2021 美國真空協會台灣分會
AVS Taiwan Chapter

尖端新穎掃描探測技術
Advances in Scanned Probe Microscopy

January 27-29, 2021

地點 | 中原大學教學大樓109
Location | Room No. 109, Chen Chih Hall, Chung Yuan Christian University

主持人 | 邱雅萍教授 國立台灣大學
Chair | Prof. Ya-Ping Chiu, National Taiwan University

主辦單位：國立臺灣大學
協辦單位：中原大學
贊助單位：MOST 科技部 Ministry of Science and Technology 科技部
國立臺灣大學、中原大學

Sponsored by Ministry of Science and Technology

2021 Taiwan-AVS Chapter:
Advances in Scanned Probe Microscopy

27/January/2021 (Wed.)		28/January/2021 (Thu.)		29/January/2021 (Fri.)	
Time	**Events**	**Time**	**Events**	**Time**	**Events**
09:00		**Chair**	**Prof. Chien-Cheng Kuo**	**Chair**	**Prof. Ya-Ping Chiu**
10:00	Registration	**09:00**	B1) Prof. Han Woong Yeom	**09:00**	E1) Prof. Randall Feenstra
11:00	Lunch	**09:45**	B2) Prof. Tien-Ming Chuang	**09:45**	E2) Prof. Maki Kawai
12:30	TPS Opening Ceremony's Performance	10:15	Break	10:30	Break
12:50	Break	11:00	TPS Plenary Talk	11:00	TPS Plenary Talk Prof. Carl Wieman
13:00	TPS Opening Ceremony	12:00-13:30	Lunch	12:00-13:30	Lunch
14:00	Break	**Chair**	**Prof. Chun-Liang Lin**	**Chair**	**Prof. Chi Chen**
14:10	TPS Plenary Talk	**13:30**	C1) Prof. Emi Minamitani	**13:30**	F1) Prof. Yu-Jung Lu
15:00	Break	**14:15**	C2) Prof. Pin-Jui Hsu	**14:00**	F2) Prof. Chun-Liang Lin
15:10	TPS Plenary Talk Prof. Hans-Joachim Freund	14:45	Break	14:30	Break
16:10	Break	**Chair**	**Prof. Yu-Jung Lu**	**Chair**	**Prof. Wen-Chin Lin**
16:30	**Opening**: (President of AVS-Taiwan Chapter)	**15:30**	D1) Prof. Hidemi Shigekawa	**15:00**	G1) Prof. Hans-Joachim Freund
Chair	**Prof. Pin-Jui Hsu**	**16:20**	D2) Prof. Takashi Kumagai	15:45	Break
16:35	A1) Prof. Matthias Bode	**17:10**	D3) Prof. Chi Chen	16:10	2021 TPS Closing Ceremony & Awards
17:20	A2) Prof. Philipp Ebert	17:40	Break	17:40	Farewell
18:05	Break	18:30	Banquet		
18:10	Reception				

Invited speakers

A1) Prof. Matthias Bode (University of Würzburg, Germany)
"The surprising world of complex spin structures"

A2) Prof. Philipp Ebert (Peter Grünberg Institut, Forschungszentrum Jülich GmbH, Germany)
"Quantifying polarization changes at nitride semiconductor interfaces by scanning tunneling microscopy and off-axis electron holography"

B1) Prof. Han Woong Yeom (Institute for Basic Science / POSTECH, Korean)
"Surface physics of adsorbates on correlated van der Waals materials"

B2) Prof. Tien-Ming Chuang (Institute of Physics, Academia Sinica, Taiwan)
"Direct Visualization of Electronic Liquid Crystal Phase in Topological Semimetals"

C1) Prof. Emi Minamitani (Institute for Molecular Science, Japan)
"Ab-initio calculation of electron-phonon coupling in layered materials"

C2) Pin-Jui Hsu (National Tsing Hua University, Taiwan)
"Proximity-Effect-Induced Superconductivity in Monatomic Ni-Pb Alloy and Ni Nanoislands"

D1) Prof. Hidemi Shigekawa (Pure and Applied Sciences, University of Tsukuba, Japan)
"Time-resolved scanning tunneling microscopy and its applications"

D2) Prof. Takashi Kumagai (Fritz-Haber Institute, Germany / Institute for Molecular Science, Japan)
"Towards Atomic-Scale Optical Spectroscopy"

D3) Prof. Chi Chen (Research Center for Applied Sciences, Academia Sinica, Taiwan)
"Near-Field Optics: from the viewpoint of scanning probe microscopy "

E1) Prof. Randall Feenstra (Department of Physics, Carnegie Mellon University, USA)
"Studies of Two-dimensional Materials using Tunneling Electrons"

E2) Prof. Maki Kawai (Institute for Molecular Science, Japan)
"Characteristic Feature of Reaction at Surfaces Probed by STM)"

F1) Prof. Yu-Jung Lu (Research Center of Applied Sciences, Academia Sinica, Taiwan / Applied Physics, National Taiwan University, Taiwan)
"Perovskite-based Plasmonic Nanolasers"

F2) Prof. Chun-Liang Lin (Department of Electrophysics, National Chiao Tung University, Taiwan)
"Scanning Tunneling Microscopy Studies of 2D Materials and Devices"

G1) Prof. Hans-Joachim Freund (Fritz Haber Institute of the Max Planck Society, Germany)
"From Crystals to Glasses in Real Space at the Atomic Level"

Name:	Matthias Bode
Position:	Professor
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Research areas (specialty) and Keywords:

(spin-polarized) scanning tunneling microscopy, nanomagnetism, topological materials, superconductivity, charge transport

REPRESENTATIVE WORKS:

[1] A. Odobesko, F. Friedrich, S.-B. Zhang, S. Haldar, S. Heinze, B. Trauzettel, and M. Bode: Anisotropic vortices on superconducting Nb(110), Phys. Rev. B 102, 174502 (2020)

[2] M. Schmitt, P. Moras, G. Bihlmayer, R. Cotsakis, M. Vogt, J. Kemmer, A. Belabbes, P.M. Sheverdyaeva, A.K. Kundu, C. Carbone, S. Blügel, and M. Bode: Indirect Chiral Magnetic Exchange through Dzyaloshinskii-Moriya–Enhanced RKKY Interactions in Manganese Oxide Chains on Ir(100), Nature Comm. 10, 2610 (2019)

[3] A. Krönlein, M. Schmitt, M. Hoffmann, J. Kemmer, N. Seubert, M. Vogt, J. Küspert, M. Böhme, B. Alonazi, J. Kügel, H.A. Albrithen, M. Bode, G. Bihlmayer, and S. Blügel: Magnetic Ground State Stabilized by Three-Site Interactions: Fe/Rh(111), Phys. Rev. Lett. 120, 207202 (2018)

[4] M. Leisegang, L. Klein, J. Kügel, and M. Bode: Analyzing the Wave Nature of Hot Electrons with a Molecular Nanoprobe, Nano Lett. 18, 2165 (2018)

[5] P. Sessi, D. Di Sante, A, Szczerbakow, F. Glott, S. Wilfert, H. Schmidt, T. Bathon, P. Dziawa, M. Greiter, T. Neupert, G. Sangiovanni, T. Story, R. Thomale, and M. Bode: Robust spin-polarized midgap states at step edges of topological crystalline insulators, Science 354, 1269 (2016)

[6] P.-J. Hsu, J. Kügel, J. Kemmer, F. Parisen Toldin, T. Mauerer, M. Vogt, F. Assaad, and M. Bode: Coexistence of charge and ferromagnetic order in fcc Fe, Nature Comm. 7, 10949 (2016)

The surprising world of complex spin structures

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The term "magnetism" subsumes a plethora of interactions originating from various physical mechanisms. Their competition often results in highly complex spin structures, such that the specific origin is masked and can only be unraveled by combining experiment and theory. Particularly illustrative examples can be found are among transition metal oxide chains on Ir and Pt(001) [1,2]. MnO_2 on Ir(001) exhibits an antiferromagnetic Mn–Mn coupling along the chain, whereas the inter-chain coupling across the non-magnetic Ir substrate is chiral with a 120° rotation between adjacent chains. Theory suggests that the inter-chain coupling is driven by a Dzyaloshinskii-Moriya-enhanced version of the well-known Ruderman-Kittel-Kasuya-Yosida (RKKY) interaction [1]. Similar to the conventional RKKY interaction this coupling proceeds via conduction electrons of the substrate but leads to a chiral coupling, qualitatively different from the collinear cases known so far.

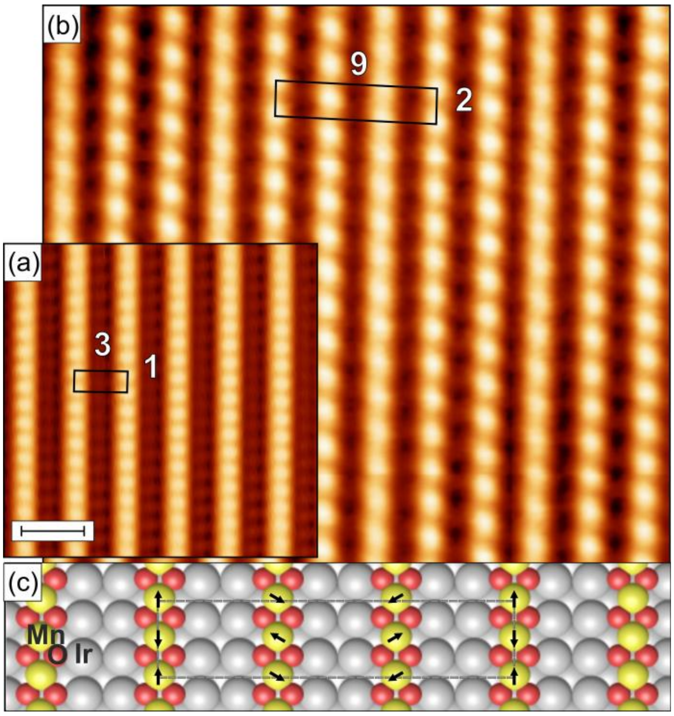

Figure: Atomic resolution scans of MnO_2 chains on Ir(001). (a) A (3 × 1) structural unit cell is observed with a non-magnetic W tip (scale bar: 1 nm). (b) With a Cr-coated W tip the magnetic (9 × 2) unit cell is resolved. (c) Schematic model of the chiral (9 × 2) spin structure of MnO_2/Ir(001).

Reference:

[1] M. Schmitt *et al.*, Nature Comm. **10**, 2610 (2019)
[2] M. Schmitt *et al.*, Phys. Rev. B **100**, 054431 (2019)

Name:	Philipp Ebert
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Affiliation:	Peter Grünberg Institut, Forschungszentrum Jülich GmbH, Germany
Email:	p.ebert@fz-juelich.de

Research areas (specialty) and Keywords:

cross-sectional scanning tunneling microscopy, electron holography, defect and interface science, nanoscience

HONORS AND AWARDS:

1997 Prize of Physics of the Academy of Sciences at Göttingen
1993 Feodor-Lynen-Research Stipend of the Alexander von Humboldt-Stiftung

REPRESENTATIVE WORKS:

[1] Y. Wang, M. Schnedler, Q. Lan, F. Zheng, L. Freter, Y. Lu, U. Breuer, H. Eisele, J.-F. Carlin, R. Butté, N. Grandjean, R. E. Dunin-Borkowski, and Ph. Ebert, "Interplay of anomalous strain relaxation and minimization of polarization changes at nitride semiconductor heterointerfaces", Phys. Rev. B, in press (2020).

[2] Hung-Chang Hsu, Bo-Chao Huang, Shu-Cheng Chin, Cheng-Rong Hsing, Duc-Long Nguyen, Michael Schnedler, Raman Sankar, Rafal E. Dunin-Borkowski, Ching-Ming Wei, Chun-Wei Chen, Philipp Ebert, and Ya-Ping Chiu, "Photo-Driven Dipole Reordering: Key to Carrier Separation in High Efficiency Halide Perovskite Solar Cells", ACS Nano **13**, 4402 (2019).

[3] M. Schnedler, T. Xu, I. Lefebvre, J.-P. Nys, S. R. Plissard, M. Berthe, H. Eisele, R. E. Dunin-Borkowski, Ph. Ebert, and B. Grandidier "Iuliacumite: A Novel Chemical Short-Range Order in a Two-Dimensional Wurtzite Single Monolayer $InAs_{1-x}Sb_x$ Shell on InAs Nanowires", Nano Lett. **19**, 8801 (2019).

[4] Bo-Chao Huang, Pu Yu, Y. H. Chu, Chia-Seng Chang, Ramamoorthy Ramesh, Rafal E. Dunin-Borkowski, Philipp Ebert, and Ya-Ping Chiu. "Atomically Resolved Electronic States and Correlated Magnetic Order at Termination Engineered Complex Oxide Heterointerfaces", ACS Nano **12**, 1089 (2018).

[5] L. Lymperakis, P. H. Weidlich, H. Eisele, M. Schnedler, J.-P. Nys, B. Grandidier, D. Stiévenar4, R. E. Dunin-Borkowski, J. Neugebauer, and Ph. Ebert, "Hidden surface states at non-polar GaN (10-10) facets: Intrinsic pinning of nanowires", Appl. Phys. Lett. **103**, 152101 (2013).

Quantifying polarization changes at nitride semiconductor interfaces by scanning tunneling microscopy and off-axis electron holography

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Group III nitride semiconductors became the material system of choice for solid-state lighting and high-power semiconductor devices. Functioning of such devices is highly dependent on doping and/or heterointerfaces. However, such interfaces may introduce localized electronic states, band offsets, and polarization changes. Particularly polarization changes, giving rise to 2D charge sheets, are partly desired (e.g., in high electron mobility transistors), but partly, they have the potential to affect, e.g., quantum wells and device performance adversely by spatial carrier separation. Therefore, the question is how to probe with atomic resolution the electronic properties at interfaces, in particular polarization and electron affinity changes.

Thus far, the only microscopic access to electronic states at interfaces has been achieved by cross-sectional scanning tunneling microscopy (STM) and spectroscopy (STS) or by off-axis electron holography (EH) in transmission electron microscopy (TEM). Both methods are, however, insufficient for a comprehensive physical understanding of nitride interfaces. On the one hand, the interpretation of tunneling spectra is surprisingly complex in the case of nitride semiconductor cleavage surfaces, as no band gaps can be measured and the empty surface state pins the Fermi level. Hence, quantifying potential fluctuations in wurtzite nitride semiconductors has not been achieved thus far, in contrast to zincblende III-V semiconductors. On the other hand, off-axis electron holography in TEM provides direct access to the local electrostatic potential integrated along the electron beam direction. However, the measured potential is severely altered by the presence of a preparation damaged so-called dead layer near the surfaces of the thin electron transparent lamellae. As a result, none of these methods taken alone provides the complete picture of electronic properties at ternary III-N interfaces.

Therefore, we developed a methodology to quantify polarization and electron affinity changes at interfaces by combining STS, off-axis EH, and self-consistent calculations of the electrostatic potential and electron phase change. We use a precisely known grown-in doping structure to calibrate the surface potential of the TEM lamella and thereby achieve a quantitative analysis of electron phase changes measured by off-axis EH. Using this calibration, we deduce quantitatively polarization and electron affinity changes for $Al_{0.06}Ga_{0.94}N$/GaN and $In_{0.05}Ga_{0.95}N/Al_{0.06}Ga_{0.94}N$ interfaces and discuss the interplay of strain relaxation and polarization changes.

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Research areas (specialty) and Keywords:

scanning tunneling microscopy, photoelectron spectroscopy, low-dimensional electronic structure

HONORS AND AWARDS:

2020 Fellow, Korean Academy of Science and Technology (2020)
2017 Fellow, Americal Physical Society (2017)
2017 Kyung-Am Award for Natural Science, Kyung-Am Foundation
2015 30th Inchon Prize for Science and Technology, Inchon Memorial Foundation and Dong-Ah Daily news paper
2015 Korea Science Award, President of Korea
2006 Scientist and Engineer of the Month, Ministry of Science and Technology of Korea
1999 Young Researcher of the Year, Japanese Society for Synchrotron Radiation Research

REPRESENTATIVE WORKS:

[1] Switching chiral solitions for algebraic operartion of topological quaternary digits, Tae-Hwan Kim, Sangmo Cheon, and Han Woong Yeom, Nature Physics 13, 444 (2017).

[2] Chiral solitons in a coupled double Peierls chain, Sangmo Cheon, Tae-Hwan Kim, Sung-Hoon Lee, and Han Woong Yeom, Science 350, 182 (2015).

[3] Self-Assembled Nanowires with Giant Rashba Split Bands, Jewook Park, Sung Won Jung, Min-Cherl Jung, Hiroyuki Yamane, Nobuhiro Kosugi, and Han Woong Yeom, Phys. Rev. Lett. 110, 036801 (2013).

[4] Coexistence of two different Peierls transitions within an atomic scale wire; Si(553)-Au, Phys. Rev. Lett. 95, 196405 (2005).

[5] Instability and charge density wave of metallic quantum chains on a silicon surface, Phys. Rev. Lett. 82, 4898 (1999).

Surface physics of adsorbates on correlated van der Waals materials

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In this talk, I will discuss the opportunity in studying surface properties of van der Waals two dimensional systems. I will focus on my own recent works for simple metal adsorbates on three transition metal dichalcogenides (TMDC). In particular, these three TMDC systems, TaS_2, $IrTe_2$, and Ta_2NiSe_5, are selected as substrates due to the presence of substantial manybody interactions such as Coulomb interaction, electron phonon interaction, and exciton-phonon interaction, which provide extraordinarily rich phase landscapes to be coupled interestingly with adsorbates. For example, on the excitonic insulator phase of Ta_2NiSe_5 we discovered that alkali metal adsorbates can locally and globally control the excitonic band gap [1]. On 1T-TaS_2, the same alkali metal adsorbates can kill the Mott gap completely and the ordered superstructure of them can induce a new correlated phase [2]. In the case of a correlated charge order phase of $IrTe_2$, we used the charge order superstructure to confine Pb adsorbates, which lead to the formation of artificial molecular structures in a strongly spin-orbit coupled regime. We call these as artificial relativistic molecules. These examples, I believe, are enough to show the great potential of surface physics in TMDC materials, which is a largely unexplored open field. At the end of the talk, I will briefly describe the new ultra-low temperature STM, which is in its final stage of construction with the aim to reach the lowest temperature with a fully UHV STM.

Reference:

[1] Electrical tuning of the excitonic insulator ground state of Ta_2NiSe_5, K. Fukutani, R. Staina, J. Jung, E. F. Schwier, K. Shimada, C. I. Kwon, J. S. Kim, and H. W. Yeom, *Phys. Rev. Lett.* **123**, 206401 (2019).

[2] Honeycomb-lattice Mott insulator on tantalium disulphide, J. Lee, K.-H. Jin, A. Cantuneanu, J. Jung, C. Won, S-W. Chung, J. Kim, F. Liu, H.-Y. Kee, and H. W. Yeom, *Phys. Rev. Lett.* **123**, 206401 (2020).

[3] Artificial relativistic molecules, J. W. Park, H. S. Kim, T. Brumme, T. Heine, and H. W. Yeom, *Nature Communications* **11**, 815 (2020).

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Position:	Associate Research Fellow
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Research areas (specialty) and Keywords:

Strongly correlated electronic systems, topological materials, scanning probe microscopy

HONORS AND AWARDS:

2017 Ta-You Wu Memorial Award, Ministry of Science and Technology, Taiwan
2012 Golden Jade Fellowship, Kenda Foundation, Taiwan

REPRESENTATIVE WORKS:

[1] Po-Hsun Wu, Ying-Ting Chan, Tzu-Chao Hung, Yi-Hui Zhang, Danru Qu, Tien-Ming Chuang, C. L. Chien, and Ssu-Yen Huang, "Effect of demagnetization factors on spin current transport", Phys. Rev. B 102, 174426 (2020).

[2] Hyoungdo Nam, Hua Chen, Philip W. Adams, Syu-You Guan, Tien-Ming Chuang , Chia-Seng Chang, Allan H. MacDonald and Chih-Kang Shih, "Geometric Quenching of Orbital Pair Breaking in a Single Crystalline Superconducting Nanomesh Network", Nature Communications 9, 5431 (2018).

[3] Chih-Chuan Su, Chi-Sheng Li, Tzu-Cheng Wang, Syu-You Guan, Raman Sankar, Fangcheng Chou, Chia-Seng Chang, Wei-Li Lee, Guang-Yu Guo, Tien-Ming Chuang, "Surface Termination Dependent Quasiparticle Scattering Interference and Magneto-transport Study on ZrSiS", New Journal of Physics 20, 103025 (2018).

[4] Syu-You Guan, Peng-Jen Chen, Ming-Wen Chu, Raman Sankar, Fangcheng Chou, Horng-Tay Jeng, Chia-Seng Chang, Tien-Ming Chuang, "Superconducting Topological Surface States in Non-centrosymmetric Bulk Superconductor $PbTaSe_2$ ", Science Advances 2, e1600894 (2016).

[5] Milan P. Allan, Kyungmin Lee, Andreas W. Rost, Mark H. Fischer, Freek Massee, Kunihiro Kihou, Chul-Ho Lee, Akira Iyo, Hiroshi Eisaki, Tien-Ming Chuang, J.C. Davis, Eun-Ah Kim, "Identifying the `Fingerprint' of Antiferromagnetic Spin-Fluctuations on Iron-Pnictide Superconductivity", Nature Physics 11, 177 (2015).

Direct Visualization of Electronic Liquid Crystal Phase in Topological Semimetals

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Strongly correlated electron systems, in which various order parameters compete or intertwine with each other, exhibit rich quantum states of matter. Electronic liquid crystal phases, which break the underlying crystalline symmetry, can form in the strongly correlated electron systems and play a crucial role in high Tc superconductors and quantum Hall states. Topological materials, which host symmetry protected Dirac or Weyl fermions with highly linear dispersion, are mostly weakly correlated. Therefore, the observation of such symmetry breaking electronic phases in topological materials is rare. Here, we report the direct visualization of electronic smectic and nematic phases in topological semimetals by using scanning tunneling microscopy. Quasiparticle scattering interference imaging reveals characteristic q-vectors from linearly dispersive Dirac bands. We further show the impact on the electronic liquid crystal phases and the dispersion of q-vectors when the system undergoes a tetragonal to orthorhombic transition upon chemical doping. Our results demonstrate such topological semimetals provide a fertile playground to study novel phenomena of correlated Dirac electrons.

Name:	Emi Minamitani
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Research areas (specialty) and Keywords:

condensed matter physics, surface science, quantum many-body theory

HONORS AND AWARDS:

2020 The 1st Award for Early Career Women Scientists of the Japan Society of Vacuum and Surface Science

2019 The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology The Young Scientists' Prize

2017 Young Scientist Award of the Physical Society of Japan

2008 L'Oréal–UNESCO Japan National Fellowships for Women in Science

REPRESENTATIVE WORKS:

[1] Emi Minamitani, Masayoshi Ogura, Satoshi Watanabe, "Simulating lattice thermal conductivity in semiconducting materials using high-dimensional neural network potential" Appl. Phys. Express, 12, 095001 (2019)

[2] Emi Minamitani, Ryuichi Arafune, Thomas Frederiksen, Tetsuya Suzuki, Syed Mohammad Fakruddin Shahed, Tomohiro Kobayashi, Norifumi Endo, Hirokazu Fukidome, Satoshi Watanabe, Tadahiro Komeda "Atomic-scale characterization of the interfacial phonon in graphene/SiC", Phys. Rev. B, 96, 155431 (2017)

[3] N. H. Shimada, E. Minamitani, S. Watanabe "Theoretical prediction of phonon-mediated superconductivity with Tc ≈25 K in Li-intercalated h-BN bilayer", Appl. Phys. Express. 10, 093101, (2017)

[4] R. Hiraoka, E. Minamitani, R. Arafune, N. Tsukahara, S. Watanabe, M. Kawai, and N. Takagi, "Single-Molecule Quantum Dot as a Kondo Simulator", Nat. Commun., 8, 16012 (2017)

[5] Emi Minamitani, Ryuichi Arafune, Noriyuki Tsukahara, Yoshitaka Ohda, Satoshi Watanabe, Maki Kawai, Hiromu Ueba, Noriaki Takagi, "Surface phonon excitation on clean metal surfaces in scanning tunneling microscopy", Phys. Rev. B, 93, 085411 (2016)

[6] Emi Minamitani, Noriyuki Tsukahara, Daisuke Matsunaka, Yousoo Kim, Noriaki Takagi, Maki Kawai, "Symmetry-driven novel Kondo effect in a molecule", Phys. Rev. Lett., 109, 086602 (2012)

Ab-initio calculation of electron-phonon coupling in layered materials

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Layered materials have attracted attention as a new class of materials. Finding a new superconducting layered material is one of the important topics, where precise ab-initio calculations on the electron-phonon coupling have played an important role. Here, we focus on the possibility of superconductivity in chemically doped layered insulators/semiconductors.

We will introduce our prediction on the superconducting transition temperature (T_c) up to 25 K in the Li-intercalated bilayer of hexagonal boron nitride (h-BN). Such a T_c higher than that of metal-intercalated graphene (MIG) can be ascribed to the characteristic spatial distribution of electronic states near the Fermi level in the Li-intercalated h-BN: the stronger overlap between the charge density and Li in-plane motion than those in MIG enhance electron-phonon coupling [1]. Even in the monolayer h-BN, superconductivity can be realized by doping with alkaline-earth metals [2]. Furthermore, we found that, in the Ca-doped case, T_c can be increased up to 12.8 K under tensile strain. We will also introduce our latest investigation for the strain effect on the superconductivity in doped MoS_2 systems [3]. These results indicate that the combination of chemical doping and strain engineering is promising to increase T_c in layered materials.

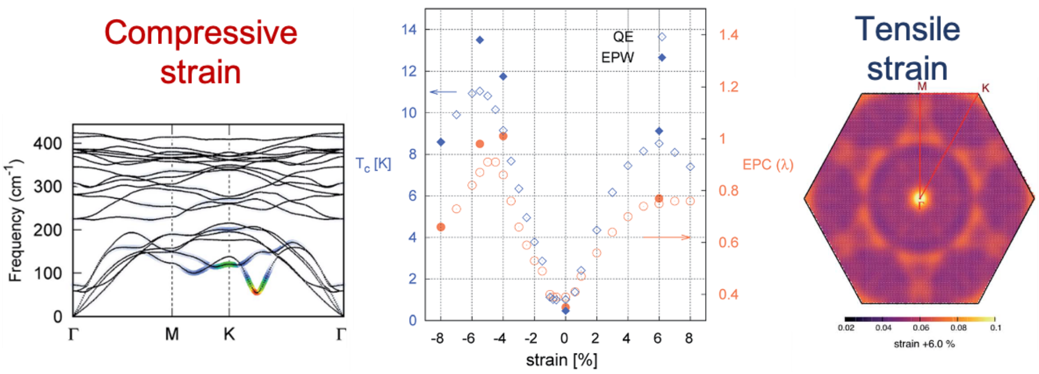

Figure: Calculation results in Li-intercalated bilayer MoS_2 **(Left)** electron-phonon interaction projected on phonon band structure under 5.5% compressive strain **(Middle)** T_c as a function of strain **(Right)** nesting function under 6% tensile strain.

Reference:

[1] N. H. Shimada, E. Minamitani, S. Watanabe, Appl. Phys. Express 10, 093101 (2017).

[2] N. H. Shimada, E. Minamitani, S. Watanabe, J. Phys.: Condens. Matter. 32, 435002 (2020).

[3] Poobodin Mano, E. Minamitani, S. Watanabe, Nanoscale Adv. 2, 3150 (2020).

Name:	Pin-Jui Hsu
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Research areas (specialty) and Keywords:

spin-polarized scanning tunneling microscopy, surface magnetism and spintronics, low-dimensional topological materials

HONORS AND AWARDS:

2019 Columbus Young Scholar Fellowship (2019), Ministry of Science and Technology (MOST)
2017 Actively Recruit Overseas Outstanding Junior Scholar Award (2017), Foundation for the Advancement of Outstanding Scholarship
2015 Fellowship of Wissenschaften, Entwicklung und Kultur Helmut und Hannelore Greve (2015), Hamburg Research Academy Society

REPRESENTATIVE WORKS:

[1] G. Y. Chen, A. Huang, Y. H. Lin, C. J. Chen, D. S. Lin, P. Y. Chang, H. T. Jeng*, G. Bihlmayer and P.-J. Hsu*, "Orbital-enhanced warping effect in Px,Py-derived Rashba spin splitting of monatomic bismuth surface alloy", npj Quant. Mat., 5, 89 (2020).

[2] J. Kügel, P.-J. Hsu, M. Böhme, K. Schneider, J. Senkpiel, D. Serrate, M. Bode, and N. Lorente, "Jahn-Teller splitting in single adsorbed molecules revealed by isospin-flip excitations", Phys. Rev. Lett., 121, 226402 (2018).

[3] P. J. Hsu*, R. Levente*, A. Finco, L. Schmidt, K. Palotás, E. Vedmedenko, L. Udvardi, L. Szunyogh, A. Kubetzka, K. von Bergmann, and R. Wiesendanger, "Inducing skyrmions in ultrathin Fe films by hydrogen exposure", Nat. Commun., 9, 1571 (2018).

[4] P. J. Hsu, A. Kubetzka, A. Finco, N. Romming, K. von Bergmann, and R. Wiesendanger, "Electric field driven switching of individual magnetic skyrmions ", Nat. Nanotech., 12, 123 (2017).

[5] P. J. Hsu*, J. Kügel, J. Kemmer, F. P. Toldin, T. Mauerer, M. Vogt, F. Assaad, and M. Bode, "Coexistence of charge and ferromagnetic order in fcc Fe", Nat. Commun., 7, 10949 (2016).

Proximity-Effect-Induced Superconductivity in Monatomic Ni-Pb Alloy and Ni Nanoislands

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Proximity effect facilitates the penetration of Cooper pairs that permits superconductivity in normal metal with reduced dimensionality, offering a promising approach to develop novel quantum phenomena and emergent phases of matter in hybrid magnetic/superconducting nanostructures. Here, we have investigated proximity-induced superconductivity in monatomic Ni-Pb alloy and Ni nanoislands grown on Pb(111) by scanning tunneling microscopy/ spectroscopy (STM/STS) combined with theoretical calculations. Through elemental Pb superconducting substrate, tunneling conductance spectra have resolved an induced superconductivity with a gap size Δ about 0.85 meV in Ni-Pb alloy, which is about 0.11 meV smaller than Pb(111). On the contrary, Ni nanoislands with honeycomb lattice display a superconductivity gap with the same size of the Pb(111) substrate. From spatially monotonic decrease of Δ across the interface between Ni-Pb alloy and Pb(111), the decay length ξ_L about 5 nm has been extracted. According to the Usadel fittings and the BdG model, a weak ferromagnetism with an effective temperature about 6 ~ 15 K explains such rather short decay length as well as reduced superconductivity gap in the Ni-Pb surface alloy. As for honeycomb-structured Ni nanoislands, asymmetric edge scattering of surface electrons on Pb(111) has been revealed and further theoretical insights on the details of strong suppression of backscattering at the bearded type of edges are currently in progress.

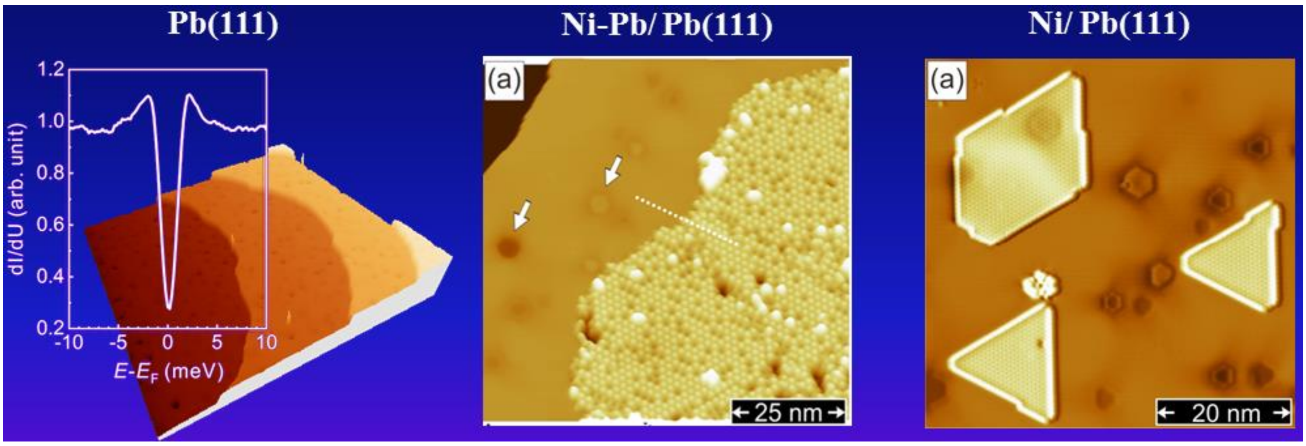

Figure: Superconducting gap measured at the pristine Pb(111) substrate **(Left).** STM topography of monatomic Ni-Pb surface alloy on Pb(111) by means of high temperature growth **(Middle).** In contrast, honeycomb-structured Ni nanoislands can be fabricated on Pb(111) by low temperature deposition **(Right).**

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Research areas (specialty) and Keywords:

scanning probe microscopy, nano science, ultrashort pulse laser technology, time-resolved analysis

Biography

He obtained Ph. D from the University of Tokyo. When he was an assistant professor of the Department of Applied Physics at the University of Tokyo, he worked as a visiting researcher at the Bell Labs beamline of National Synchrotron Light Source (NSLS) in the Brookhaven National Laboratory (NY, USA). After returning to Japan, he started working with scanning probe microscopy (SPM). He has been interested in nanoscale science and has been developing new microscopy techniques by combining SPM with quantum optics technologies. He received the Medal with Purple Ribbon for his works in 2019. He is now the President of the Japan Society of Vacuum and Surface Science.

REPRESENTATIVE WORKS:

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[5] K. Yoshioka et al., “Real-space coherent manipulation of electrons in a single tunnel junction by single-cycle terahertz electric fields”, Nature Photonics 10, 762-765 (2016).

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Time-resolved scanning tunneling microscopy and its applications

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With size reduction, the differences in the electronic properties of materials and devices, for example, those caused by the structural nonuniformity in each element, have an ever-increasing effect on macroscopic functions. For further advances in nanoscale science and technology, developing a method for exploring the transient dynamics of local quantum functions in organized small structures is essential. Since the invention of scanning tunneling microscopy (STM), the addition of high time-resolution to STM has been one of the most challenging issues [1]. One of the successful approaches is combing STM with optical pump-probe (OPP) techniques [2-6]. Some cycles are included in ordinary laser pulses, whose phase is called the carrier-envelope phase (CEP). The CEP is random and fluctuates in pulses, which is why the pulse width limits the time resolution. Recently, new laser technologies have become applicable, where the CEP is the same and locked in all pulses. Furthermore, the CEP can be controlled. Based on such technologies, a new microscopy technique, THz-STM, has been developed [7-11]. The tip-enhanced THz monocycle pulses have enabled taking a snapshot of ultrafast dynamics. When CEP-controlled pulses with a single electric field are used for pump and probe pulses, dynamics controlled by the electric field in a CEP-controlled pump-pulse can be examined by a CEP-controlled probe pulse with sub-cycle time resolution [12].

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[3] S. Yoshida et al., Nature Nanotechnology, **9**, 588-593 (2014).
[4] H. Shigekawa et al., Nature Photonics, **8**, 815-817 (2014).
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[10] K. Yoshida, et al., ACS Photonics, **6**, 1356-1364 (2019).
[11] C. Guo et al., Phys. Rev. Lett., 124, 206801 (2020).
[12] K. Yoshioka et al., Optics Letters 44, 21, 5350-5353 (2019).

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Research areas (specialty) and Keywords:

Physical Chemistry, Surface Science, Scanning Probe Microscopy, Nanospectroscopy

HONORS AND AWARDS:

2013 Inoue Research Award for Young Scientists

2014 Morino Award for Molecular Science

2016 Gerhard Ertl Young Investigator Award

2020 Gaede Prize

2020 Young Scientists' Prize for the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology

2020 Heinrich Rohrer Medal

REPRESENTATIVE WORKS:

1. S. Liu, B. Cirera, M. Müller, Y. Sun, I. Hamada, A. Hammud, M. Wolf, and T. Kumagai, Dramatic Enhancement of Tip-Enhanced Raman Scattering Mediated by Atomic Point Contact Formation. *Nano Lett*. **20**, 5879-5884 (2020).

2. S. Liu, M. Müller, Y. Sun, I. Hamada, A. Hammud, M. Wolf, T. Kumagai, Resolving the Correlation between Tip-Enhanced Resonance Raman Scattering and Local Electronic States with 1 nm Resolution. *Nano Lett.* **19**, 5725–5731 (2019).

3. H. Böckmann, S. Liu, M. Müller, A. Hammud, M. Wolf, T. Kumagai, Near-Field Manipulation in a Scanning Tunneling Microscope Junction with Plasmonic Fabry-Pérot Tips. *Nano Lett.* **19**, 3597–3602 (2019).

4. H. Böckmann, S. Gawinkowski, J. Waluk, M.B. Raschke, M. Wolf, T. Kumagai, Near-Field Enhanced Photochemistry of Single Molecules in a Scanning Tunneling Microscope Junction. *Nano Lett.* **18**, 152–157 (2018).

5. S. Liu, M. Wolf, T. Kumagai, Plasmon-Assisted Resonant Electron Tunneling in a Scanning Tunneling Microscope Junction. *Phys. Rev. Lett.* **121**, 226802 (2018).

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Ag(110) Surface. *J. Am. Chem. Soc.* **139**, 12681–12687 (2017).

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10. T. Kumagai, A. Shiotari, H. Okuyama, S. Hatta, T. Aruga, I. Hamada, T. Frederiksen, H. Ueba, Hydrogen relay reactions in real space. *Nature Materials* **11**, 167–172 (2012).

Towards Atomic-Scale Optical Spectroscopy

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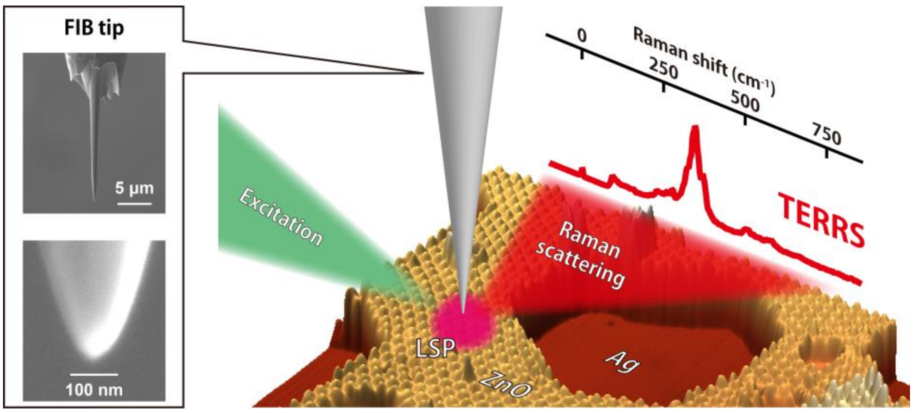
In order to understand complex processes on material surfaces like heterogeneous catalysis, it is necessary to obtain detailed chemical information about the composition and structure of surfaces. Optical spectroscopy can provide rich information on chemical structures/dynamics and is used to characterize various substances in a broad range of scientific areas from physics, chemistry, biology, to medical science. However, the spatial resolution is limited to be hundreds nm in the visible range by the diffraction limit. Scanning near-field optical microscopy has overcome this limit, but the spatial resolution has remained typically the range of a few tens of nm and atomic-scale optical spectroscopy is a great challenge. We have developed a low-temperature scanning probe microscopy for local optical excitation and detection, aiming at performing optical spectroscopy at the atomic scale. I will discuss our recent researches toward atomic-scale optical spectroscopy in plasmonic junctions, including precise control of cavity-mode plasmons and ultrahigh resolution tip-enhanced resonance Raman spectroscopy [1-3].



Resolving the Correlation between Tip-Enhanced Resonance Raman Scattering and Local Electronic States of ultrathin zinc oxide films with 1 nm Resolution [2].

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Research areas (specialty) and Keywords:

Scanning Near-field optical microscopy (SNOM), Tip-enhanced Raman spectroscopy (TERS), AFM/STM instrumentation, Spectroscopy of single molecules and nanomaterials

REPRESENTATIVE WORKS:

[1] J.-R. Yu, H.-C. Chou, C.-W. Yang, W.-S. Liao, I.-S. Hwang and Chi. Chen, A horizontal-type scanning near-field optical microscope with torsional mode operation toward high-resolution and non-destructive imaging of soft materials. *Rev. Sci. Instrum.* 91, 073703(2020).

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Near Field Optics: from The Viewpoint of Scanning Probe Microscopy

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Scanning near-field optical microscopy (SNOM) or near-field scanning optical microscopy (NSOM) is a branch of optical imaging techniques, which combines optics with scanning probe microscopy (SPM) to achieve sub-diffraction limit optical resolution. Various ways of combing a STM or an AFM with optical access will be briefly introduced. Artefacts, problems, and challenges in near-field optics will also be discussed.

Based on the speaker's experiences, three kinds of SNOM techniques will be presented and compared in the talk: 1. STM-electroluminescence (STM-EL) in LHe temperature and UHV environment. 2. STM based tip-enhanced Raman (STM-TERS) in the ambient. 3. AFM based aperture SNOM (AFM-*a*SNOM) in various environments. We will focus mostly on our recent efforts in developing AFM-*a*SNOM in liquids and inside the glove box for soft materials imaging. Different interchain couplings of polymer nanowires and fluorescence domains in lipid bilayers are successfully visualized by our new setups.

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scanning tunneling microscopy and spectroscopy, 2-dimensional materials, semiconductors

HONORS AND AWARDS:

2018 Davisson-Germer Prize of the American Physical Society
2000 Alexander von Humboldt Foundation Research Award
1998 Fellow of the American Physical Society
1994 Fellow of the American Vacuum Society
1989 Peter Mark Memorial Award of the American Vacuum Society

REPRESENTATIVE WORKS:

[1] Coexistence of quantum spin Hall edge state and proximity-induced superconducting gap in monolayer 1T'-WTe_2, Felix Lüpke, Dacen Waters, Sergio C. de la Barrera, Michael Widom, David G. Mandrus, Jiaqiang Yan, Randall M. Feenstra, Benjamin M. Hunt, Nature Physics **16**, 526 (2020). DOI: 10.1038/s41567-020-0816-x

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[3] Substitutional mechanism for growth of hexagonal boron nitride on epitaxial graphene, P. C. Mende, J. Li, and R. M. Feenstra, Appl. Phys. Lett. **113**, 031605 (2018). DOI: 10.1063/1.5039823

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[5] Magnitude of the Current in Two-Dimensional Interlayer Tunneling Devices, R. M. Feenstra, S. de la Barrera, J. Li, Y. Nie, and K. Cho, J. Phys.: Condens. Matter **30**, 055703 (2018). DOI: 10.1088/1361-648X/aaa4b0

Studies of Two-dimensional Materials using Tunneling Electrons*

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Over the past decade, much research world-wide has focused on two-dimensional (2D) materials, in which the electrons are localized within a single atomic plane. Obtaining μm-size flakes of 2D material by "exfoliating" (peeling apart) layers using adhesive tape has been a standard practice for many decades, but only relatively recently has this method been applied to produce small, microfabricated electronic devices on the flakes (Geim and Novoselov, Nobel Prize 2010). However, for practical electronics of the future, such devices must be produced on grown (deposited), large-area 2D layers, rather than on flakes. In this talk, studies of the structure of grown 2D layers will be described, focusing on heterobilayers of MoS_2 on WSe_2. The method of scanning tunneling microscopy is used to obtain detailed, atomic-scale views of the structure of the layers. Additionally, through spectroscopic measurements with the tunneling microscope, band gaps of the materials and band offsets between neighboring layers are determined. We find, in particular, the occurrence of localized electron states associated with the moiré pattern that forms when one layer of a 2D material (MoS_2) is placed on another layer (WSe_2) with different lattice constant. The significance of such states and their potential impact on device properties are discussed.

*Work performed in collaboration with D. Waters, F. Lüpke, Y. Pan, S. Fölsch, G. Frazier, Y. Nie, Y.-C. Lin, B. Jariwala, K. Zhang, K. Cho, and J. A. Robinson

Reference:

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Research areas (specialty) and Keywords:

scanning tunneling microscopy, single molecule spectroscopy, surface science, nanoscience

HONORS AND AWARDS:

2020 Japan Academy Prize
2019 Honorary Fellow, Royal Society of Chemistry.
2019 L'Oreal-UNESCO Women in Science
2017 Medal with Purple Ribbon, Japan
2017 Humboldt Research Award
2016 AVS Medard W. Welch Award
2015 Gerhard Ertl Lecture award, Fritz-Haber Institute der Max Plank Society
2015 The IUPAC 2015 Distinguished Women in Chemistry / Chemical Engineering
2010 American Physical Society (APS) Fellow

REPRESENTATIVE WORKS:

[1] R. Hiraoka, E. Minamitani, R. Arafune, N. Tsukahara, S. Watanabe, M. Kawai, N. Takagi, "Single-molecule quantum dot as a Kondo simulator", ***Nature commun.*** **8**, 16012 (2017).

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Characteristic Feature of Reaction at Surfaces Probed by STM

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Chemical reaction of complex molecules at surfaces is multi-dimensional in its nature, where reaction coordinates are thermalized under the reaction condition. Keeping the system temperature low enough to hold the molecular vibrational states at ground state and examine individual vibrational state to be excited to an equivalent level to overcome the reaction barrier, the experimental examination of the dynamics of the reaction may realize.

Utilizing the ultimate spatial resolution, STM is a useful tool to unveil the site-specific character of molecules at surfaces. Inelastic electron tunneling spectroscopy (IETS) is widely used to identify the electronic states and is applicable to detect vibrational state when the molecule is in contact with solid surfaces. Tunneling electron with tuned acceleration energy also plays an important role as an energy source to excite individual vibrational states of molecules at a specific site and the action spectroscopy of adsorbed molecules is another measure of vibrational spectroscopy of individual molecules at surfaces. Reaction yield reflects dynamical phenomena of molecules including the excitation of molecular states and how molecular vibrations can couple with the relevant dynamical processes. At the conference I will show some examples of the coupling between the vibrational modes excited and the reaction coordinates.

References:

Y. Kim, et al., *Progress in Surface Science*, **90** (2015) 85-143., and the references within.

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Research areas (specialty) and Keywords:

Dr. Lu is a material physicist, her research interests are within an interdisciplinary field of active plasmonics/optoelectronics with a particular focus on halide perovskite nanostructure devices to investigate harvesting, generating, and manipulating light at the nanoscale.

HONORS AND AWARDS:

2020 Youth Optical Engineering Award, Taiwan Photonics Society
2018 Career Development Award, Academia Sinica
2018 56th Ten Outstanding Young Persons, Taiwan
2014 Postdoctoral Research Abroad Fellowship, Taiwan Ministry of Science and Technology
2013 Taiwan Outstanding Women in Science—Chui-Chu Mon Fellowship
2013 Chien-Shiung Wu Fellowship, Physical Society of the Republic of China
2010 The President's Scholarship of NTHU
2010 The Honorary Member of the Phi Tau Phi Scholastic Honor Society of the Republic of China

REPRESENTATIVE WORKS:

[1] Y-H Hsieh, B-W Hsu, K-N Peng, K-W Lee, C. W. Chu, S-W Chang, H-W Lin, T-J Yen, and Y-J Lu, Perovskite Quantum Dot Lasing in a Gap-Plasmon Nanocavity with Ultralow Threshold. ACS Nano 14, 11670–11676 (2020). (Issue cover)

[2] C.H. Lin, T.Y. Li, J. Zhang, Z.Y. Chiao, P.C. Wei, H.C. Fu, L. Hu, M.J. Yu, G.H. Ahmed, X.W. Guan, C.H. Ho, T. Wu, B.S. Ooi, O.F. Mohammed, Y.J. Lu, X.S. Fang, and J.H. He, Designed Growth and Patterning of Perovskite Nanowires for Lasing and Wide Color Gamut Phosphors with Long-Term Stability. Nano Energy 73, 104801 (2020).

[3] H-S Tsai, Y-H Huang, P-C Tsai, Z-Y Chiao, Y-J Chen, H. Ahn, S-Y Lin, and Y-J Lu, Ultrafast Exciton Dynamics in Scalable Monolayer MoS_2 Synthesized by Metal Sulfurization. ACS Omega 5, 10725-10730 (2020). (Issue cover)

[4] Y-J Lu, R. Sokhoyan, W-H Cheng, G. K. Shirmanesh, A. Davoyan, R. A. Pala, K. Thyagarajan, and H. A. Atwater, Dynamically Controlled Purcell Enhancement of Visible Spontaneous Emission in a Gated Plasmonic Heterostructure. Nature Communications 8, 1631 (2017).

[5] Y-J Lu, J. Kim, H-Y Chen, C. Wu, N. Dabidian, C. E. Sanders, C-Y Wang, M-Y Lu, B-H Li, X. Qiu, W-H Chang, L-J Chen, G. Shvets, C-K Shih, and S. Gwo, Plasmonic Nanolaser Using Epitaxially Grown Silver Film. Science 337, 450 (2012).

Perovskite-based Plasmonic Nanolasers

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Progress in understanding resonant subwavelength optical structures has fueled a worldwide explosion of interest in both fundamental processes and nanophotonic/plasmonic devices for imaging, sensing, solar energy conversion and information processing. In this talk, Dr. Lu will present an overview of her research works on the plasmonic/ nanophotonic devices in the recent years [1-4], such as plasmonic nanolasers[5-6], perovskite nanolasers [1-2], perovskite solar cells and gate-tunable optoelectronic modulators [4]. I'll mainly discuss our recent results regarding continuous-wave (CW) lasing from a single lead halide perovskite ($CsPbBr_3$) quantum dot (PQD) in a gap plasmon nanocavity with an ultralow threshold (lower than 90 $mWcm^{-2}$) under 4 K. The ultrasmall mode volume ($\sim \lambda^3/500$) dramatically enhances the light-matter interaction to achieve CW lasing. By raising the temperature, a clear lasing threshold can be observed at temperatures above 80 K. The demonstration of single QD lasing, which operates in the strong coupling regime, provides a new approach for realizing electrically driven lasing and integration into ultracompact optoelectronic devices. The detail mechanism of plasmonic lasing will be discussed. In the end, I will also discuss the current status and the challenge of the nanolasers.

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[1] Yu-Hung Hsieh, Bo-Wei Hsu, Kang-Ning Peng, Kuan-Wei Lee, Chih Wei Chu, Shu-Wei Chang, Hao-Wu Lin*, Ta-Jen Yen*, and Yu-Jung Lu*, Perovskite Quantum Dot Lasing in a Gap-Plasmon Nanocavity with Ultralow Threshold. (2020). ACS Nano 14, 11670. (issue cover)

[2] C.H. Lin, T.Y. Li, J. Zhang, Z.Y. Chiao, P.C. Wei, H.C. Fu, L. Hu, M.J. Yu, G.H. Ahmed, X.W. Guan, C.H. Ho, T. Wu, B.S. Ooi, O.F. Mohammed, Y.J. Lu, X.S. Fang,* and J.H. He*, Designed Growth and Patterning of Perovskite Nanowires for Lasing and Wide Color Gamut Phosphors with Long-Term Stability. (2020). Nano Energy 73, 104801.

[3] Hsu-Sheng Tsai, Yung-Hung Huang, Po-Cheng Tsai, Zong-Yi Chiao, Yi-Jia Chen, Hyeyoung Ahn, Shih-Yen Lin, and Yu-Jung Lu*, Ultrafast Exciton Dynamics in Scalable Monolayer MoS2 Synthesized by Metal Sulfurization. (2020). ACS Omega 5, 10725–10730.

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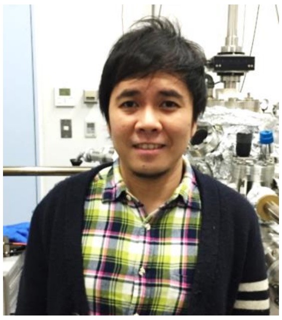
[5] Y-J Lu et al. Plasmonic Nanolaser Using Epitaxially Grown Silver Film. (2012) Science 337, 450.

[6] Y-J Lu et al. All-Color Plasmonic Nanolasers with Ultralow Thresholds: Auto-tuning Mechanism for Single-Mode Lasing. (2014) Nano Lett. 14, 4381.



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Research areas (specialty) and Keywords:

scanning tunneling microscopy, surface science, layered materials, topological materials

HONORS AND AWARDS:

2018 The Physical Society of Japan, Outstanding Young Scientist Award.
2013 The Physical Society of Taiwan, Outstanding Paper Award.
2011 Ministry of Science and Technology, ROC, Overseas Research Fellowships
2009 The Best Poster Award at 27th Spectroscopy Technology and Surface Science Conference.
2006 The Physical Society of Taiwan, Outstanding Thesis Award

REPRESENTATIVE WORKS:

1. Chun-Liang Lin et al., “Scanning Tunneling Spectroscopy Studies of Topological Materials” **J. Phys.: Condens. Matter** 32,243001 (2020).
2. Chun-Liang Lin et al., “Visualizing Type-II Weyl Points in Tungsten Ditelluride by Quasiparticle Interference” **ACS Nano** 11, 11459 (2017).
3. Chun-Liang Lin et al., “Spectroscopic Identification of Ag-terminated “Multilayer Silicene” Grown on Ag(111)” **J. Phys. Chem. C** 120, 6689 (2016).
4. Chun-Liang Lin et al., “Substrate-Induced Symmetry Breaking in Silicene” **Phys. Rev. Lett.** 110, 076801 (2013)
5. Chun-Liang Lin et al., “Structure of Silicene Grown on Ag(111)” **Appl. Phys. Express** 5, 045802 (2012)

Scanning Tunneling Microscopy Studies of 2D Materials and Devices

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Current semiconductor industry is facing a limit of scaling. Thus, it is urgent to find a new type of material to replace Si. Two-dimensional (2D) materials, especially those with a proper band gap provide a solution to this problem since the thickness of a monolayer of 2D materials can be reduced to only few atoms. Scanning tunneling microscopy (STM) is a powerful method to reveal both the geometry and electronic structure down to atomic scale. In this presentation, I will discuss several issues of 2D materials and devices studied by STM. First, the growth behavior of silicene, a monolayer honeycomb structure of Si, is clearly revealed. Second, the location of defect in monolayer transition metal dichalcogenides (TMDs) is clearly identified though the quasiparticle interference. Besides, to recover the imperfect TMD surfaces is realized through in situ sputtering and annealing. Finally, the defect induced mobility modulation in 2D devices is visualized by STM. It is clear that STM can provide vital information for helping the developments of 2D materials and devices.

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HONORS AND AWARDS:

2019 2019 ACS Award in Surface Chemistry
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2017 Visiting Einstein Professor at University of Science and Technology of China
2015 Honorary Fellow of Chinese Chemical Society
2012 Blaise Pascal Medal in Material Science of the European Academy of Sciences
2011 Karl-Ziegler-Award of the German Chemical Society and Karl-Ziegler Foundation
2007 Gabor A. Somorjai Award of the American Chemical Society for Creative Research in Catalysis
1995 Leibniz-Award of the German Research Foundation (DFG)

REPRESENTATIVE WORKS:

[1] L. Lichtenstein, M. Heyde, H.-J. Freund, "Atomic Arrangement in Two-Dimensional Silica: From Crystalline to Vitreous Structures." J. Phys. Chem. C, 116, 20426 (2012).

[2] L. Lichtenstein, M. Heyde, H.-J. Freund, „Crystalline-vitreous Interface in Two Dimensional Silica", Phys. Rev. Lett., 109, 106101-1-5 (2012).

[3] A. L. Lewandowski, S. Tosconi, L. Gura, P. Schlexer, P. Marschalik, W.-D. Schneider, M. Heyde, G. Pacchioni, H.-J. Freund, "From Crystalline to Amorphous Germania Bilayer Films at the Atomic Scale: Preparation and Characterization", Angew. Chem. Int. Ed., 58, 10903 (2019).

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From Crystals to Glasses in Real Space at the Atomic Level

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The crystal-glass transition has been studied in the past mainly via x-ray or neutron scattering and theoretical modelling of correlation functions. We have developed an approach to prepare thin silica and germania films on metal supports which are prone to investigation with scanning tunneling microscopy and were able in the past to verify for the first time William Zachariasen's proposal for the structure of amorphous silica from 1932. Detailed statistical analysis of the structural features shows strong correlation with the expectations for three-dimensional amorphous silica. Here we present and discuss results for silica and germania bi-layer films and are able to catch some of the characteristic differences between the two materials, i.e. silica and germania previously deduced from bulk material studies. We also investigated the variation in structure and stability of the silica and germania films as a function of the metallics substrate, they are grown upon.