

Curriculum Vitae

Phark, Soo-hyon

Center for Quantum Nanoscience (QNS), Institute for Basic Science (IBS)
Ewha Womans University, Seoul 03760, Korea
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EDUCATIONS

1990.03 – 1998.02 **B. S.**, Department of Physics, Chonnam Nat'l Univ., Korea
1998.03 – 2000.02 **M. S.**, School of Physics, Seoul Nat'l Univ., Korea
2000.03 – 2006.08 **Ph. D.**, School of Physics, Seoul Nat'l Univ., Korea, title of thesis:
"Study on the powders and films of sulfur-terminated Mn₁₂ single-
molecule magnets", supervised by Prof. Zheong G. Khim

RESEARCH CAREERS

2006.09 – 2009.02 Postdoc, Department of Physics, Seoul Nat'l Univ.
2009.03 – 2010.02 Research Professor, Department of Physics, Ewha W. Univ.
2010.03 – 2014.08 Postdoc, Max-Planck-Institut für Mikrostrukturphysik, Germany
2014.09 – 2015.08 Research Asso. Professor, CCES, IBS & Physics Dept. Seoul Nat'l Univ.
2015.09 – 2016.09 Research Fellow, Korea Research Institute of Standards and Science
2019.01 – 2020.06 Visiting Scholar, IBM Almaden Research Center, CA. USA.
2016.10 – Present Research Fellow, QNS, IBS & Research Professor, Ewha W. Univ.
PI of QNS subgroup "Electron spin qubits on surfaces"

AWARDS

2024.04 Minister's commendation for outstanding scientists of the year,
Korean Ministry of Science and ICT

TEACHING

1999.03 – 2001.02 Teaching Assistant, Seoul Nat'l Univ.
2003.03 – 2010.02 Lecturer, The Catholic Univ. of Korea (Electromagnetism; Solid State
Electronic Devices; Computational Physics; Electronic Circuits
Experiments)

Curriculum Vitae

2004.03 – 2006.06	<u>Lecturer</u> , Sejong University (Fundamental Physics & Experiments)
2009.09 – 2009.12	Ewha Womans Univ. (Grad. course: Advanced Physics Experiment)
2017.03 – 2017.08	Ewha Womans Univ. (Fundamental Physics Experiment)
2018.06 – 2018.07	Ewha Womans Univ. (International Summer School: Quantum Physics)
2020.09 – 2020.12	Ewha Womans Univ. (Grad. course: Advanced Quantum Nanoscience)

THESIS SUPERVISING

2015.02	<u>Minji Kwon</u> , PhD Thesis, Ewha Womans Univ. "Resonant Modes and Surface Plasmons in Metal and Semiconductor Nanostructures: Optical and Scanning Probe Microscopy based Characterizations"
2023.02	<u>Yeonjin Jung</u> , MS Thesis, Ewha Womans Univ. "Development and characterization of low temperature Scanning Tunneling Microscope in fast ramping magnetic field for single molecule magnets study"
2024.08	<u>Hong T. Bui</u> , PhD Thesis, Ewha Womans Univ. "An atomic scale qubit platform using single atom spins on surfaces"

CAREERS: MISC.

1992.02 – 1994.09	<u>Military service</u> in the Navy of Korea
2002.07 – 2003.02	<u>Visiting student</u> at The Univ. of Texas at Austin, USA

RESEARCH TOPICS

- 1. Single Molecule Magnet: Seoul National Univ. (PhD thesis)**
 - a. Magnetism of Mn₁₂-SMM functionalized by Sulfur-terminated ligands.
 - b. Structural/electrical properties of Mn₁₂-SMM on Au(111) using SPM.
- 2. Ultra-thin Oxide Film Grown by Pulsed-laser-deposition: Seoul National Univ.**
 - a. Characterization of submonolayer NiO/Ag(100) using UHV-VT STM/AFM and XPS.
 - b. Structural/electrical properties of perovskites on SrTiO₃ using UHV-VT SPM and XPS.
 - c. Oxygen atoms adsorbed on Ag(100) using UHV-VT STM and *ab initio* calculation.
- 3. Metal-oxide & Metal-semiconductor Interface: Ewha Woman's Univ.**
 - a. Chemical composition studies on Pt/NiO and Ag/NiO using XPS.
 - b. Structural/electrical properties of Pt/GaN junction using conductive-AFM.

Curriculum Vitae

- 4. Graphene: Max-Planck-Institut für Mikrostrukturphysik**
 - a. Structural/electronic properties of graphene edges on Ir(111) using low-temp. STM.
 - b. Quantum confinement phenomena in graphene nanoislands using low-temp. STM.
- 5. Magnetic Nanostructure: Max-Planck-Institut für Mikrostrukturphysik**
 - a. Noncollinear magnetism of Fe nanoislands on Cu(111) using spin-polarized STM.
 - b. Magnetism of collinear-noncollinear spin interface using spin-polarized STM.
 - c. Magnetic interactions of tip & sample in spin-polarized STM.
- 6. Single atomic/molecular spins on surfaces: QNS, IBS**
 - a. Electron spin resonance of single spins on a surface using STM.
 - b. Electron spin qubits on surfaces.
 - c. Coherent control of quantum states of molecular spins on surfaces.

TECHNICAL EXPERIENCES

1. Instrumentation

- a. Design/Construction of an ultra-high vacuum low temperature scanning tunneling/probe microscope [Zheong G. Khim's group at Seoul Nat'l Univ.]
- b. Construction of a low temperature magnetic force microscope [Alex de Lozanne's group at The Univ. of Texas at Austin]
- c. Construction of an ultra-high vacuum 3He-cooled scanning tunneling microscope with 14 T magnet [CCES, IBS (director: Prof. Tae Won Noh) at Seoul Nat'l Univ.]
- d. Design of an ultrahigh vacuum spin-polarized scanning electron microscopy [KRISS]
- e. Scanning tunneling microscope combined with electron spin resonance in a fast ramping magnetic field [QNS, IBS]

2. Sample Preparation/Fabrication

- a. Atomically flat metal film and nanoisland growths by electron-beam evaporation
- b. Oxide thin film growths using pulsed laser deposition (PLD) equipped with RHEED
- c. Graphene on metal surface by CVD
- d. Isolated single atoms and molecules on oxide surfaces

3. Experimental Characterization Techniques

- a. UHV-LT spin-polarized STM/S (7 K, 7 T)
- b. UHV-VT STM/AFM (Omicron GmbH)
- c. Ambient AFM, MFM, EFM, and conductive-AFM

Curriculum Vitae

- d. X-ray Photoemission Spectroscopy (PSP vacuum) & Auger Electron Spectroscopy
- e. Electron spin resonance in STM

4. Simulation Techniques

- a. CW and Pulsed ESR of coupled atomic spins (Matlab)
- b. Open quantum system simulations (Python with Qutip package)

ORGANIZING SCIENTIFIC EVENTS

1. "International Conference on Quantum Computing (ICQC 2022)", Seoul (Jun 2022).
2. "Coherent manipulation of artificial surface quantum spins", Pioneer Symposium of KPS Meeting, On-line (Apr 2022).
3. "Quantum coherent control at a nanoscale", Pioneer Symposium of KPS Meeting, On-line, Chief organizer (Oct 2021).
4. "The 2nd Workshop on Advanced Scanning Probe Microscopy (ASPM2018)", Busan Korea, Chief organizer (Aug 2018).
5. "The 1st Workshop on Advanced Scanning Probe Microscopy (ASPM2017)", Gonjiam Korea, Chief organizer (Aug 2017).

INVITED & COLLOQUIUM TALKS

1. "An atomic scale multi-qubit platform with electron spins on a surface", International Colloquium on Scanning Probe Microscopy (ICSPM31), Tokyo (Japan) (Dec 2023).
2. "Quantum coherence of spins on surface: towards on-surface qubit platform", Spins on Surfaces 3, San-Sebastian (Spain) (Sep 2023).
3. "A Novel Solid-state Qubit Platform with Electron Spins on a Surface", The 20th International Microscopy Congress, Busan (Korea) (Sep 2023).
4. "A novel multi-qubit platform with electron spins on a surface", 3rd IBS-RIKEN Conference on Surface Atomic Wires and 2nd IBS-RIKEN STM Workshop, Gyeongju (Korea) (Aug 2023).
5. "Atom-by-atom electron spin resonance: towards electron spin qubits on a surface", ICMAT workshop: Advanced Scanning Probe Methods, Singapore (Jun 2023).
6. "An electron-spin qubit platform crafted atom-by-atom on a surface", 11th International Conference on Materials for Advanced Technologies (ICMAT), Singapore (Jun 2023).

Curriculum Vitae

7. "Atom-by-atom electron spin resonance: towards electron spin qubits on a surface", International Conference on Quantum Computing (ICQC 2022), Seoul (Jun 2022).
8. "Atomic Scale Electron Spin Resonance: towards Electron Spin Qubits on a Surface", ISSP Workshop "Frontier of scanning probe microscopy and related nano science", Kashiwa (Japan) (Mar 2022).
9. "Double Electron Spin Resonance of Engineered Atomic Structures on a Surface", The 9th International Symposium on Surface Science (ISSS-9), On-line (Japan) (Nov 2021).
10. "Double resonance spectroscopy of coupled atomic spins on surface", Korean Physical Society Fall Meeting: Pioneer Symposium, On-line (Korea) (Oct 2021).
11. "Double Electron Spin Resonance of Engineered Atomic Structures on a Surface", International Workshop on Scanning Probe Microscopy 2021, Jeju (Korea) (Aug 2021).
12. "Proximal Atom-field-driven Single Atom Magnetic Resonance", International Workshop on Scanning Probe Microscopy 2020, On-line (Korea) (Aug 2021).
13. "Spin-polarized scanning tunneling microscopy: tailoring some textbook examples for nanomagnetism", Department of Physics Colloquium, University of Ulsan (Korea) (May 2017).
14. "Magnetic Proximity Effects at Collinear-noncollinear Spin Interface of Co-Fe Nanoscale Contact", 2014 EMN Open Access Week Meeting "Energy, Materials and Nanotechnology", Chengdu (China) (Sep 2014).
15. "Helical spin density wave in Fe nanoisland", Department of Physics Colloquium, Chungnam Nat'l Univ. (Korea) (Oct 2014).
16. "Revealing nanomagnetism with quantitative insights into spin-polarized scanning tunneling spectroscopy", International Conference on Small Science (ICSS 2013), Las Vegas (USA) (Dec 2013).
17. "Quantitative insights into nanomagnetism with subnanometer resolution by spin-polarized scanning tunneling spectroscopy", Korean Physical Society Fall Meeting 2013, (Oct 2013).

Curriculum Vitae

PUBLICATIONS

1. Hong T. Bui, Christoph Wolf, Yu Wang, Masahiro Haze, Arzhang Ardavan, Andreas J. Heinrich*, **Soo-hyon Phark***, "All-electrical driving and probing of dressed states in a single spin", *ACS Nano* 18, 12187 (2024).
2. Yu Wang, Yi Chen, Hong T. Bui, Christoph Wolf, Masahiro Haze, Cristina Mier, Jinkyung Kim, Deung-Jang Choi, Christopher P. Lutz, Yujeong Bae*, **Soo-hyon Phark***, Andreas J. Heinrich*, "An atomic scale multi-qubit platform", *Science* 382, 87-92 (2023).
3. **Soo-hyon Phark**, Yi Chen, Hong T Bui, Yu Wang, Masahiro Haze, Jinkyung Kim, Yujeong Bae*, Andreas J Heinrich*, Christoph Wolf*, "Double-Resonance Spectroscopy of Coupled Electron Spins on a Surface", *ACS Nano* 17, 14144-14151 (2023).
4. **Soo-hyon Phark**, Hong Thi Bui, Alejandro Ferrón, Joaquin Fernández-Rossier, Jose Reina-Gálvez, Christoph Wolf, Yu Wang, Kai Yang, Andreas J Heinrich*, Christopher P Lutz*, "Electric-Field-Driven Spin Resonance by On-Surface Exchange Coupling to a Single-Atom Magnet", *Advanced Science* 10, 2302033 (2023).
5. Yu Wang, Masahiro Haze, Hong T Bui, We-hyo Soe, Herve Aubin, Arzhang Ardavan, Andreas J Heinrich*, **Soo-hyon Phark***, "Universal quantum control of an atomic spin qubit on a surface", *npj Quantum Information* 9, 48 (2023).
6. Hyuk Jin Kim, Young Hwan Choi, Dongkyu Lee, In Hak Lee, Byoung Ki Choi, **Soo-Hyon Phark**, Young Jun Chang*, "Enhanced passive thermal stealth properties of VO₂ thin films via gradient W doping", *Appl. Surf. Sci.* 561, 150056 (2021).
7. Kai Yang, **Soo-Hyon Phark**, Yujeong Bae, Taner Esat, Philip Willke, Arzhang Ardavan, Andreas J. Heinrich*, Christopher P. Lutz*, "Probing resonating valence bond states in artificial quantum magnets", *Nat. Commun.* 12:993 (2021).
8. Kai Yang, William Paul, **Soo-Hyon Phark**, Philip Willke, Yujeong Bae, Taeyoung Choi, Taner Esat, Arzhang Ardavan, Andreas J. Heinrich*, Christopher P. Lutz*, "Coherent spin manipulation of individual atoms on a surface", *Science* 366, 509–512 (2019).
9. Jeison A. Fischer, Leonid M. Sandratskii*, **Soo-Hyon Phark***, Dirk Sander, Stuart S. P. Parkin, "Atomic structure governed diversity of exchange-driven spin helices in Fe nanoisland: experiment and theory", *Phys. Rev. B* 96, 140407(R) (2017).
10. **Soo-Hyon Phark***, Dirk Sander, "Spin-polarized scanning tunneling microscopy with quantitative insights into magnetic probes", *Nano Convergence* 4:8 (2017).

Curriculum Vitae

11. Young J. Chang, **Soo-Hyon Phark***, "Atomic-scale visualization of initial growth of perovskites on SrTiO₃(001) using scanning tunneling microscope", *Curr. Appl. Phys.* 17, 640-656 (2017).
12. Jeison A. Fischer, Leonid M. Sandratskii*, **Soo-Hyon Phark***, Safia Ouazi, Andre A. Pasa, Dirk Sander, Stuart S. P. Parkin, "Probing the spinor nature of electronic states in nanosize non-collinear magnets", *Nat. Commun.* 7:13000 (2016).
13. Young J. Chang, **Soo-hyon Phark***, "Direct Nanoscale Analysis of Temperature-Resolved Growth Behaviours of Ultrathin Perovskites on SrTiO₃", *ACS Nano* 10, 5383-5390 (2016).
14. Minji Gwon, Ahrum Sohn, Yunae Cho, **Soo-hyon Phark**, Jieun Ko, Youn Sang Kim, Dong-Wook Kim*, "Plasmon-enhanced surface photovoltage of ZnO/Ag Nanogratings", *Sci. Rep.* 5, 16727 (2015).
15. **Soo-Hyon Phark**, Seoung Chul Chae*, "Initial defect configuration in NiO film for reliable unipolar resistance switching of Pt/NiO/Pt structure", *J. Phys. D: Appl. Phys.* 48, 155102 (2015).
16. **Soo-Hyon Phark**, Young J. Chang*, "Nucleation and growth of primary nanostructures in SrTiO₃ homoepitaxy", *Nanoscale Res. Lett.* 10, 80 (2015).
17. Ranju Jung, **Soo-Hyon Phark**, Dong-Wook Kim, Mary Upton, Diego Casa, Thomas Gog, Junggho Kim*, "Indirect probing of defects in unipolar resistive switching NiO_x thin films by Ni K-edge resonant inelastic X-ray scattering", *Appl. Phys. Express* 8, 021101 (2015).
18. **Soo-hyon Phark***, Jeison A. Fischer, Marco Corbetta, Dirk Sander, Kohji Nakamura, Jürgen Kirschner, "Reduced dimensionality induced helimagnetism in Iron nanoislands", *Nat. Commun.* 5:5183 doi: 10.1038/ncomms6183 (2014).
19. Dirk Sander*, **Soo-hyon Phark**, Marco Corbetta, Jeison Fischer, Hirofumi Oka, Jürgen Kirschner, "The impact of structural relaxation on spin polarization and magnetization reversal of individual nano structures studied by spin-polarized scanning tunneling microscopy", *J. Phys.: Condens. Matter* 26, 394008 (2014).
20. **Soo-hyon Phark**, Jeison A. Fischer, Marco Corbetta, Dirk Sander*, Jürgen Kirschner, "Superparamagnetic response of Fe-coated W tips in spin-polarized scanning tunneling microscopy", *Appl. Phys. Lett.* 103, 032407 (2013).
21. Seolun Yang, H.-K. Park, J.-S. Kim*, **S.-H. Phark**, Young Jun Chang, T. W. Noh, H.-N. Hwang, C.-C. Hwang, H.-D. Kim, "Reduction of charge fluctuation energies in ultrathin NiO films on Ag(001)", *Surf. Sci.* 616, 12 (2013).

Curriculum Vitae

22. **Soo-hyon Phark***, Jérôme Borme, Augusto León Vanegas, Marco Corbetta, Dirk Sander, Jürgen Kirschner, "Atomic structures and spectroscopy of graphene edges on Ir(111)", *Phys. Rev. B* 86, 045442 (2012).
23. **Soo-hyon Phark***, Jérôme Borme, Augusto León Vanegas, Marco Corbetta, Dirk Sander, Jürgen Kirschner, "Scanning tunneling spectroscopy of epitaxial graphene nanoisland on Ir(111)", *Nanoscale Res. Lett.* 7, 255 (2012).
24. Hogyoung Kim*, **Soo-Hyon Phark**, Keun Man Song, Dong-Wook Kim, "Schottky contacts to polar and nonpolar n-type GaN", *J. Kor. Phys. Soc.* 60, 104 (2012).
25. Hogyoung Kim*, **Soo-Hyon Phark**, Keun Man Song, Dong-Wook Kim, "Electrical characterization of Pt Schottky contacts to a-plane n-type GaN", *AIP Conf. Proc.* 1399, 923 (2011).
26. **Soo-hyon Phark***, Jérôme Borme, Augusto León Vanegas, Marco Corbetta, Dirk Sander, Jürgen Kirschner, "Direct observation of electron confinement in epitaxial graphene nanoislands", *ACS Nano* 5, 8162 (2011).
27. **Soo-Hyon Phark**, Hogyoung Kim*, Keun Man Song, Dong-Wook Kim, "Observation of Barrier Inhomogeneity in Pt/*a*-plane n-type GaN Schottky Contacts", *J. Kor. Phys. Soc.* 58, 1356 (2011).
28. **Soo-Hyon Phark***, Young J. Chang, and Tae Won Noh, "Selective growth of perovskite oxides on SrTiO₃(001) by control of surface reconstructions", *Appl. Phys. Lett.* 98, 161908 (2011).
29. **Soo-Hyon Phark**, Hogyoung Kim, Keun Man Song, Phil Geun Kang, Heung Soo Shin, Dong-Wook Kim*, "Characterization of Pt/*a*-plane GaN Schottky contacts using conductive atomic force microscopy", *J. Nanosci. Nanotechnol.* 11, 1413(2011).
30. Haeri Kim, Dong-Wook Kim*, **Soo-Hyon Phark**, "Transport behaviors and nanoscopic resistance profiles of electrically stressed Pt/TiO₂/Ti planar junctions", *J. Phys. D: Appl. Phys.* 43, 505305(2010).
31. **Soo-Hyon Phark**, Hogyoung Kim*, Keun Man Song, Phil Geun Kang, Heung Soo Shin, Dong-Wook Kim, "Current transport in Pt Schottky contacts to *a*-plane n-type GaN", *J. Phys. D: Appl. Phys.* 43, 165102 (2010).
32. Sungjoo Lee, **Soo-Hyon Phark**, and Dong-Wook Kim*, "Influences of interface states on the electrical properties of Pt/SrTiO₃ junctions", *J. Kor. Phys. Soc.* 56, 362 (2010).

Curriculum Vitae

33. Young Jun Chang, Choong H. Kim, **S.-H. Phark**, Y. S. Kim, J. Yu, and T. W. Noh*, "Fundamental thickness limit of itinerant ferromagnetic SrRuO₃ thin films", *Phys. Rev. Lett.* 103, 057201 (2009).
34. **S. H. Phark***, Young Jun Chang, T. W. Noh, and J.-S. Kim, "Initial stages of nickel oxide growth on Ag(001) by pulsed laser deposition", *Phys. Rev. B* 80, 035426 (2009).
35. **S. H. Phark**, R. Jung, Y. J. Chang, T. W. Noh, and D.-W. Kim*, "Interfacial reactions and resistive switching behaviors of metal/NiO/metal structures", *Appl. Phys. Lett.* 94, 022906 (2009).
36. **S. H. Phark**, Z. G. Khim*, and S. Yoon, "Growth of a single layer gold stripe and investigation of the preferable growth direction on reconstructed Au(111) surface using STM", *Current Appl. Phys.* 8, 822 (2008).
37. Seolun Yang, Shijin Seong, J.-S. Kim*, Hanna Hwang, C.-C. Hwang, Young J. Chang, **Soo-Hyon Phark**, H. G. Min, "XPS study of NiO growth on Ag(100)", *J. Kor. Vac. Soc.* 16, 311 (2007).
38. **S. H. Phark**, Z. G. Khim, J. M. Lim, J. Kim, and S. Yoon*, "Study on the films of a single-molecule magnet Mn₁₂ modified by the selective insertion of a Sulfur-terminated ligand", *J. Mag. Mater. Mag.* 310, e483 (2007).
39. Casey E. Israel, Changbae Hyun, Alex de Lozanne*, **Soohyon Phark**, Zheong G. Khim, "Compact variable-temperature magnetic force microscope with optical access and lateral cantilever positioning", *Rev. Sci. Instrum.* 77, 023704 (2006).
40. B. J. Kim, B. J. Suh*, S. Yoon, **S. H. Phark**, Zheong G. Khim, J. Kim, J. M. Lim, and Y. Do, "Magnetic properties of a Mn₁₂O₁₂(O₂CC₄H₃S)₁₆(H₂O)₄ single-molecule magnet", *J. Kor. Phys. Soc.* 45, 1593 (2004).
41. **Soohyon Phark**, Zheong G. Khim, B. J. Kim, B. J. Suh, S. Yoon*, J. Kim, J. M. Lim, and Y. Do, "Atomic force microscopy study of Mn₁₂O₁₂(O₂CC₄H₃S)₁₆(H₂O)₄ single-molecule magnet adsorbed on Au surface", *Jap. J. Appl. Phys.* 43, 8273 (2004).
42. J. S. Yang, D. H. Kim, S. D. Bu, T. W. Noh*, **S. H. Phark**, Z. G. Kim, I. W. Lyo, and S.-J. Oh, "Surface structures of a Co-doped anatase TiO₂ (001) film investigated by scanning tunneling microscopy", *Appl. Phys. Lett.* 82, 3080 (2003).