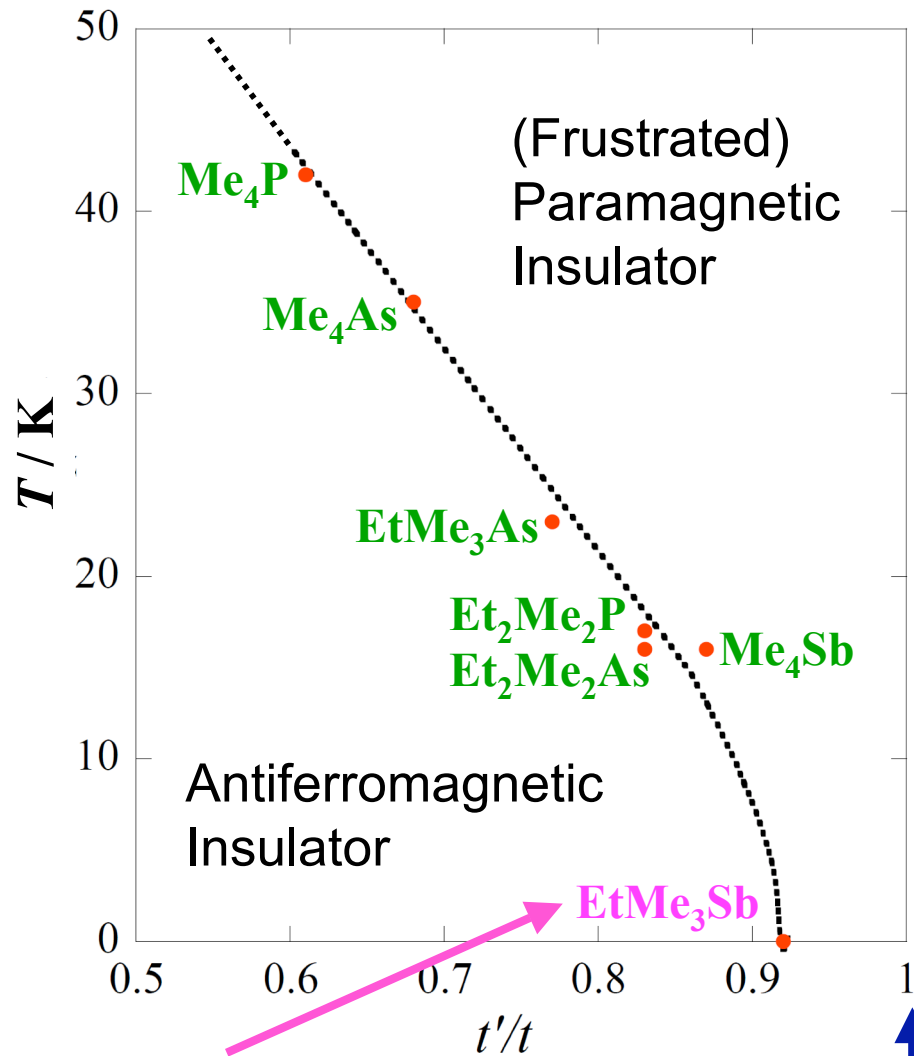
Electronic Structure of (Cation)[Pd(dmit)₂]₂

At ambient pressure, most of Pd(dmit)₂ salts behave as Mott insulators where one spin is localized on each dimer.

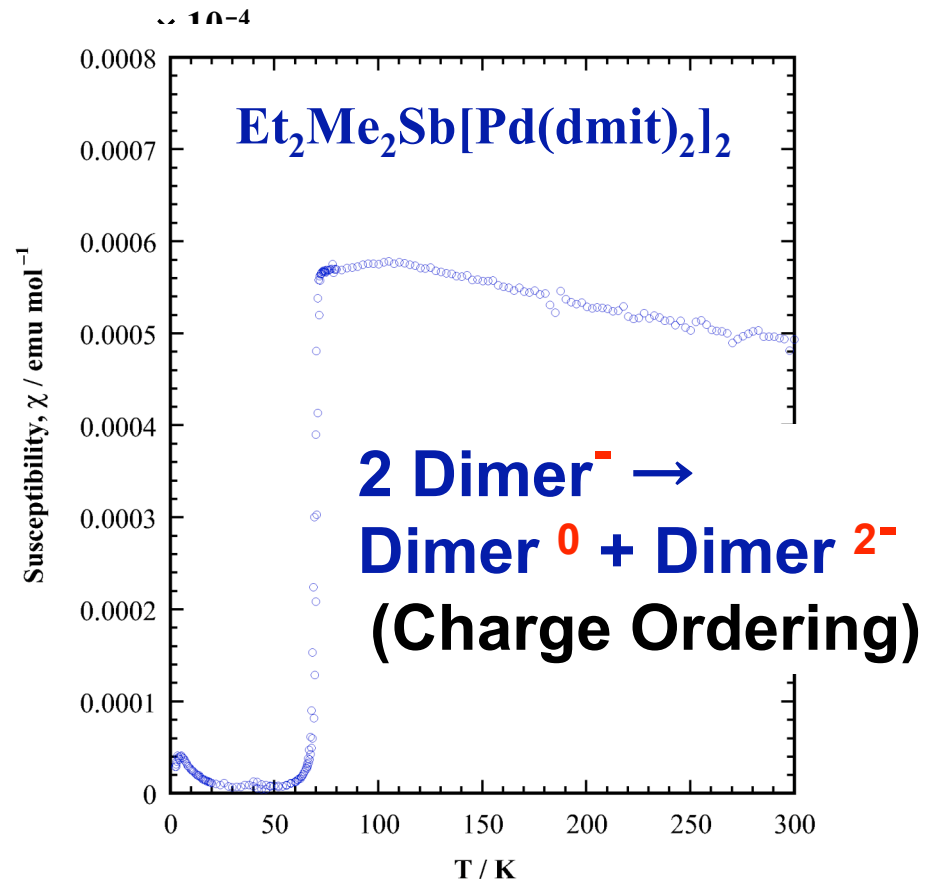


Mott Insulator with a Quasi-Triangular Lattice

b'-(Cation)[Pd(dmit)₂]₂



Magnetic susceptibility



The antiferromagnetic ordering is not the only way to remove the frustration

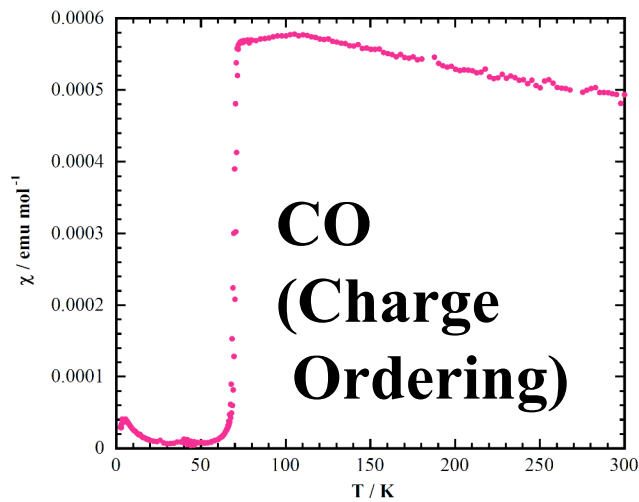
Gapless Spin Liquid

T. Itou et al., *PRB*, **77** (2008) 104413

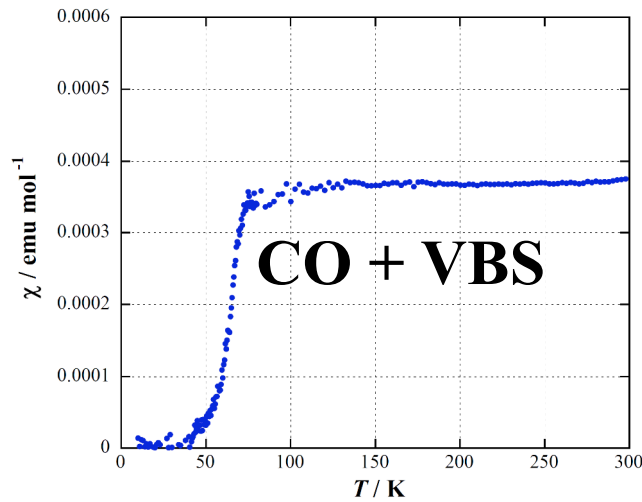
$\text{Et}_2\text{Me}_2\text{Sb}$

Valence bond (VB) formation -Transitions towards a singlet state-

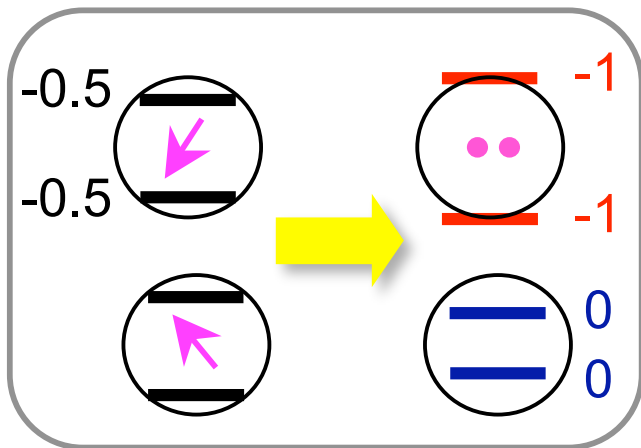
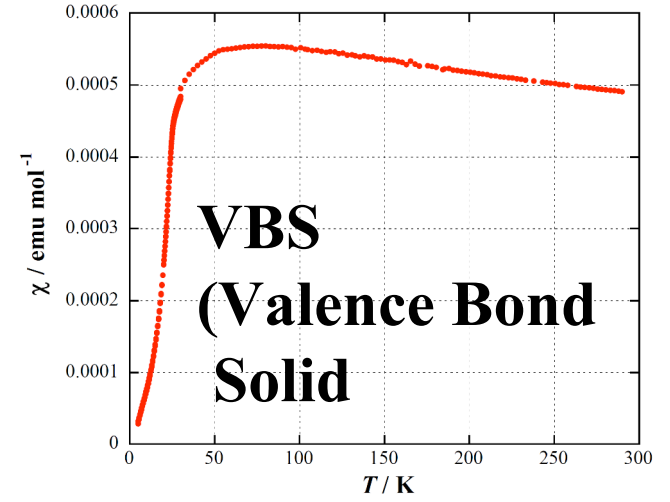
Et₂Me₂Sb



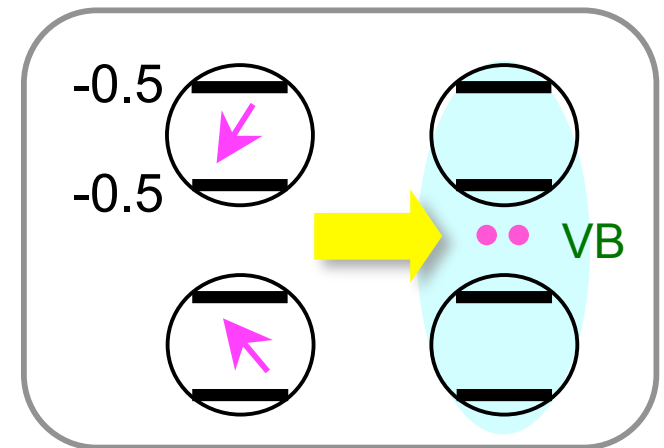
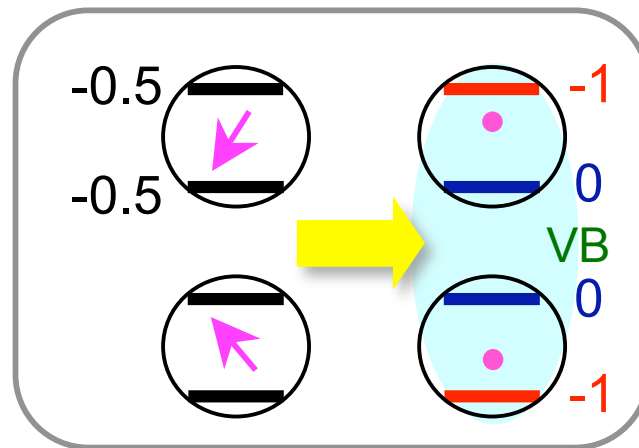
EtMe₃P (Triclinic)



EtMe₃P (Monoclinic)

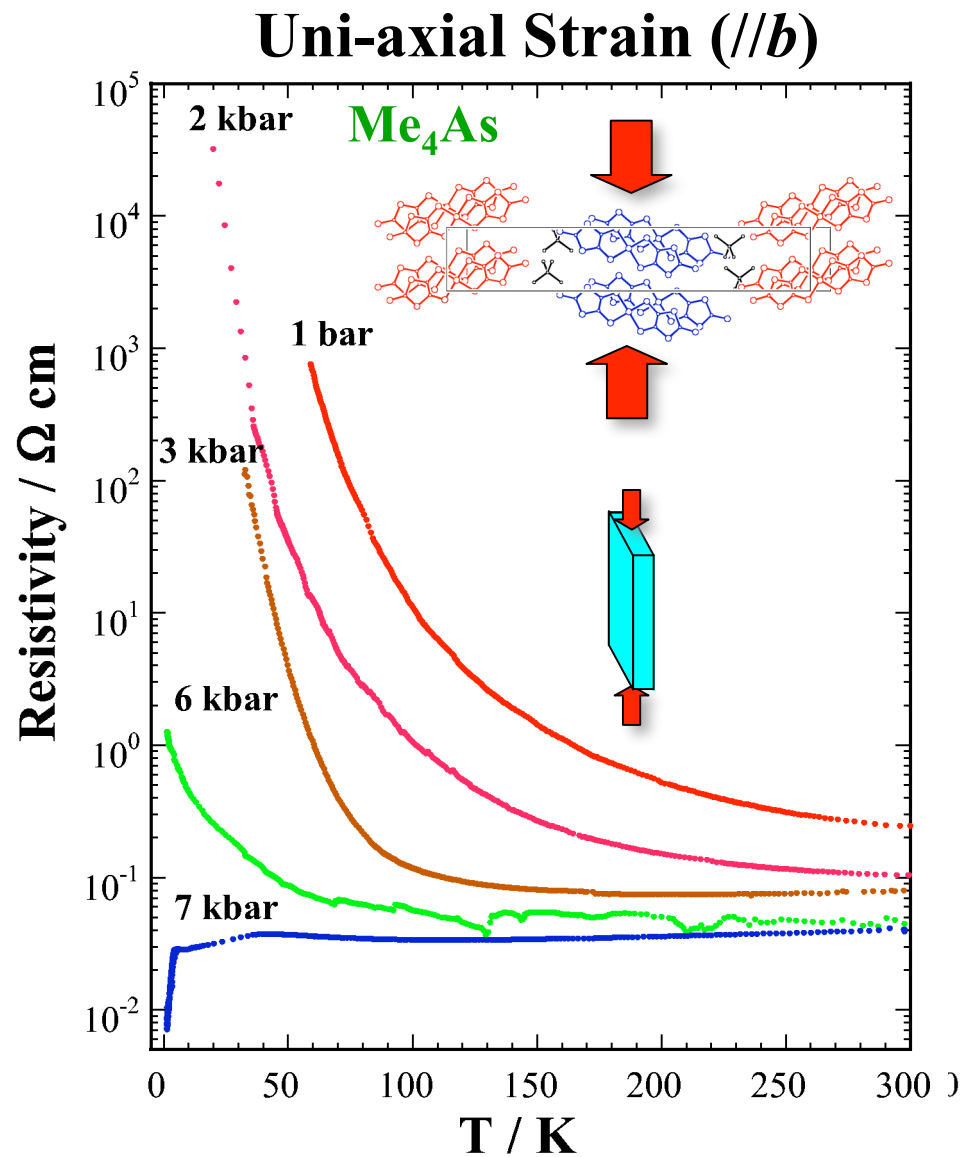
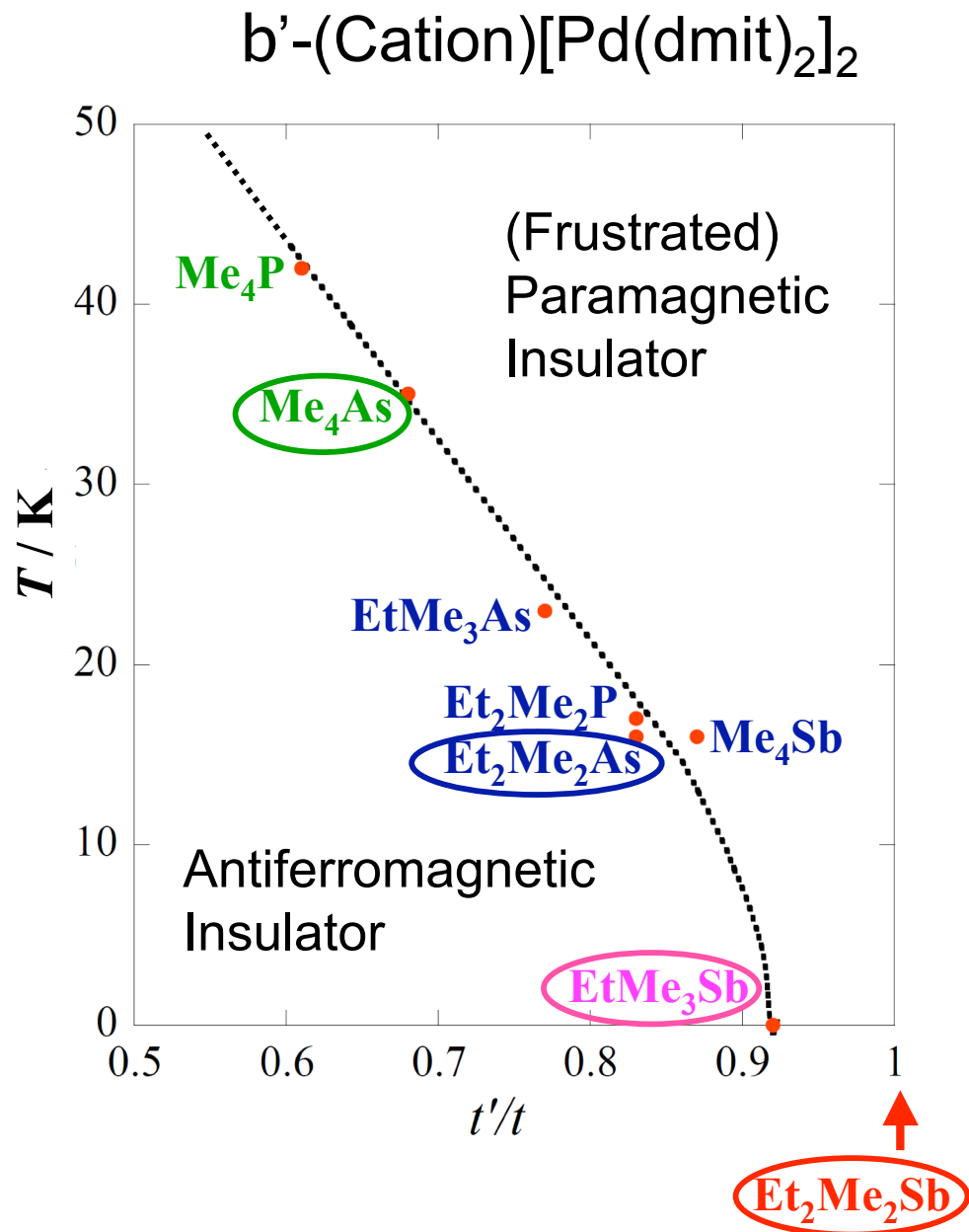


M. Tamura et al, CPL,
411 (2005) 133



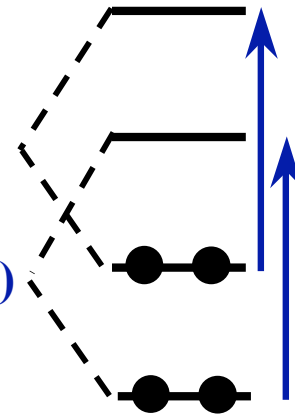
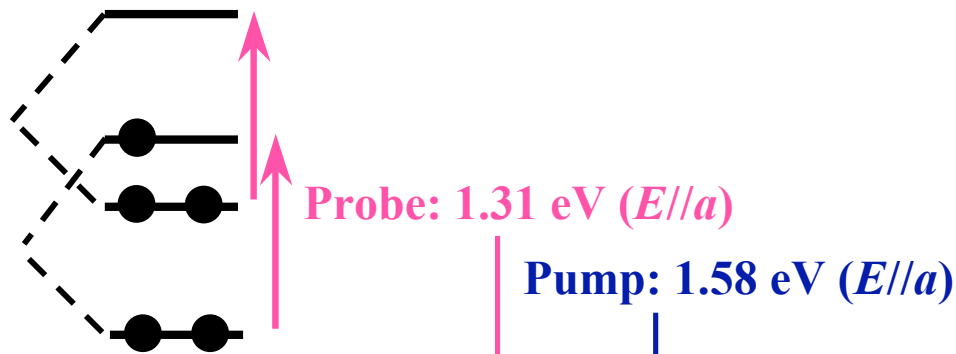
M. Tamura et al, JPSJ,
75 (2006) 093701

Pressure-induced metallic and superconducting states



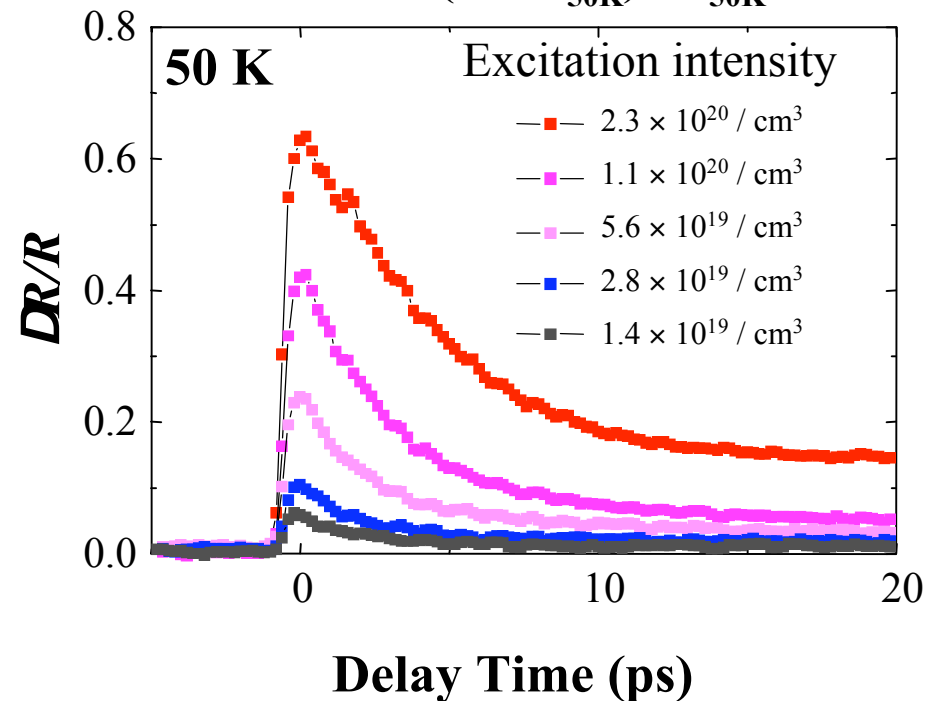
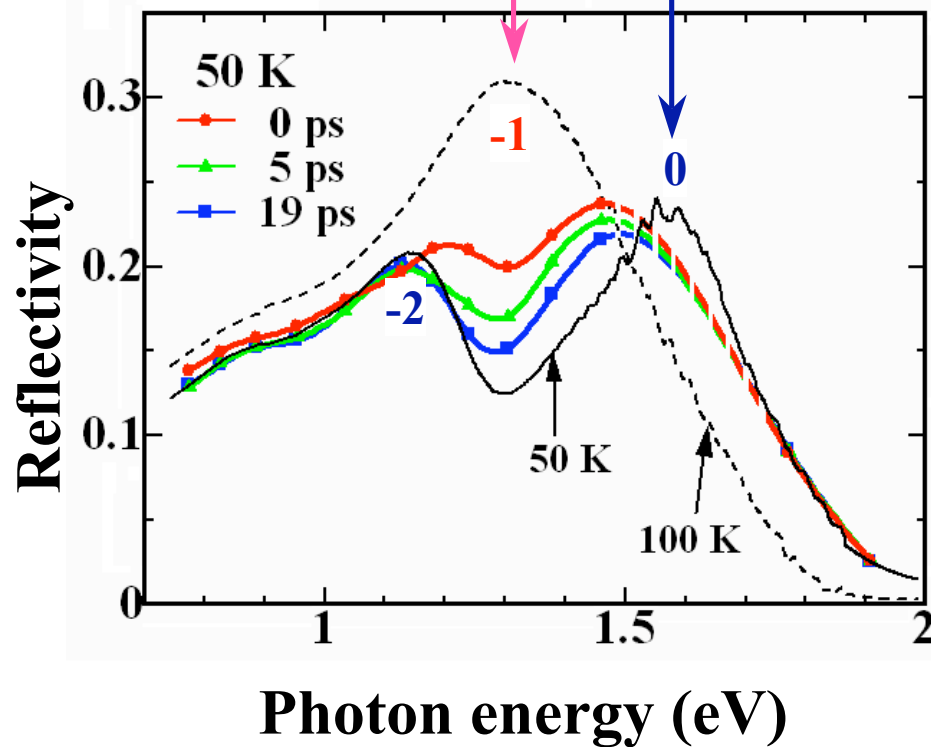
Pump-probe time resolved spectroscopy for $\text{Et}_2\text{Me}_2\text{Sb}[\text{Pd}(\text{dmit})_2]_2$ ($T_{\text{CO}} = 70 \text{ K}$)

**Koshihara Group
(TIT, ERATO)**



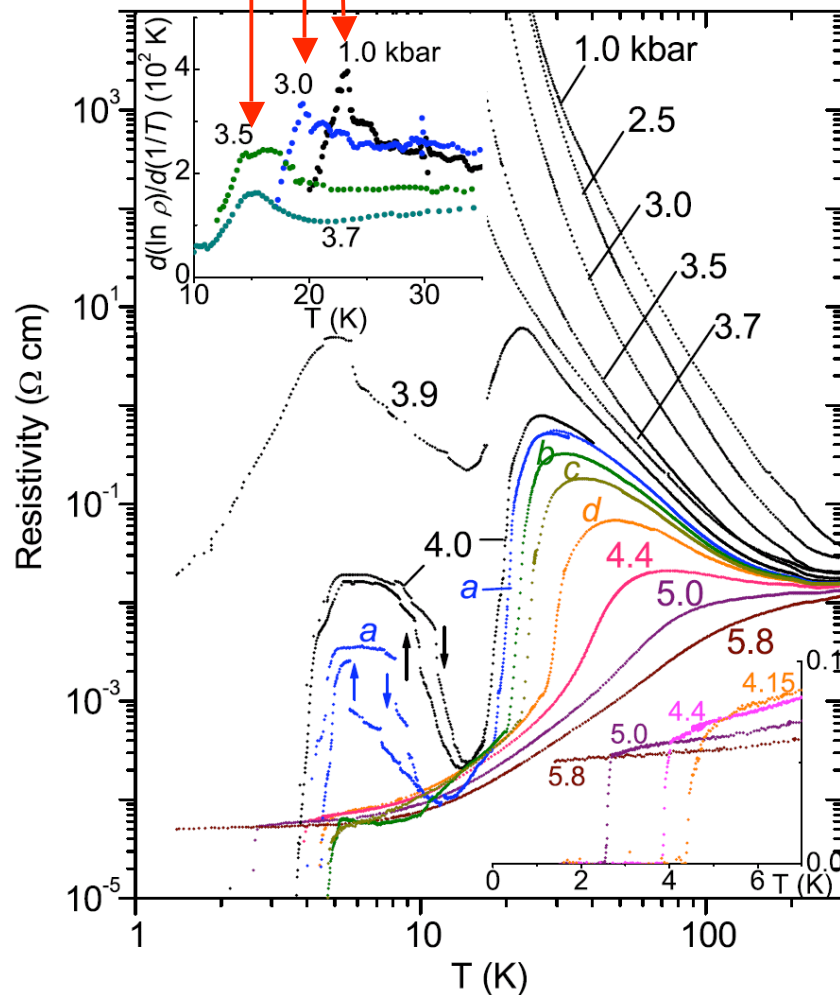
The lifetime of the photo-induced state is short within 20ps.

$$DR/R = (R - R_{50\text{K}}) / R_{50\text{K}}$$

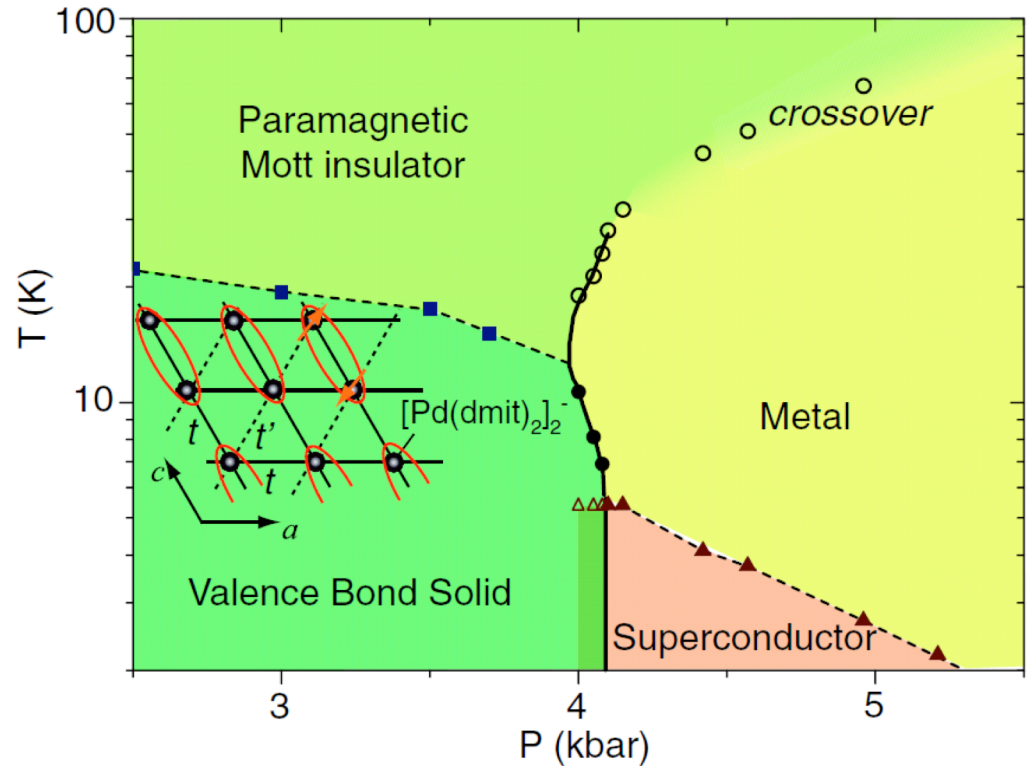


EtMe₃P[Pd(dmit)₂]₂ (Monoclinic): Superconductivity and Valence Bond Solid

VBS transition



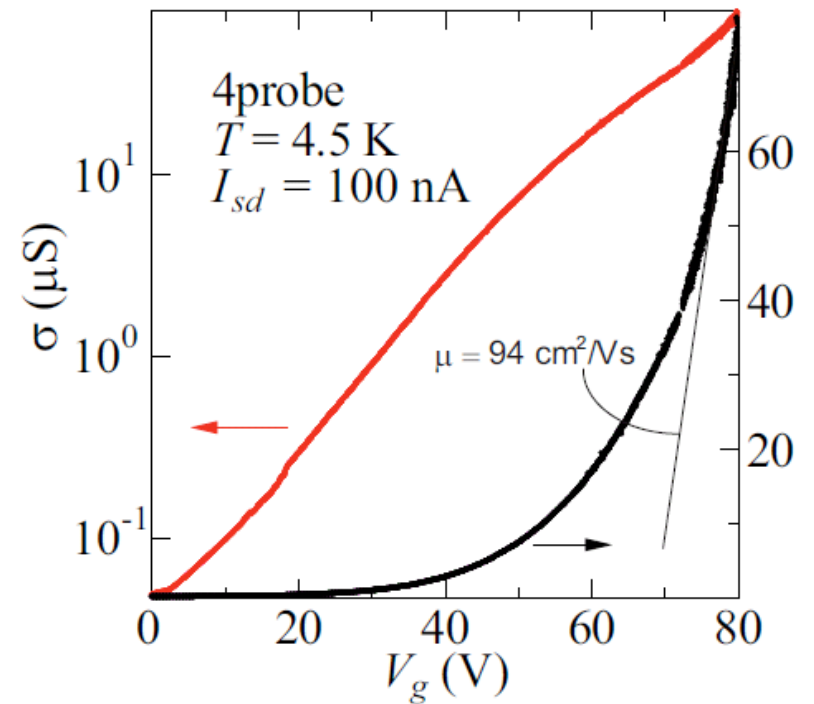
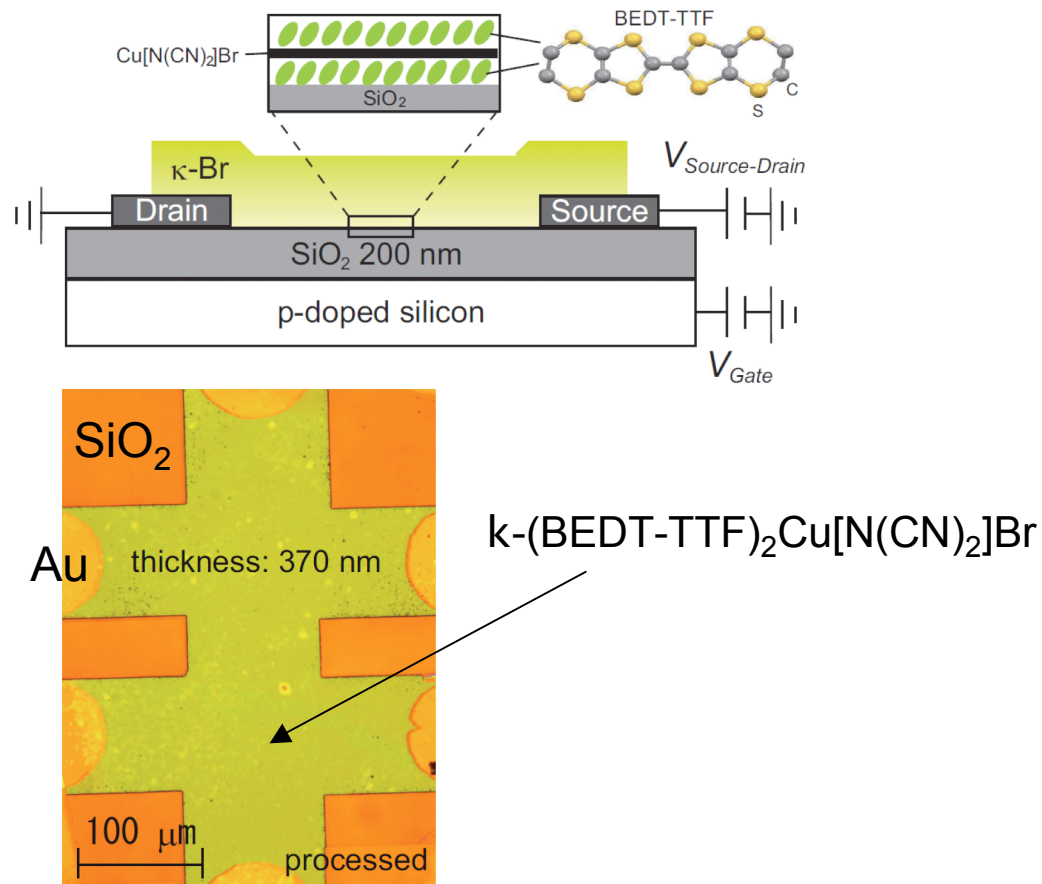
a=4.08, b=4.10, c=4.12, d=4.15 kbar



The valence bond solid phase neighbors the superconductor and metal phases

Field effect transistor (FET) behavior of π electrons in an organic Mott insulator

Organic Mott FET



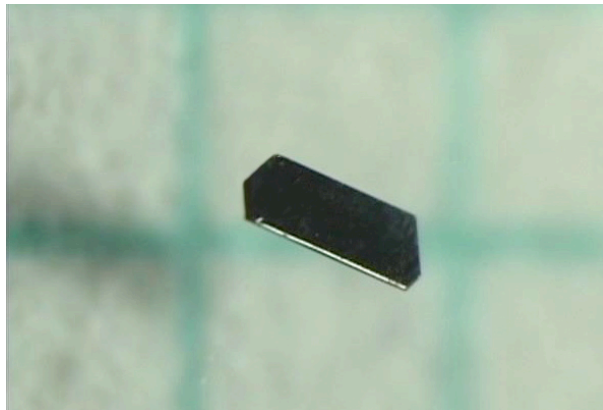
- n -type
- $\mu = 94 \text{ cm}^2 / \text{Vs}$
- On / Off ratio $> 10^7$



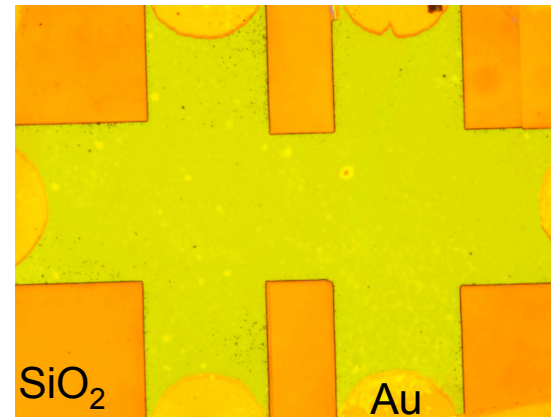
Expanding Possibilities of **IMSS** for Molecular Conductors

Reizo KATO (RIKEN)

“Advanced Tools” inspire “Advanced Sciences”.



p-frustration system
Bulk crystal



p-FET
Interface

In collaboration with

A. Tajima, Y. Kawasugi, M. Hosoda, N. Tajima, H. M. Yamamoto, K. Kubo, Y. Ishii, A. Nakao (KEK), A. Fukaya (IHI), T. Yamamoto (Osaka Univ.), Y. Shimizu (Nagoya Univ.), M. Tamura (Tokyo Univ. of Science), K. Tsukagoshi (AIST)