Technology and Instrumentation

Research Instrumentation

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Electronic and Magnetic Properties at High Pressure

Dr. Andrew Cornelius
Department of Physics & Astronomy
Phone (702) 895-1727

Expertise:

- Experimental high pressure measurements
- Magnetism
- Superconductivity

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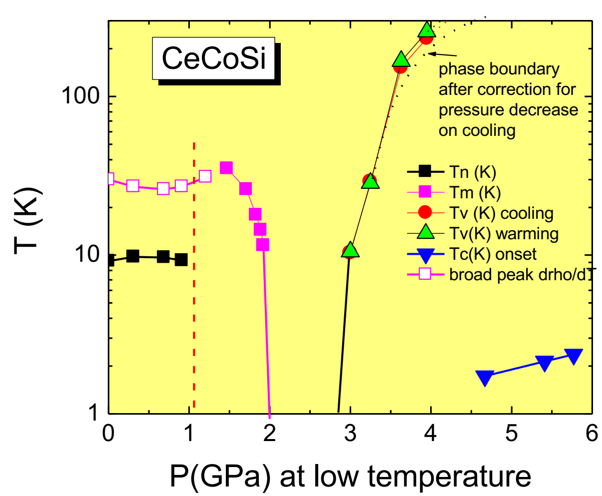
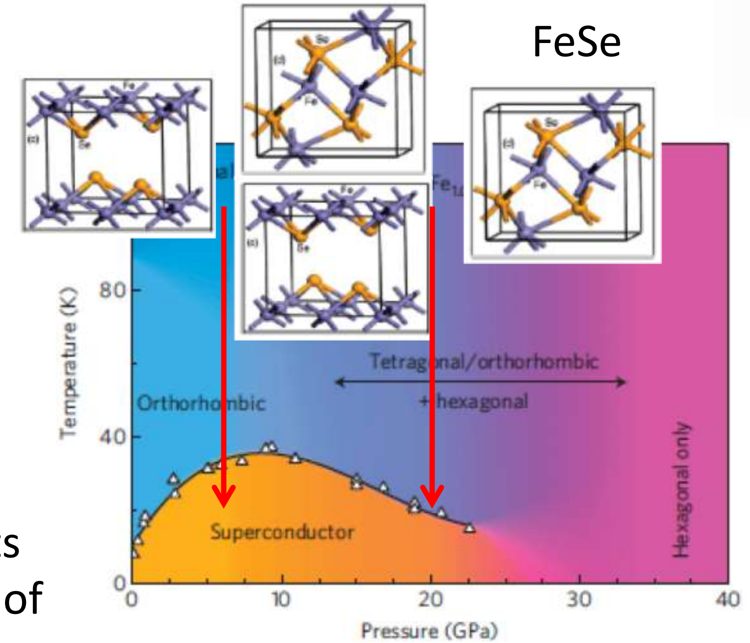
Superconductivity

Quantum Design PPMS at UNLV

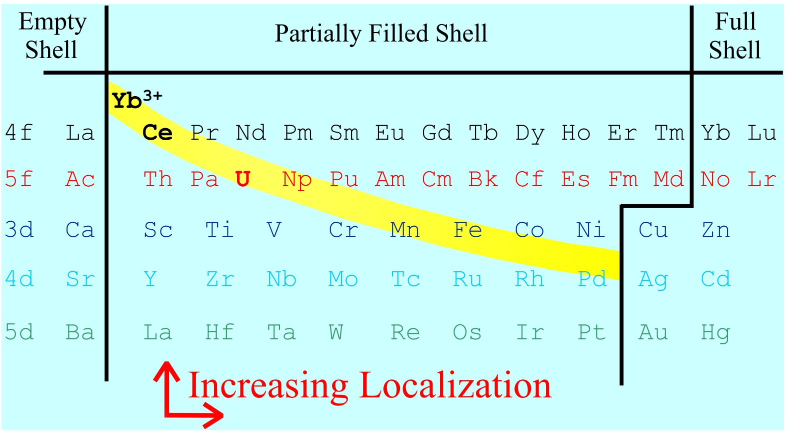
- Measurements from 0.3 K to 400 K
    - Heat capacity, electric and thermal transport, and AC/DC magnetization
- Pressure cells to measure electrical properties (clamp to 3 GPa and diamond anvil cell to >100 GPa)





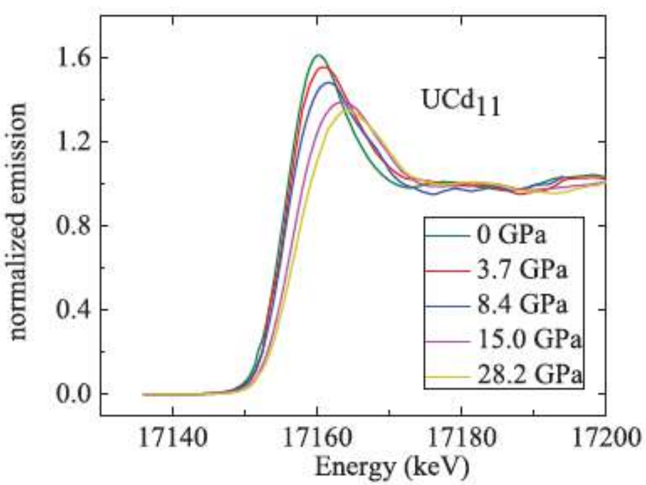
Addition of high pressure synchrotron experiments (diffraction and X-ray absorption) allows mapping of complex superconducting phase diagrams

Correlated-Electron Systems

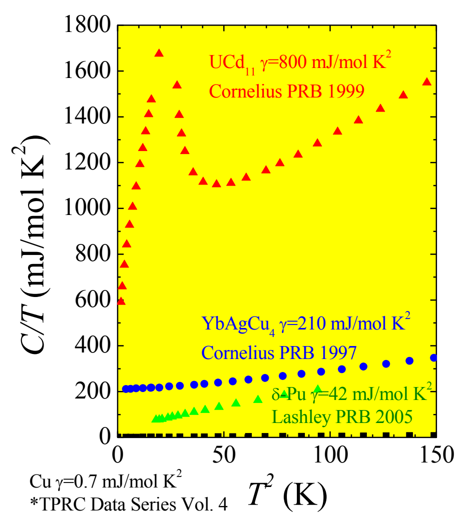


Modified periodic table

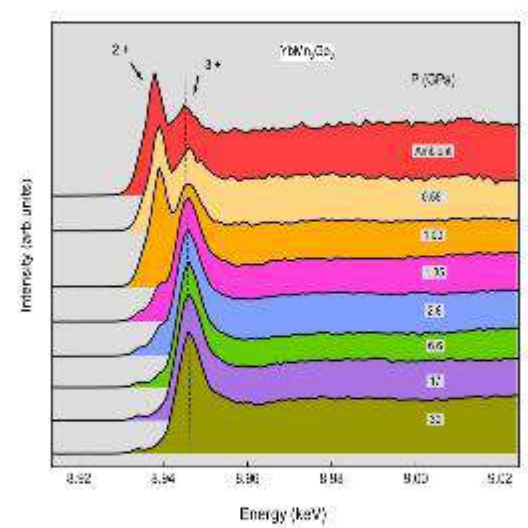
- Going from localized to delocalized electrons one often finds strong electron-electron correlations
- Correlated electron systems can yield interesting behavior: fluctuating valence, superconductivity, non-Fermi liquid, heavy fermion and many more



f-electron delocalization
X-ray absorption



Heavy fermions
Heat Capacity



Fluctuating valence
X-ray fluorescence

Art Gelis

Director, Radiochemistry Program

Actinide Separations and Recovery

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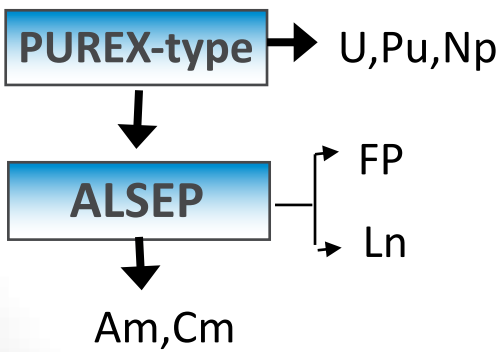
Design and Testing of Advanced Separation Processes using Additive Manufacturing

- **Liquid-Liquid Extraction and Separation of Plutonium, Uranium, Minor Actinides, Lanthanides and Fission Products**
- **Twenty-seven 3D-printed acrylic centrifugal contactors (CC), fabricated at Argonne National Lab are available at UNLV**
- **Contactors can be 3D-printed in stainless steel or any alloy**
- **Solvent extraction separations can be tailored to a specific goal**
- **Example: Actinide Lanthanide SEParation process - ALSEP, designed and tested for DOE-NE**

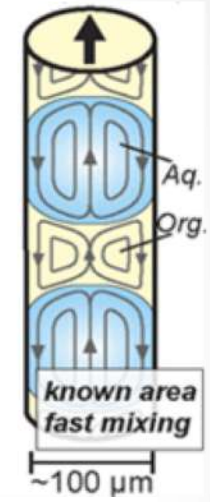


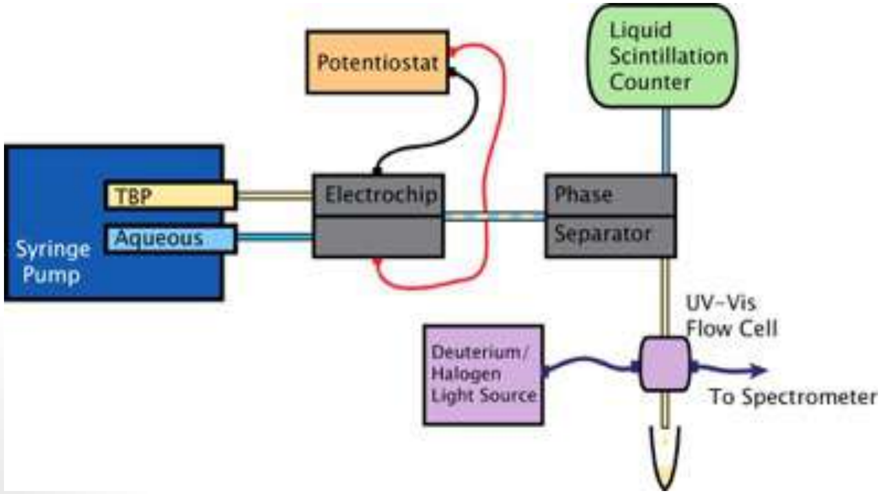
10+1 acrylic CC

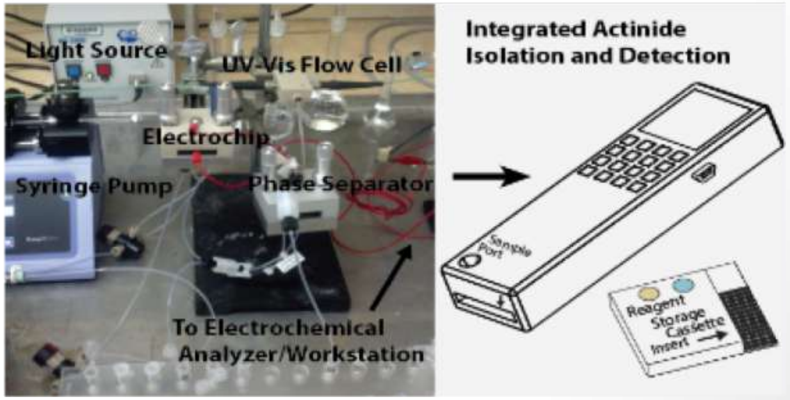
Steel CC

Microfluidic Systems for Rapid Radionuclide Separation and Detection

- **Microfluidic device to combine aqueous and organic phases, rapidly mix, then separate phases, following by analysis**
- **Selective Extraction of radionuclides on a very small scale**
- **Can be implemented either as a bench-top setup or as a portable detector**
- **Potential applications: rapid Pu separation and detection from Uranium and FP for safeguards; ”dirty bomb” analysis**







PUBLICATIONS

- Artem V Gelis, Peter Kozak, Andrew T Breshears, M Alex Brown, Cari Launiere, Emily L Campbell, Gabriel B Hall, Tatiana G Levitskaia, Vanessa E Holfeltz, Gregg J Lumetta *Closing the Nuclear Fuel Cycle with a Simplified Minor Actinide Lanthanide Separation Process (ALSEP) and Additive Manufacturing.* **Scientific Reports** volume 9, Article number: 12842 (2019)
- Kevin P. Nichols, Rebecca R. Pompano, Liang Li, Artem V. Gelis and Rustem F. Ismagilov Mechanistic Understanding of Nuclear Reprocessing Chemistries by Quantifying Lanthanide Solvent Extraction Kinetics via Microfluidics with Constant Interfacial Area and Rapid Mixing. *J. Am. Chem. Soc., 2011, 133 (39), 15721–15729*.
- Artem V. Gelis and Gregg J. Lumetta. Actinide Lanthanide Separation Process—ALSEP. Ind. Eng. Chem. Res., 2014, 53 (4), pp 1624–1631
- M. Alex Brown, Alena Paulenova, and Artem V. Gelis Aqueous Complexation of Thorium(IV), Uranium(IV), Neptunium(IV), Plutonium(III/IV), and Cerium(III/IV) with DTPA. *Inorg. Chem., 2012, 51 (14), 7741–7748*
- Gelis, A. V., Vandegrift, G. F., Bakel, A., Bowers, D. L., Hebden, A. S., Pereira, C., & Regalbuto, M. (2009). Extraction behaviour of actinides and lanthanides in TALSPEAK, TRUEX and NPEX processes of UREX+. *Radiochimica Acta*, *97*(4–5). https://doi.org/10.1524/ract.2009.1601
- Gelis, A.V., Pereira C, Nichols, K. Microfluidic process monitor for industrial solvent extraction system. US Patent # 9233859
- Gelis A.V. - Actinide and lanthanide separation process (**ALSEP**) US Patent 8,354,085, 2013

- More @google scholar profile https://scholar.google.com/citations?user=0C7sSjMAAAAJ&hl=en

Surface and Interface Characterization of Materials for Energy Conversion

Dr. Clemens Heske

Professor

Department of Chemistry and Biochemistry

heske@unlv.nevada.edu

Expertise

- Electronic and Chemical Structure of Energy-Conversion Materials
- Surface and Interface Characterization
- Soft x-ray and Electron Spectroscopy
- Scanning Probe Microscopy
- Synchrotron Radiation

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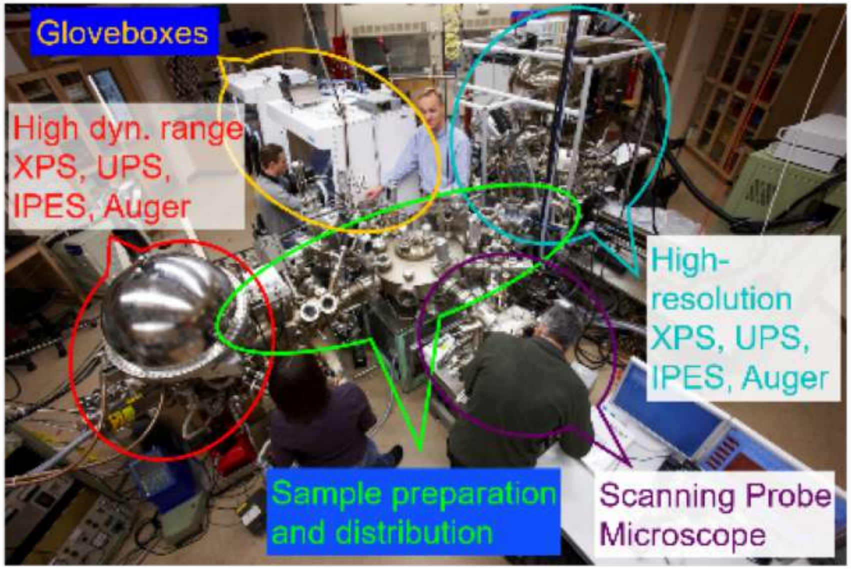
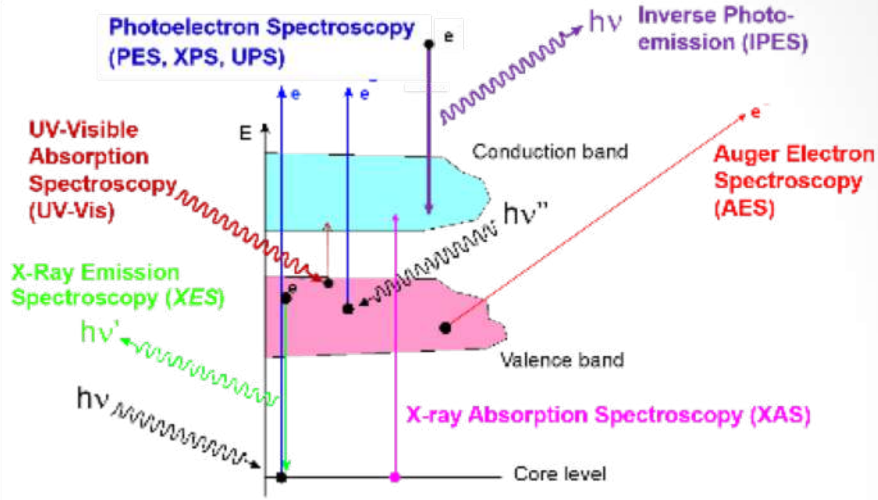
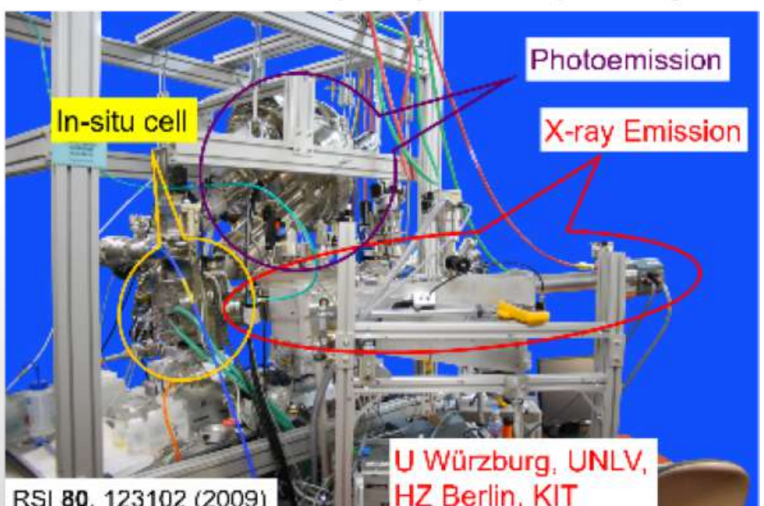
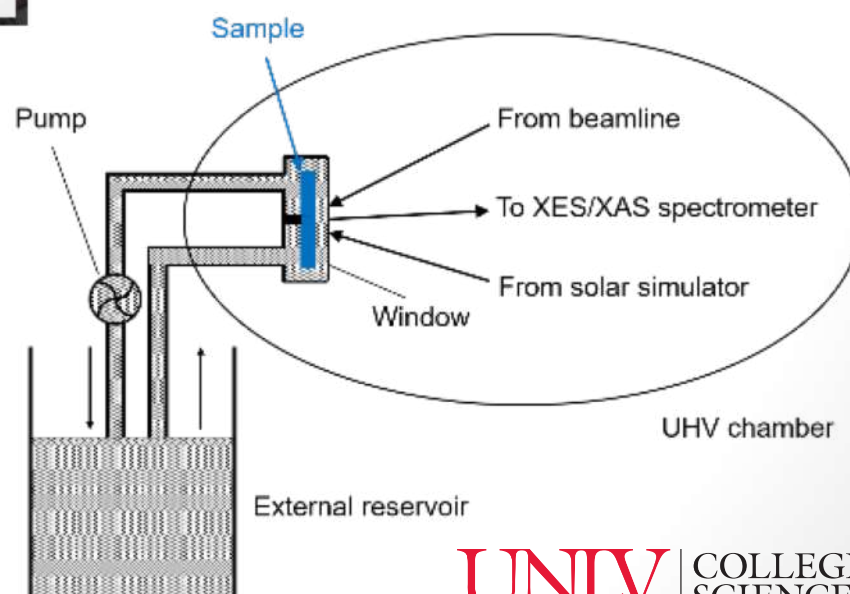
Surface and Interface Characterization





SALSA: Solid And Liquid Spectroscopic Analysis





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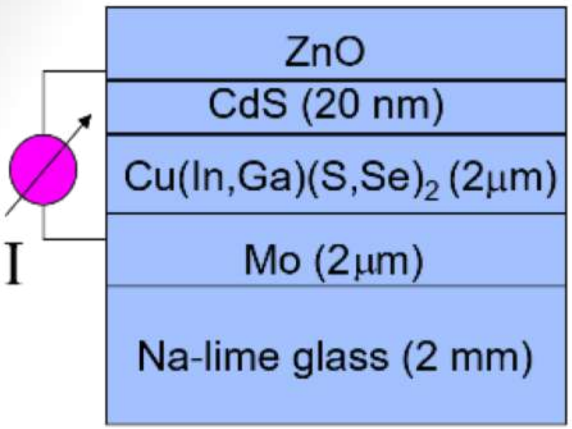
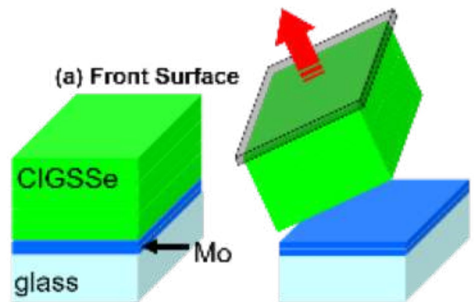
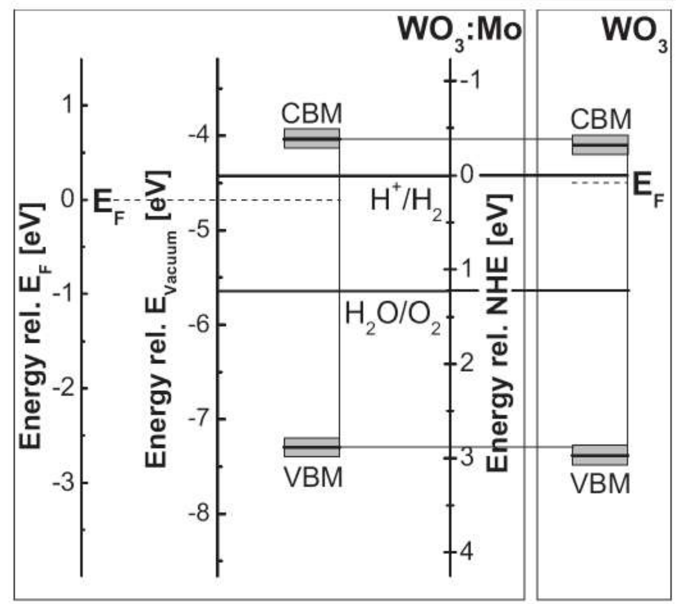
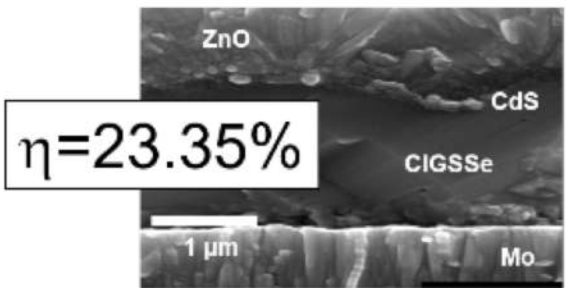
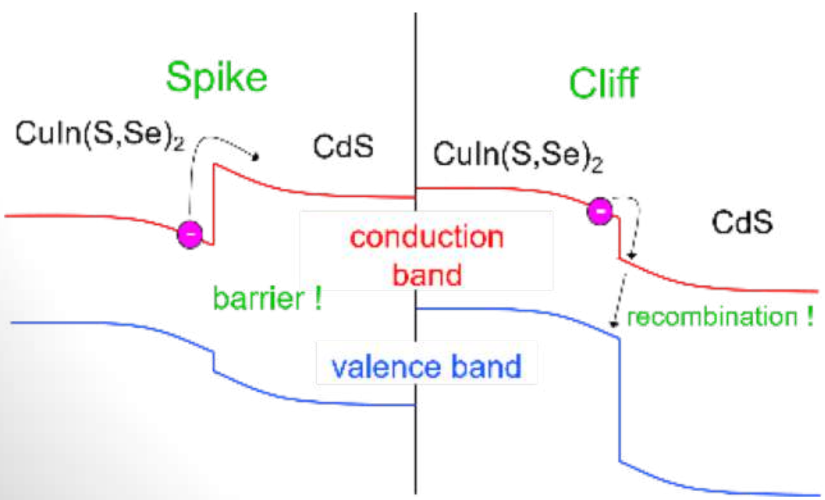
Materials for Energy Conversion

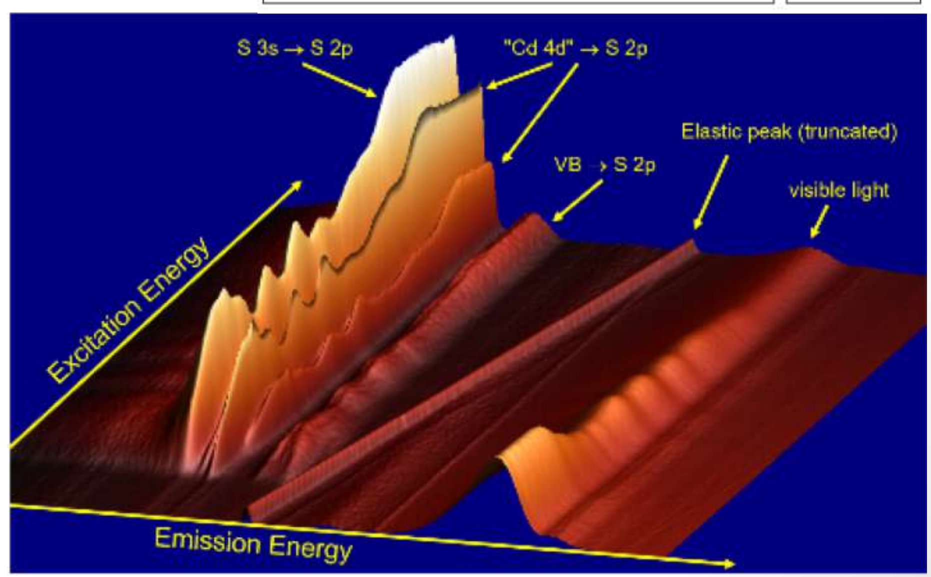












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High Temperature Geochemistry

Dr. Shichun Huang
Department of Geoscience
Phone: (702) 895-2635
Email: shichun.huang@unlv.edu

Expertise:

Chemistry of earth's mantle and early solar systems

Non-traditional stable isotopes

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UNLV Inductively Coupled Plasma Mass Spectrometer (ICP-MS) lab

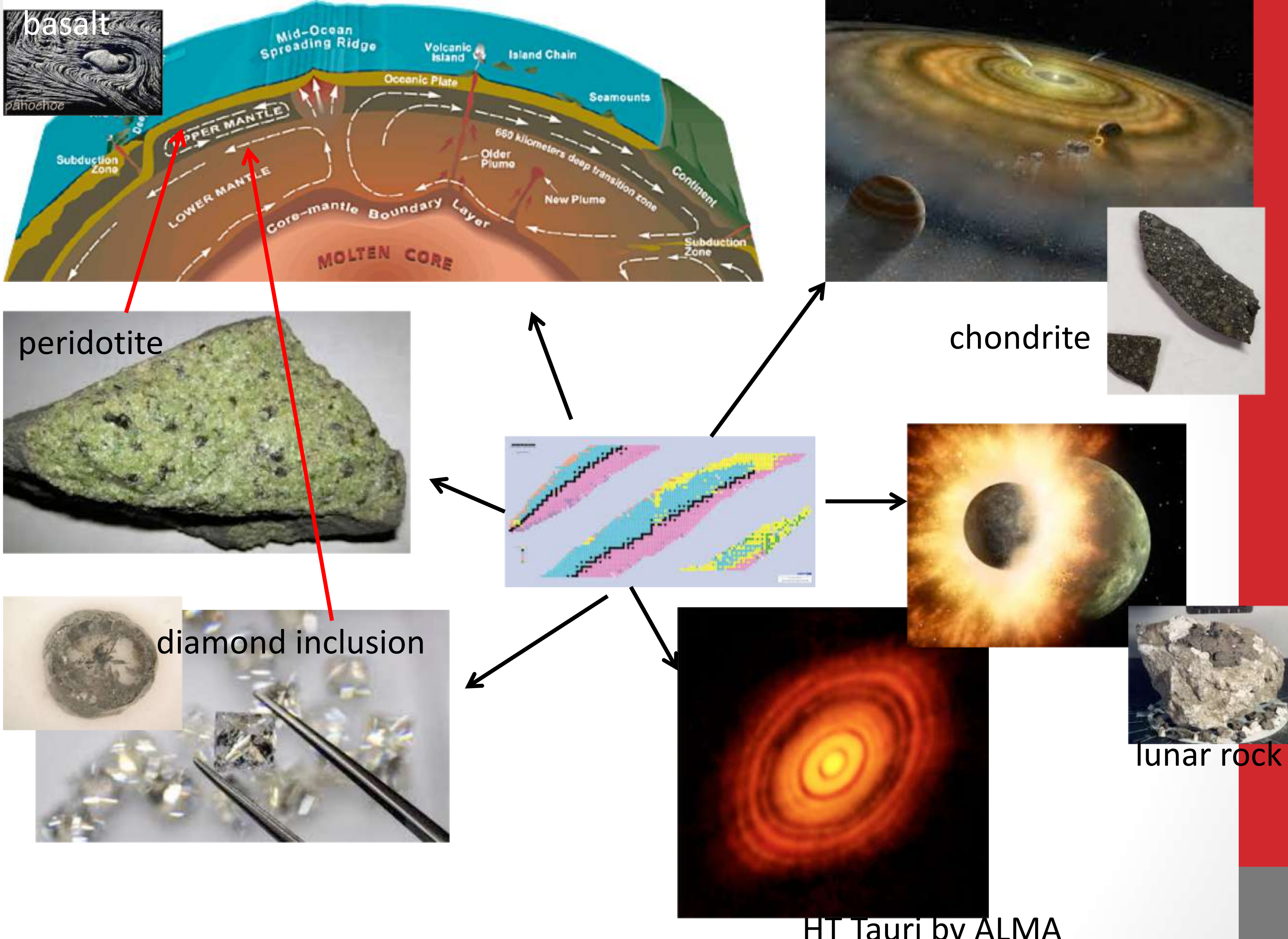
iCAP Qc ICP-MS from ThermoFisher (installed in 2015)

Multi-Collector ICP-MS (to be installed in 2021, funded by NSF MRI)

193 nm excimer laser ablation system (to be installed in 2020, funded by NASA PME)

wet chemistry lab under positive air pressure

- ❑ elemental and isotopic measurements for almost all non-volatile elements
- ❑ solution mode: detection limits at **10s of ppq (10^{-15}) level** for lanthanides and **actinides**
- ❑ in situ measurement: spatial resolution at **< 5 micron**

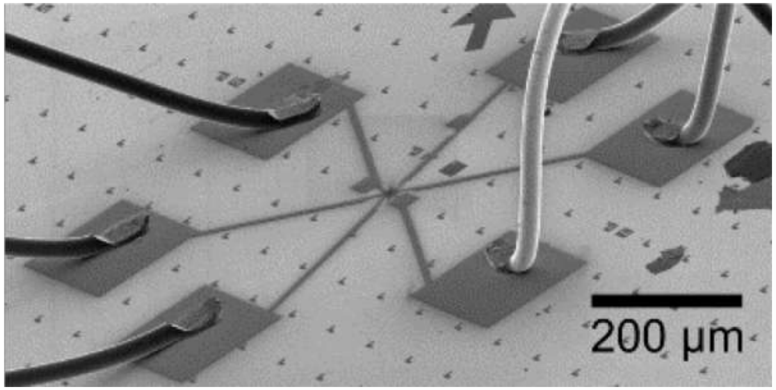


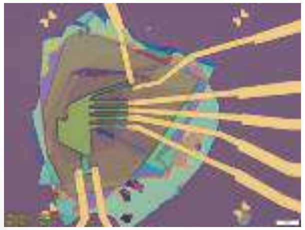
- I use elemental and isotopic tracers to study the solid Earth and the early solar systems
- applied science: trace metals in local aqua systems; Cr remediation

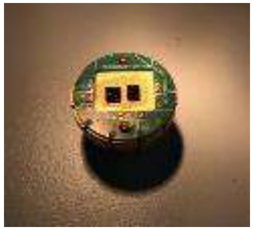
Island – Quantum computing, quantum sensing

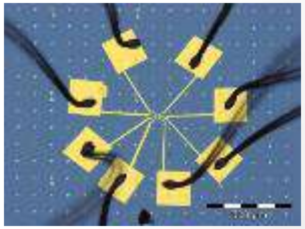
Areas of Research

- Nanotechnology, device physics
- Photodetection and quantum sensing
- Quantum computing, topological qubits
- Non-equilibrium, driven systems
- Superconductivity, proximity effects
- Low dimensional materials





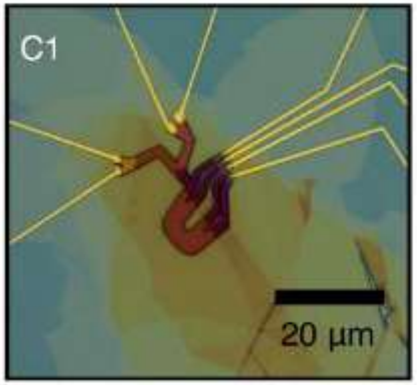


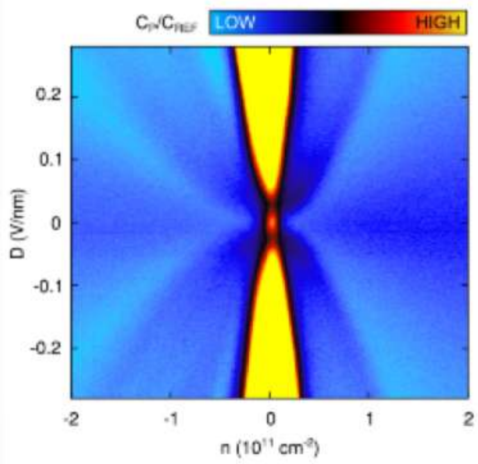



http://islandlab.faculty.unlv.edu/

Island – Quantum computing, quantum sensing

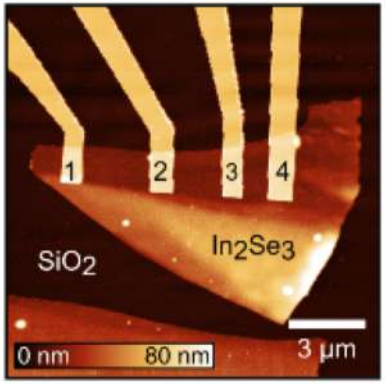
Quantum computing: Topological phases for fault-tolerant, universal quantum computing.

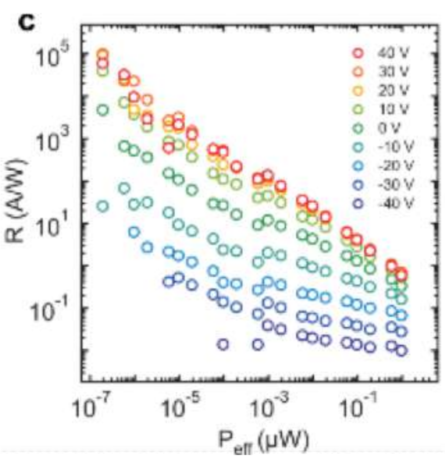




Island, J. O., et al. *Nature* **571** (2019): 85–89.

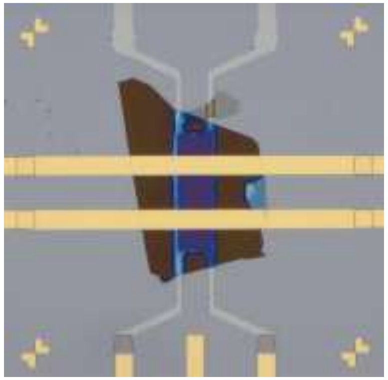
Industry-disruptive photodetectors: Ultra-sensitive phototransistors designed with 2D materials and heterostructures.

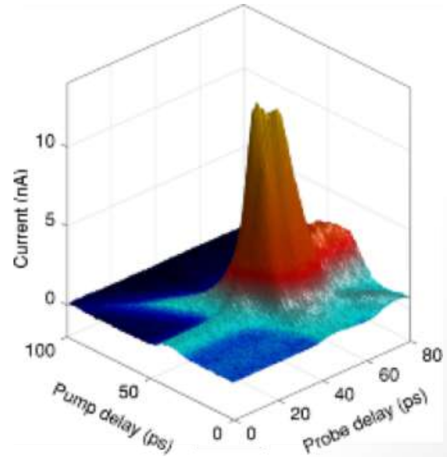




Island, J. O., et al. *Nano Letters* **15** (2015): 7853-7858.

Transient phases of driven systems: Non-equilibrium response of pumped nanomaterials below the diffraction limit.





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Island – Quantum computing, quantum sensing

Journal publications

Spin-orbit-driven band inversion in bilayer graphene by van der Waals proximity effect
J. O. Island, X. Cui, C. Lewandowski, J. Y. Khoo, E. M. Spanton, H. Zhou, D. Rhodes, J. C. Hone, T. Taniguchi, K. Watanabe, L. S. Levitov, M. P. Zaletel, A. F. Young, *Nature* **571**, 85-89 (2019). (arXiv)

Enhanced superconductivity in atomically thin TaS2
E. Navarro-Moratalla*, J. O. Island*, S. Manas-Valero, E. Pinilla-Cienfuegos, A. Castellanos- Gomez, J. Quereda, G. Rubio-Bollinger, L. Chirolli, J. A. Silva-Guilln, N. Agrat, G.A. Steele, F. Guinea, H.S.J. van der Zant, E. Coronado, *Nature Communications* **15**, 7853 (2016). (arXiv)

Proximity-induced Shiba states in a molecular junction
J. O. Island, R. Gaudenzi, J. de Bruijckere, E. Burzuri, C. Franco, M. Mas-Torrent, C. Rovira, J. Veciana, T. M. Klapwijk, R. Aguado, H. S. J. van der Zant, *Physical Review Letters* **118**, 117001 (2017). (arXiv)

TiS3 transistors with tailored morphology and electrical properties
J. O. Island, M. Barawi, R. Biele, A. Almazan, J.M. Clamagirand, J.R. Ares, C. Sanchez, H.S.J. van der Zant, J.V. Alvarez, R. D'Agosta, I. J. Ferrer, A. Castellanos-Gomez, *Advanced Materials* **27**, 2595 (2015). (arXiv)

Environmental instability of few-layer black phosphorus
J. O. Island, G.A. Steele, H.S.J. van der Zant, and A. Castellanos-Gomez, *2D Materials* **2**, 011002 (2015). (arXiv)

Ultrahigh photoresponse of few-layer TiS3 nanoribbon transistors
J. O. Island, M. Buscema, M. Barawi, J.M. Clamagirand, J.R. Ares, C. Sanchez, I.J. Ferrer, G.A. Steele, H.S.J van der Zant, and A. Castellanos-Gomez, *Advanced Optical Materials* **2**, 641 (2014). (arXiv)

Gate controlled photocurrent generation mechanisms in high-gain In2Se3 phototransistors
J. O. Island*, S.I. Blanter*, M. Buscema, H.S.J. van der Zant, and A. Castellanos-Gomez, *Nano Letters* **15**, 7853 (2015). (arXiv)

Precise and reversible band gap tuning in single-layer MoSe2 by uniaxial strain
J. O. Island, A. Kuc, E.H. Diependaal, H.S.J. van der Zant, T. Heine, and A. Castellanos- Gomez, *Nanoscale* **8**, 2589 (2016). (arXiv)

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Economic Geology

Dr. Simon Jowitt

Department of Geoscience

simon.jowitt@unlv.edu

Expertise:

Geochemistry, mineral exploration, ore deposit geology, mineral economics, mineral exploration technique development, igneous petrology, environmental impact of mining

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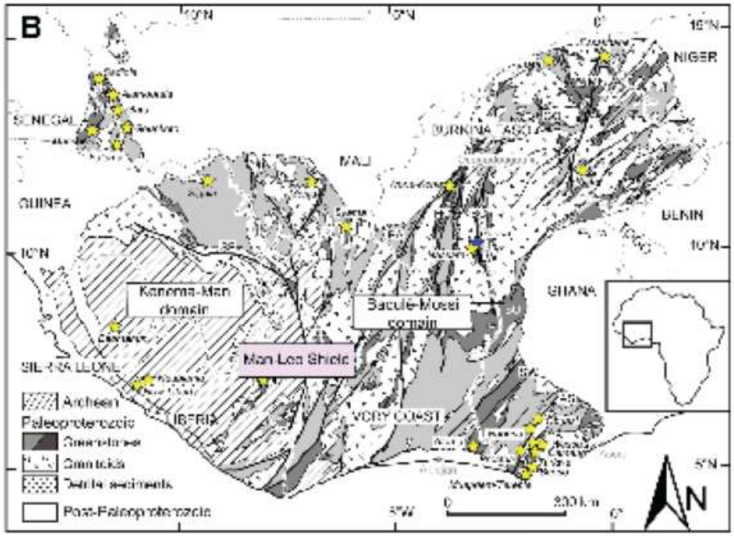
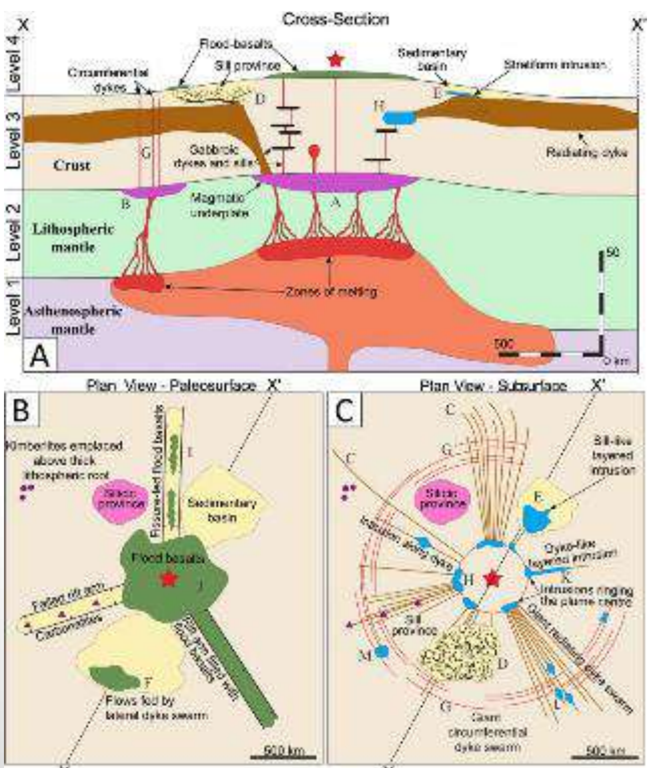
Geochemistry

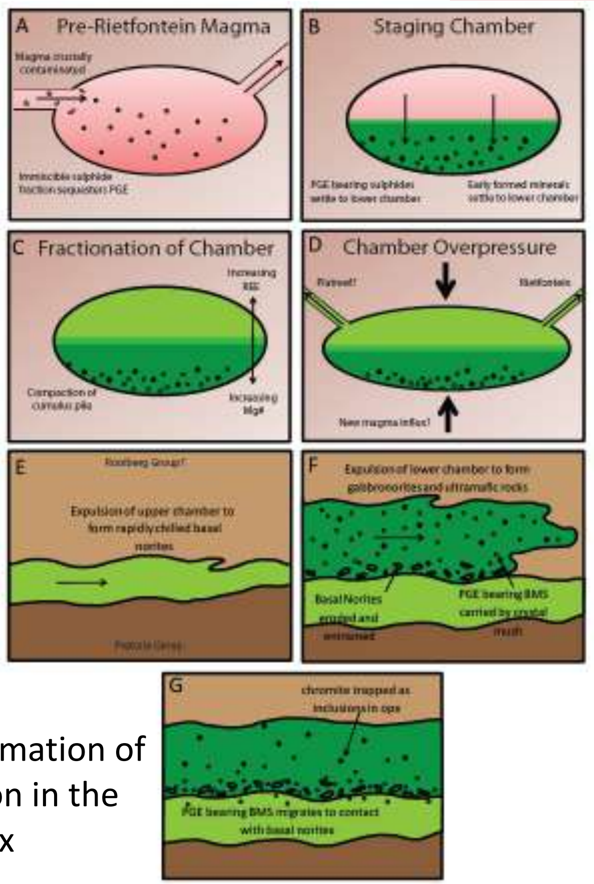
- Understanding mineralizing systems
- Links between tectonic and magmatic events and mineral systems
- Development of mineral exploration tools

Distribution of Orogenic Au deposits within West Africa





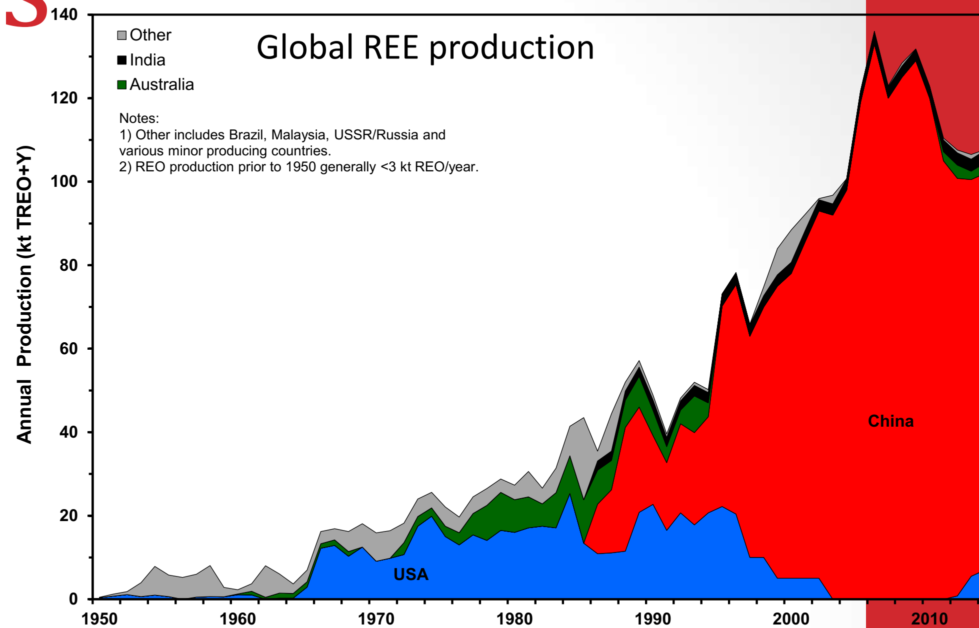
Links between Large Igneous Province plumbing systems and mineralization



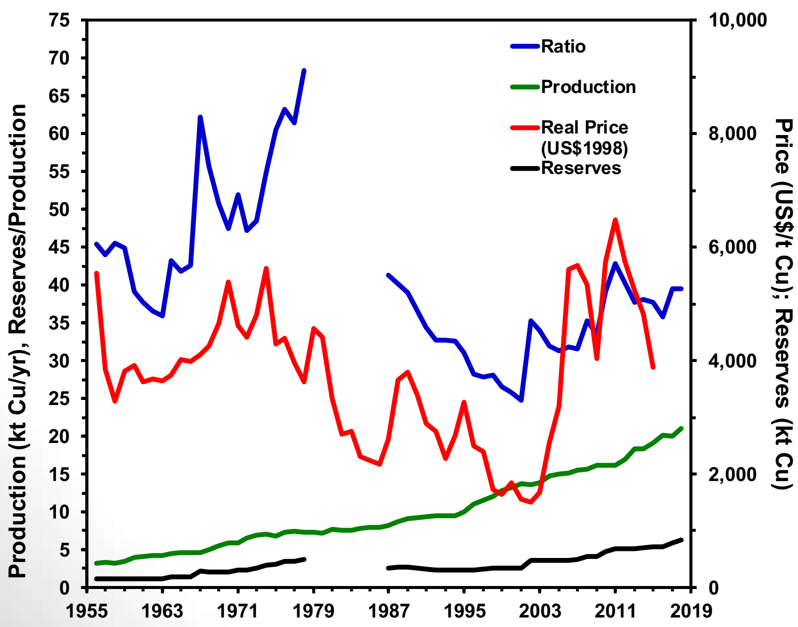
Model for the formation of PGE mineralization in the Bushveld Complex

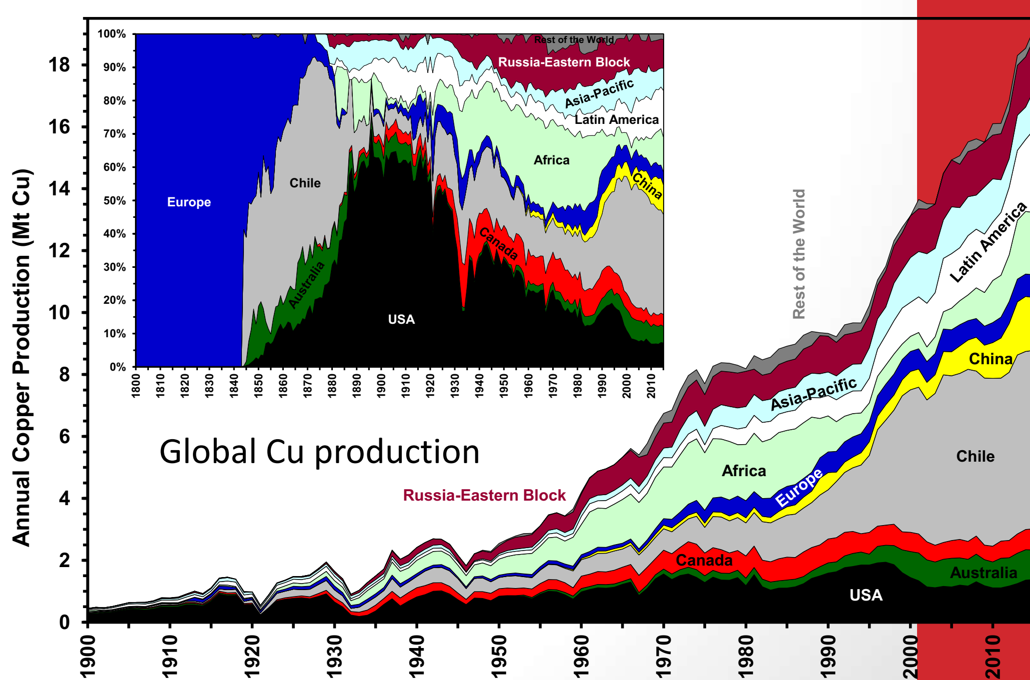
Mineral economics

- Understanding global metal resources
- Assessing future demand and supply
- Materials for green technology and critical metals



Understanding global metal reserves and production

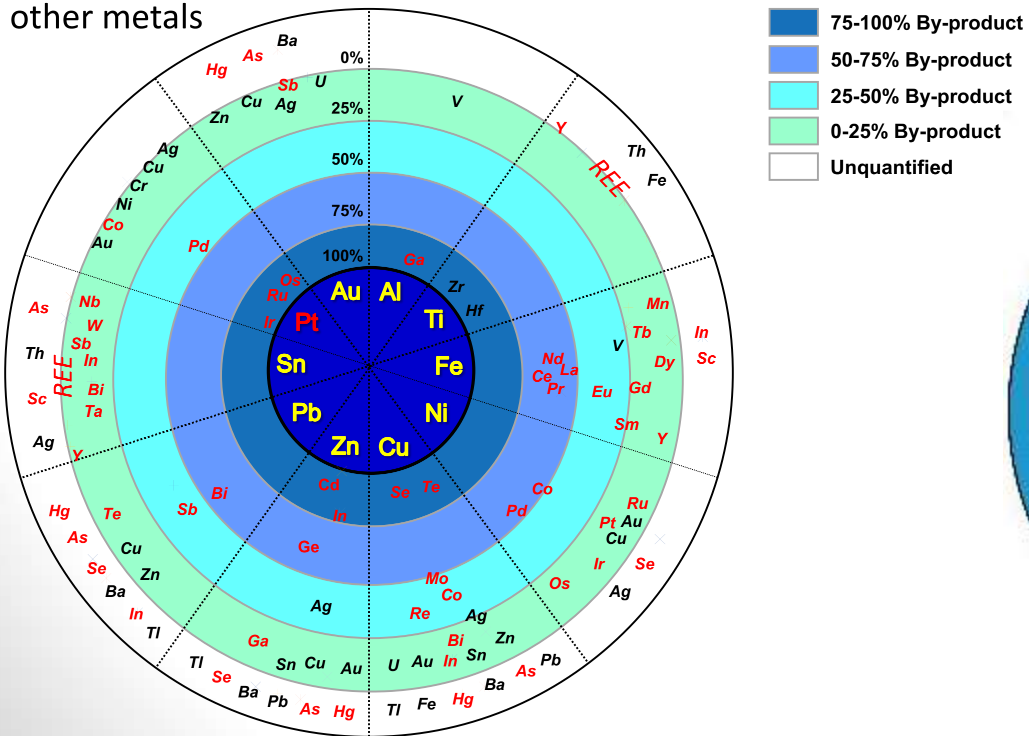




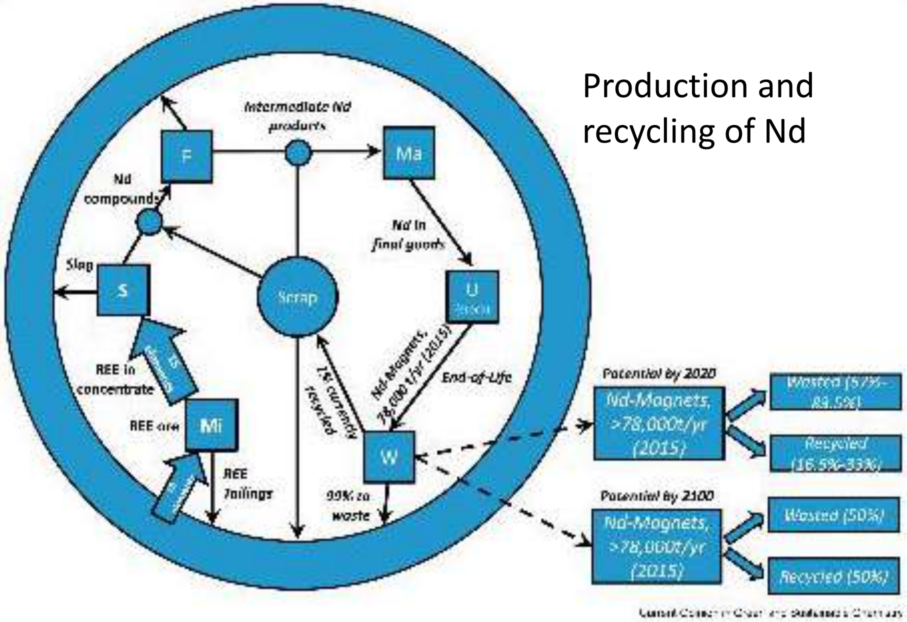
Critical metals

- Identification of potential sources of the critical metals
- Determining the processes that concentrate critical elements and development of associated exploration tools

Metal companionality; understanding how critical metal production is reliant on other metals



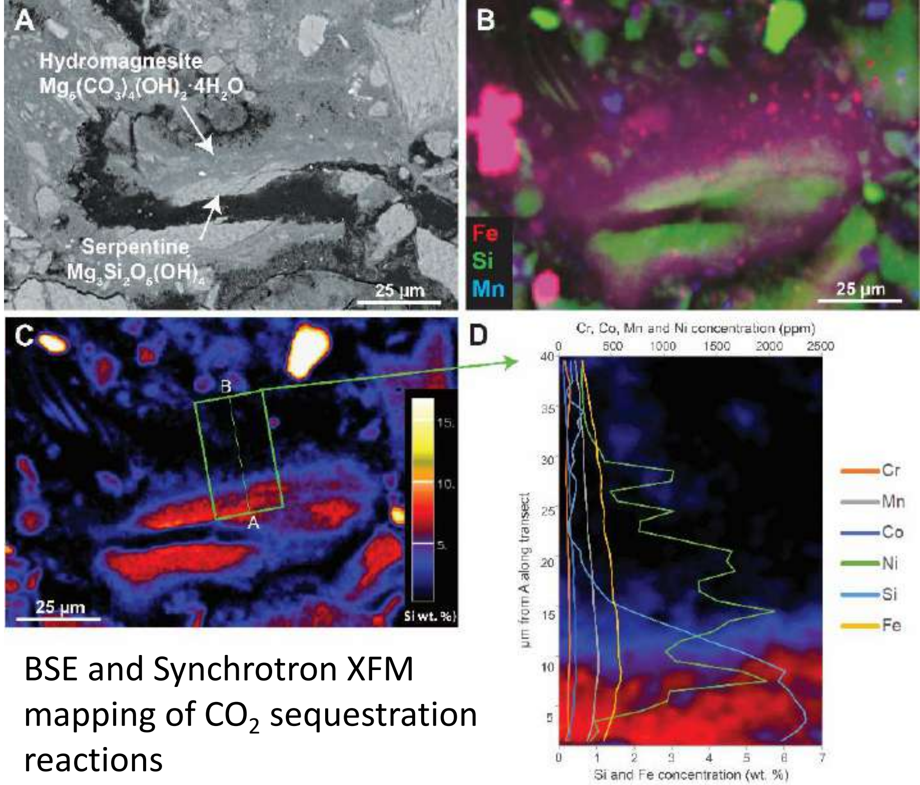
Be-bearing rare metal pegmatite, southern Nevada



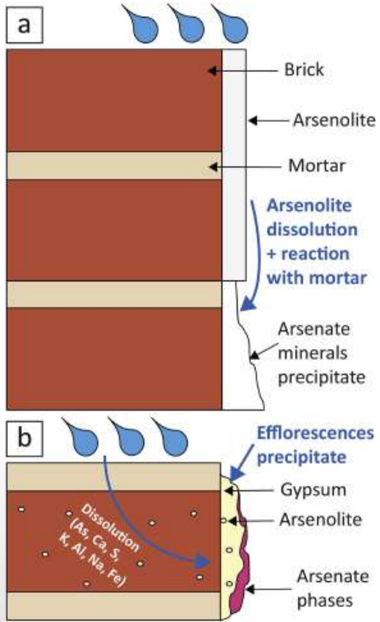
Production and recycling of Nd

Environmental impact of mining

- Assessing environmental impacts
- Potential of wealth from waste; assessing mining waste metal production and CO_2 sequestration potential

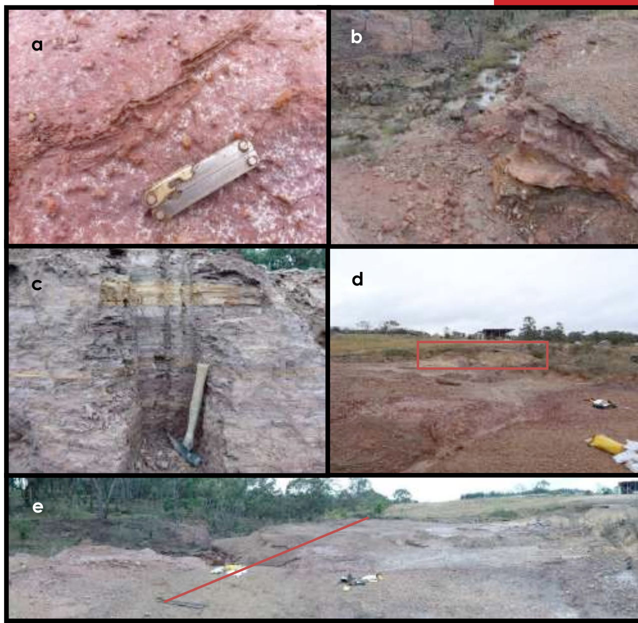


BSE and Synchrotron XFM mapping of CO_2 sequestration reactions



Understanding arsenic mobility in mining and mineral processing environments

Assessing the environmental impact and critical metal potential of mineral processing waste and tailings



Other research areas

- GIS-based mineral prospectivity modeling in 2D and 3D space
- Machine learning approaches to exploration targeting
- Igneous petrology and the formation of Large Igneous Provinces
- Pegmatites and highly evolved rhyolites as sources of critical metals

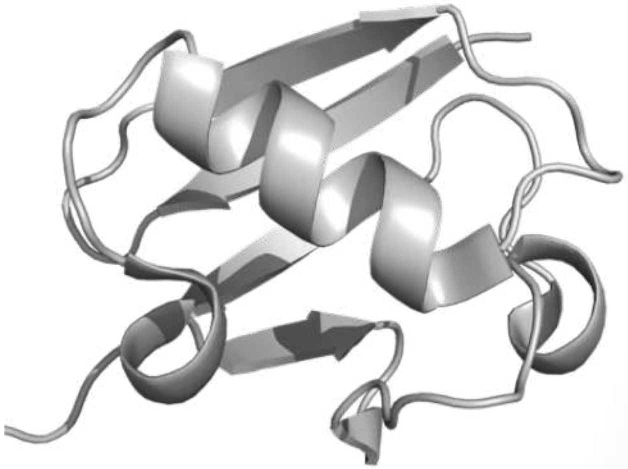
- I run a well-equipped fluid inclusion lab that allows the determination of the composition and the temperature and pressure of trapping of hydrothermal fluids associated with mineral deposit formation. I also have a wide range of expertise in other analytical fields, including SIMS, ICP-MS, LA-ICP-MS, ICP-OES and XRF, stable and radiogenic isotopes, XRD, EPMA, SEM, and synchrotron beam analytical approaches.

Ubiquitin-mediated protein degradation

Dr. Gary Kleiger
Associate Professor
Department of Chemistry and Biochemistry
gary.kleiger@unlv.edu

Expertise

- Structural biology
- Proteomics
- Enzyme kinetics and biophysical assays
- Cell biology



Protein structure of Ubiquitin.

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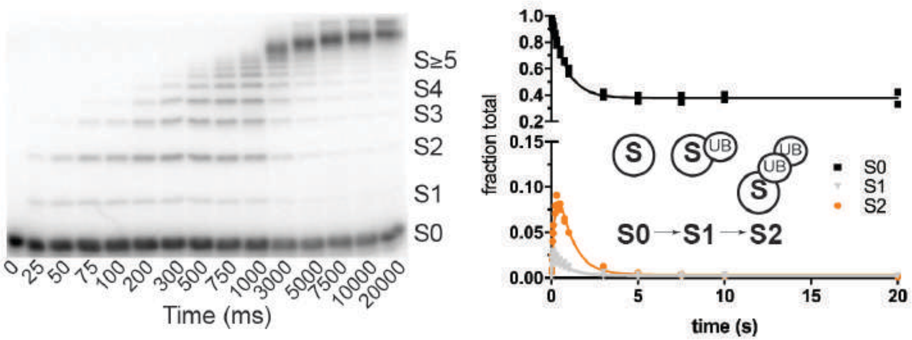
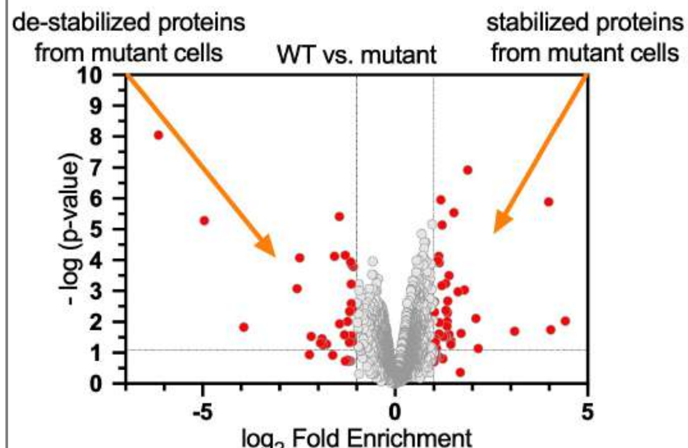
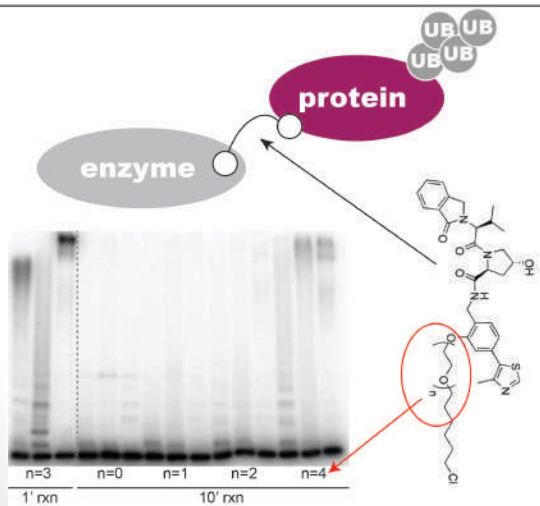
Uncovering how the enzymes that promote protein degradation function in human cells.

Kinetics help us understand how enzymes select protein targets for modification with ubiquitin.



High-resolution mass-spectrometry tells us how mutations in enzymes that lead to human disease affect the stabilities of key human cellular proteins.





Small molecule inducers of protein degradation can be used to treat human disease. We study the mechanism of how they function both in test tubes and cells.

The Kleiger lab partners with both industry and academic labs to help discover treatments for human diseases such as cancer.

Mass-spec proteome exploration with Dr. Don Kirkpatrick at Genentech Inc.

How to utilize small molecules to induce the degradation of disease-causing proteins with Dr. Craig Crews (Yale and founder of Arvinas Inc.).

Cryo-EM and structural biology with Max Planck Institute of Biochemistry Director Dr. Brenda Schulman.

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Novel Chemistry Using Highly Ionizing Radiation

Michael Pravica, Ph.D.
Professor of Physics
Department of Physics and Astronomy
Phone: (702)895-1723
Email: michael.Pravica@unlv.edu

Expertise:
- *Useful Hard X-ray photochemistry*
- High pressure
- Spectroscopy
- *Ion Beam Nuclear Transmutation Doping*

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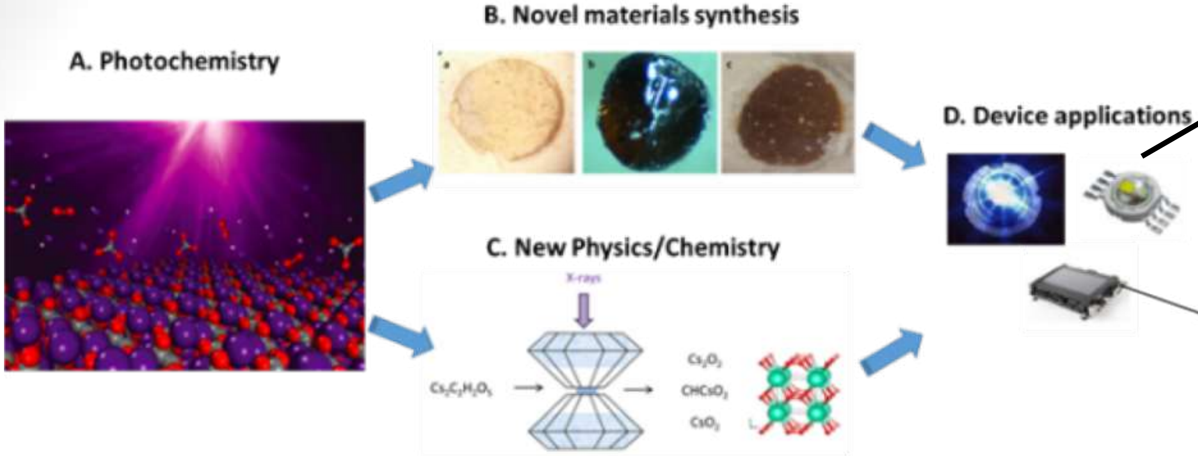
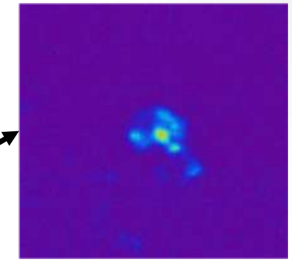
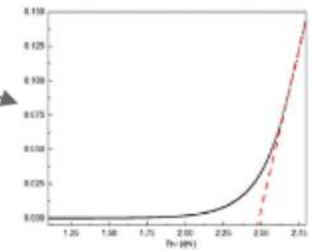
Pravica Group Research





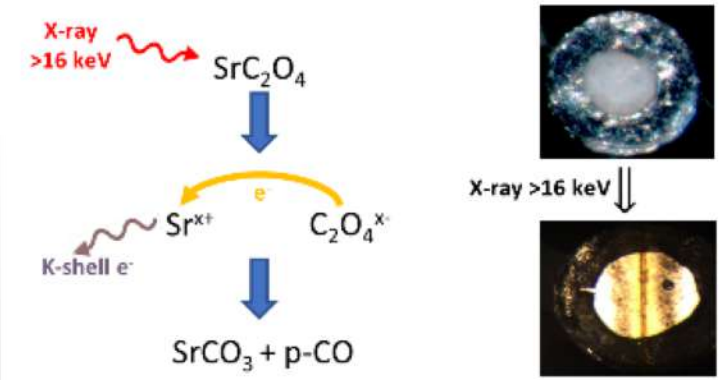
Optical mixer

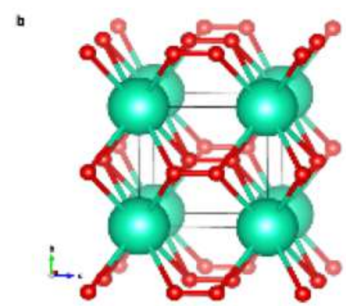


Wide bandgap semiconductor

Radiation-hardened sensors/direct energy conversion devices for EXTREME CONDITIONS
or tuned solar materials

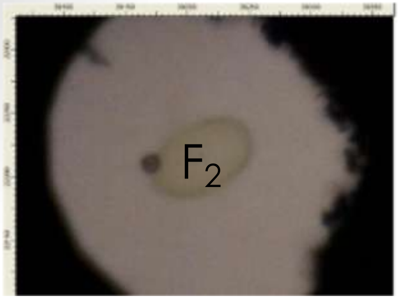
Useful hard x-ray photochemistry

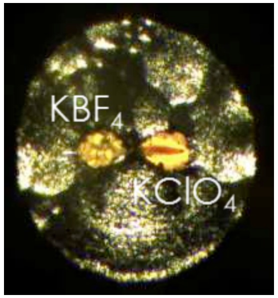




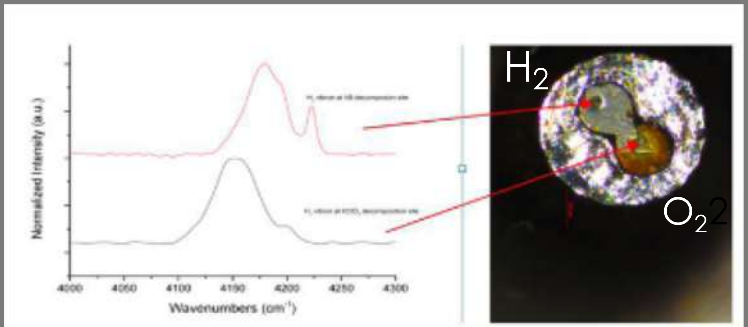
Novel structures of known materials produced
With hard x-rays and high pressure (e.g. CsO_2)

High Pressure Fluorine Chemistry



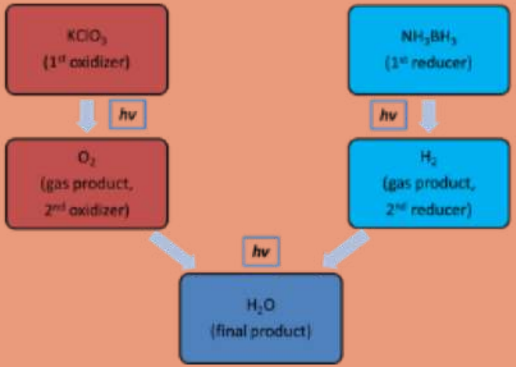


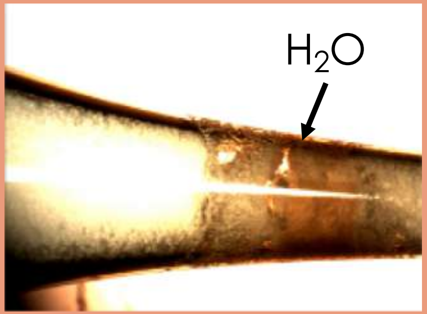
$2F_2 + O_2 \xrightarrow{h\nu} 2OF_2$ @ 3 GPa



5 GPa

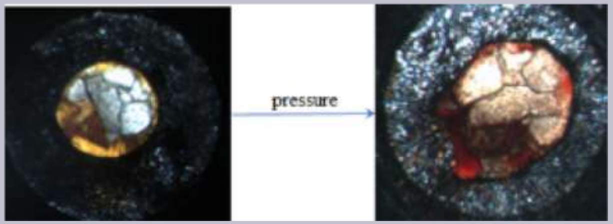
Molecular mixtures at high pressure





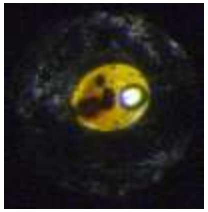
X-ray induced combustion

Inner shell chemistry at high pressure



$XeF_2 \xrightarrow{h\nu} Xe + F_2$ (*in situ* x-ray fluorination)

$HgF_2 + F_2 \xrightarrow{h\nu} HgF_4$



UV-irradiation produced N_2 bubble

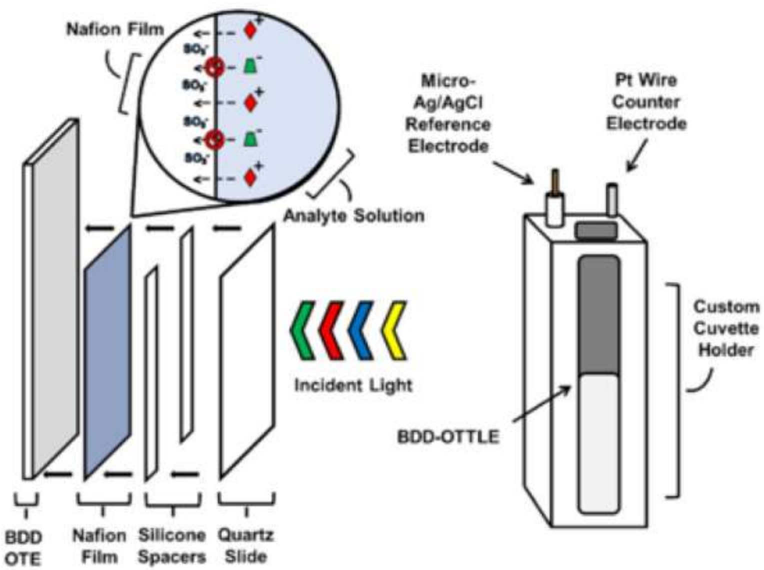
UV irradiation facility

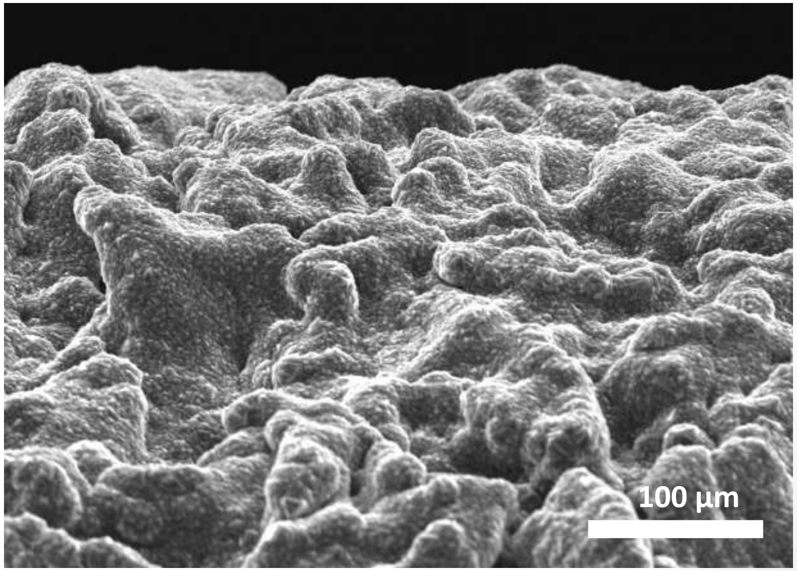
Large Volume Press
For pressure-induced chemistry

Electrochemistry and Spectroelectrochemistry in molten salts for the development of the molten salt nuclear reactor

- Fundamental redox and thermodynamic properties of nuclear fuel can be gained using electrochemistry and spectroelectrochemistry.

- Diamond electrodes are specifically amenable to use as the sensing material due to its robustness and tunable properties

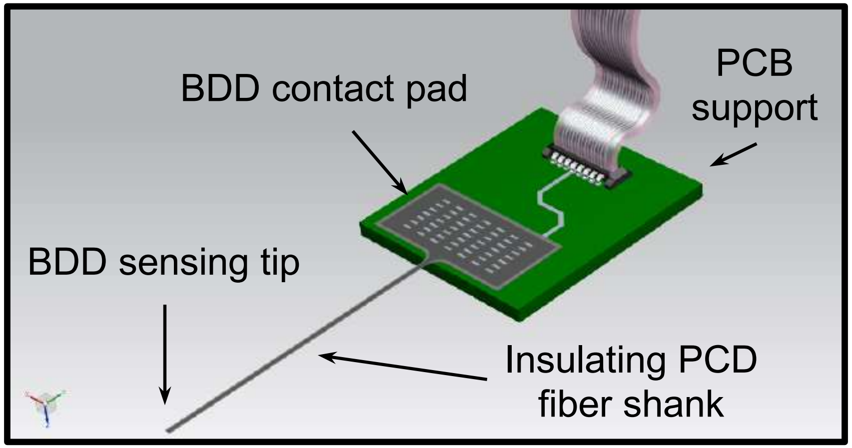


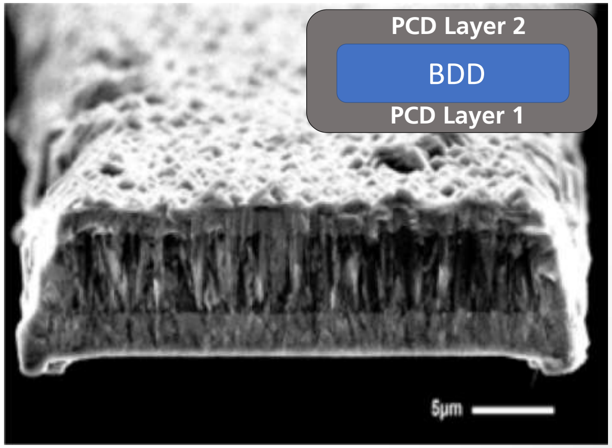


SEM image of diamond film

Detection of clinically- and environmentally-relevant analytes with electrochemical sensors

- The all-diamond microfiber electrodes are a supremely biocompatible electrode. With the advantagouss properties of diamond electrodes, the suite of potential analytes is expanded.
- The conductive BDD core is covered along the shank with un-doped diamond, there by making the device non-reactive.
- The batch-fabricated nature of these devices make them attractive compared to others.





Publication track record

“Polymer-coated Boron Doped Diamond Optically Transparent Electrodes for Spectroelectrochemistry” C.A Rusinek, M. Becker, R. Rechenberg, D. Zhao, K. Ojo, N. Kaval, and W.R. Heineman. Electroanalysis, 2016, 28, 2228-2236.

“Fabrication and characterization of boron doped diamond microelectrode arrays of varied geometry” C.A Rusinek, M. F. Becker, R. Rechenberg, T. Schuelke, Electrochemistry Communications, 2016, 73, 10-14

.

“Large-scale, All Polycrystalline Diamond Structures Transferred on Flexible Parylene-C Films for Neurotransmitter Sensing” B. Fan, Y. Zhu, R. Rechenberg, C.A Rusinek, M.F. Becker, W. Li, Lab-on-a-Chip, 2017, 17, 3159-3167.

“Isatin Detection using an All Boron-doped Diamond 3-in-1 Sensing Platform” M. Ensch, V.Y. Maldonado, G. M. Swain, R. Rechenberg, M.F. Becker, T. Schuelke, C.A Rusinek, Analytical Chemistry, 2018, 90, 1951-1958.

“Analysis of Ag(I) Biocide in Water Samples using Anodic Stripping Voltammetry with a Boron-doped Diamond Disk Electrode” V.Y. Maldonado, P.J. Espinoza, C.A Rusinek, G.M. Swain, Analytical Chemistry, 2018, 90 (11), 6477–6485.

“All Diamond Microfiber Electrodes for Neuroelectrochemistry” C.A Rusinek, Y. Guo, R. Rechenberg, E. Purcell, C. McKinney, M.F Becker, W. Li, Journal of the Electrochemical Society, 2018, 165 (12), G3087-G3092.

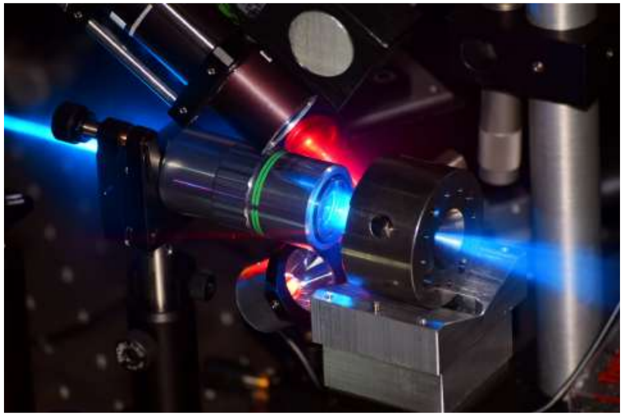
“Indium Tin Oxide Film Characteristics for Cathodic Stripping Voltammetry” M. Ensch, B. Wehring, G.D Landis, M.F Becker, T. Schuelke, C.A Rusinek, ACS Applied Materials and Interfaces, 2019, 11 (18), 16991-17000.

“Detemination of Lead with a Copper-Based Electrochemical Sensor” W. Kang, X. Pei, C.A Rusinek, A Bange, E.N Haynes, W.R Heineman, I. Papautsky. Analytical Chemistry, 2017, 89, 3345-3352.

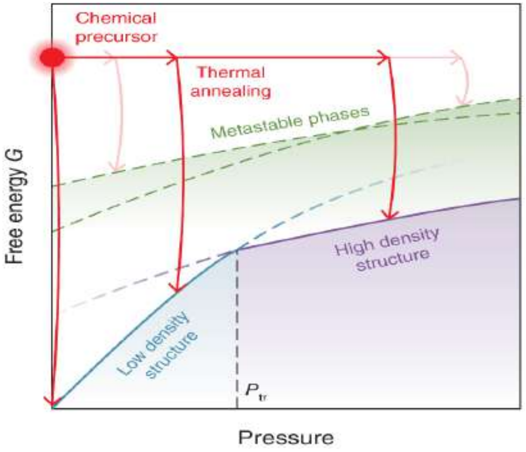
Google Scholar:

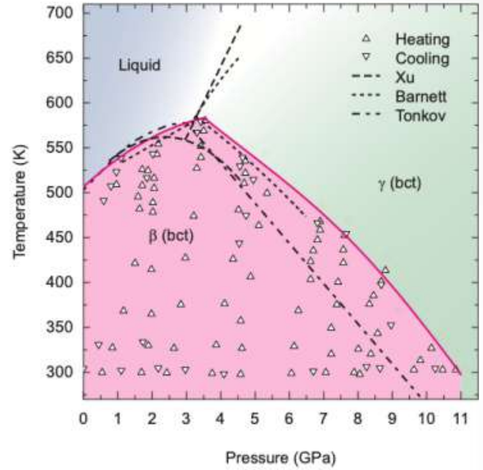
https://scholar.google.com/citations?user=uZyA2VUAAAAJ&hl=en&authuser=1

Salamat Group – Collaboration with MSTS

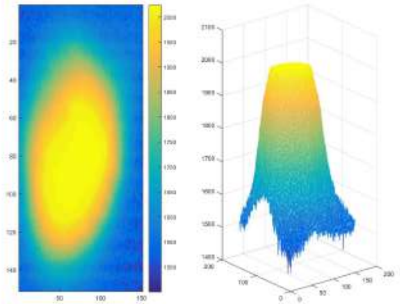


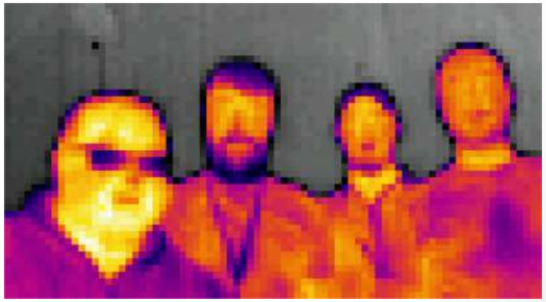
Metrology – accurate mapping of P, V, T





High temperature modelling – understanding emissivity under extreme conditions

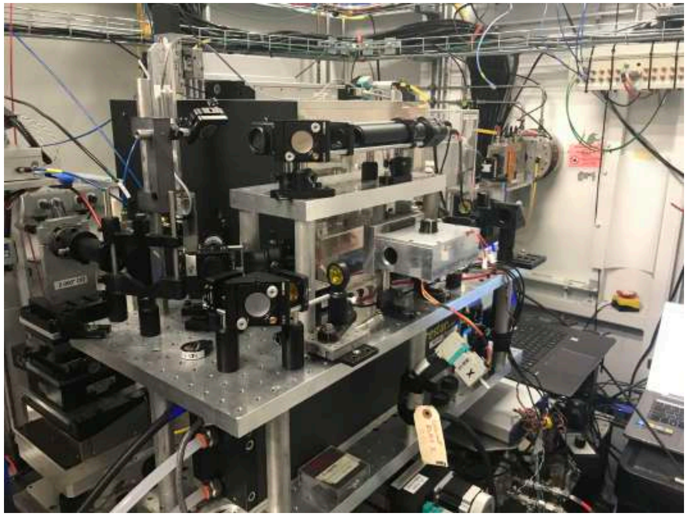


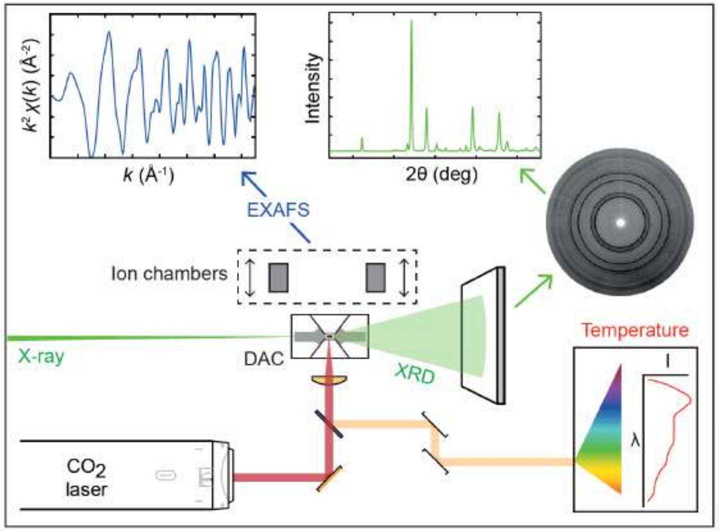


Warm dense matter – probed using EXAFS

- Development of a CO_2 laser heating
- Direct heating of non-metallic systems in a DAC
- First HTHP EXAFS measurements of insulators

- In situ and post heating measurements
- Determining absolute temperature from X-ray spectroscopy





Publications

(1) D. Smith, D. Sneed, N. Dasenbrock-Gammon, E. Snider, G. A. Smith, C. Childs, J. S. Pigott, N. Velisavljevic, C. Park, K. V. Lawler, R. P Dias, A. Salamat*, Anomalous Conductivity in the Rutile Structure Driven by Local Disorder The Journal of Physical Chemistry Letters 10 18 5351-5356 (2019)

(2) J. Kearney M. Grauzinyte D. Smith A. Gulans D. Sneed C. Childs, J. Hinton C. Park J. S. Smith, E. Kim, S. D. S. Fitch, A. L. Hector, C. J. Pickard J. A. Flores-Livas, A. Salamat*, Pressure tuneable visible range band gap in the ionic spinel tin nitride Angewandte Chemie International Edition, 57, 11623-11628 (2018)

(3) C. Childs, K. V. Lawler, A. L. Hector, S. Petitgirard, O. Noked, J. S. Smith, D. Daisenberger, L. Bezacier, M. Jura, C. J Pickard, A. Salamat*, Covalency is Frustrating: $La_2Sn_2O_7$ and the Nature of Bonding in Pyrochlores under High Pressure Temperature Conditions Inorganic chemistry, 57, 15051-15061, (2018)

(4) D. Smith, K. V. Lawler, M. Martinez-Canales, A. W. Daykin, Z. Fussell, G. A. Smith, C. Childs, J. S. Smith, C. J. Pickard, and A. Salamat*, Postaragonite phases of $CaCO_3$ at lower mantle pressures Physical Review M 2, 013605 (2018)

(5) D. Smith, J. S. Smith, C. Childs, E. Rod, R. Hrubiak, G. Shen, A. Salamat*, A CO_2 laser heating system for in situ high pressure-temperature experiments at HPCAT Review of Scientific Instruments 89, 083901 (2018)

(6) R. Briggs, D. Daisenberger, O. T. Lord, A. Salamat, E. Bailey, M. J. Walter, P. F. McMillan*, High-pressure melting behavior of tin up to 105 GPa Physical Review B 95, 054102 (2017)

(7) M. Zaghoo, A. Salamat, I. F. Silvera*, A first order phase transition to metallic hydrogen. Physical Review B 93, 155128 (2016)

(8) A. Salamat*, R. Fischer, R. Briggs, M. I. McMahon, S. Petitgirard, In situ synchrotron X-ray diffraction in the laser heated diamond anvil cell: melting phenomena and synthesis of new materials. Coordination Chemistry Reviews 277-278, 15 (2014)

Google Scholar: Ashkan Salamat

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Materials Compression & Strain

Dr. Oliver Tschauner
Research Professor
Department of Geoscience
Phone: 702-895-3137
Email: olivert@physics.unlv.edu

Expertise:

- Dynamic compression
- Crystal structure analysis
- Minerology

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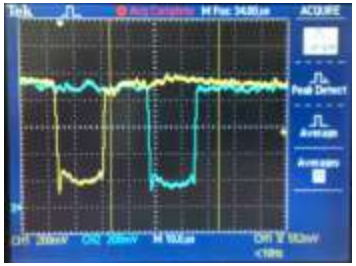
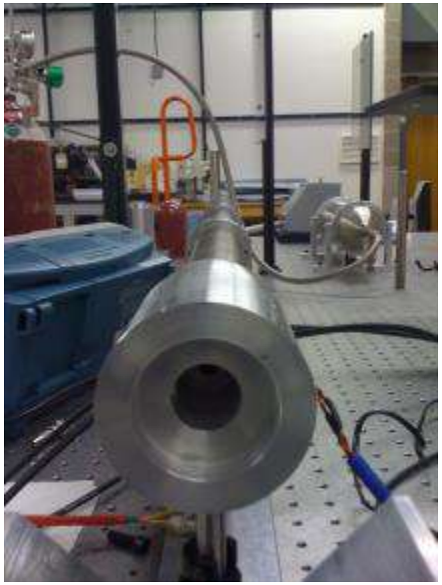
Dynamic Compression

Shockwave Lab:

Compressed He gas, single-stage guns, vertical gun

- Velocimeter, impedance match calculation of sample shock pressure
- Recovery Experiments
- Advantage of advanced structural and chemical characterization at synchrotrons





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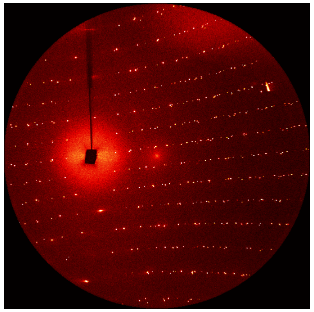
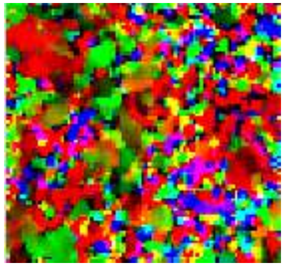
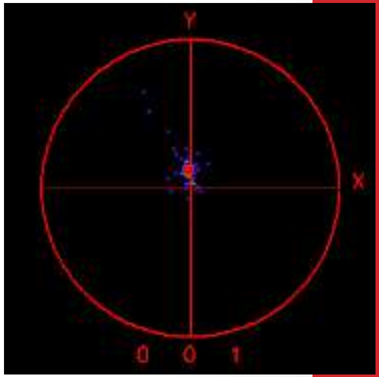
Microscale analysis: Structure, Strain, HE materials

A. Microscale Structure
analysis HPCAT

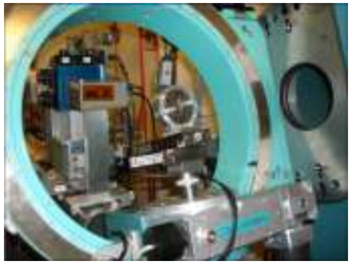


B. Dynamic compression
strain mapping
Laue XRD





C. HE materials
EOS
HPCAT, LLNL



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Explore New Physics Beyond the Standard Model

Dr. Yan Zhou

Department of Physics and Astronomy
Phone: 702-895-3084
Email: yan.zhou@unlv.edu

Expertise

- Precision measurements
- Quantum information processing
- Cold and ultracold molecules
- High-resolution spectroscopy

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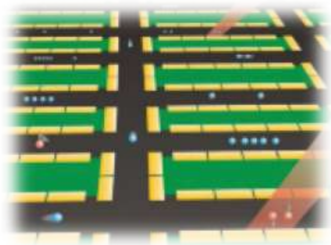
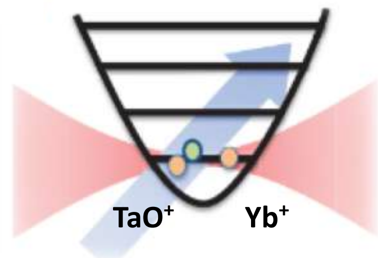
Exploring new phyiscs beyond the Standard Model using ultracold molecular ions and highly-charged ions

Trap



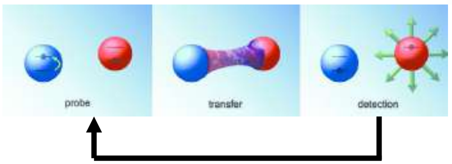
Nature, 417, 709 (2002)

Sympathetic cooling



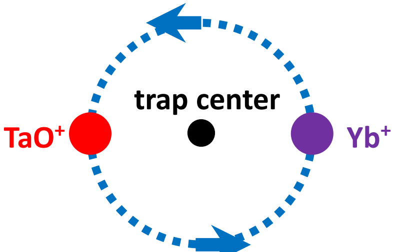
State readout & control

Quantum Logic scheme



feedback

Bias E-field

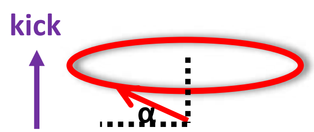


~10 V/cm at 5 MHz

Bias B-field

$$H_{Zeeman} = m_F \mu_B B_{rot}$$

$$H_{Berry} = m_F \omega_{rot} \langle \alpha \rangle$$



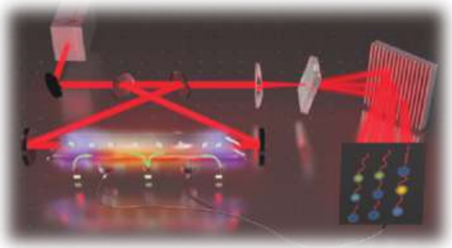
Universal platform

- $^{232}ThF^+$ for eEDM
- $^{229}ThF^+$ for NMQM
- $^{181}TaO^+$ for NMQM
- $^{179}HfO^+$ for NSD-PV
- All can be for Axion

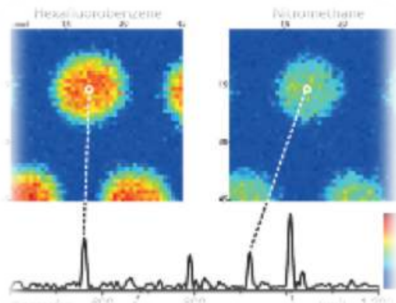
. . .

New technology and new applications based on optical frequency comb

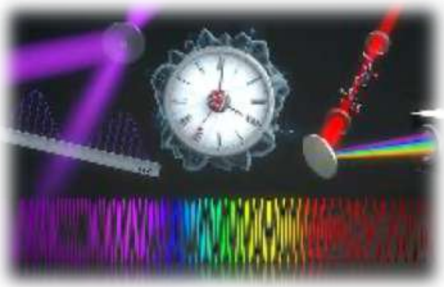
high resolution spectroscopy



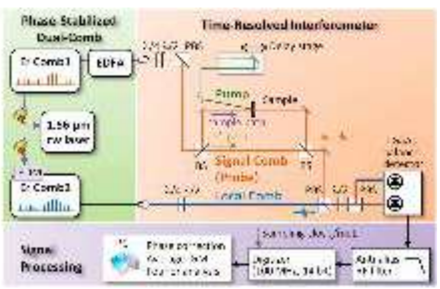
nonlinear spectroscopy

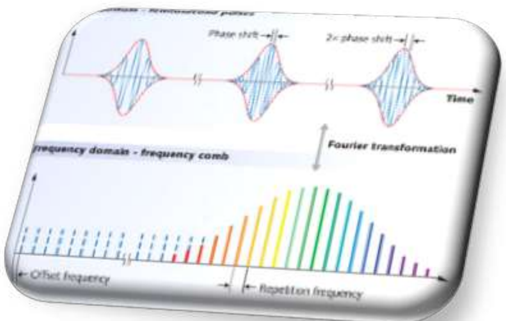


Atomic clock

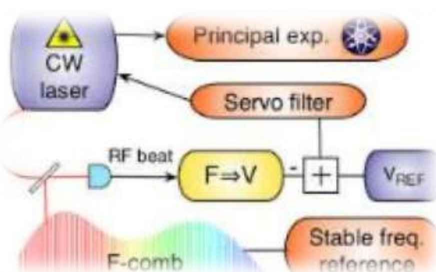


ultrafast spectroscopy

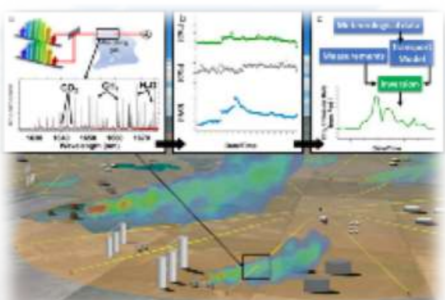




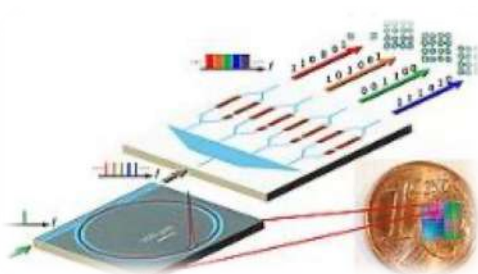
Laser stabilization



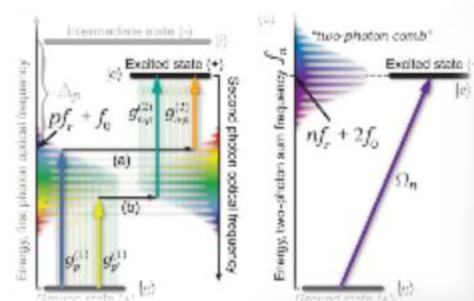
Tracing detection



Communication

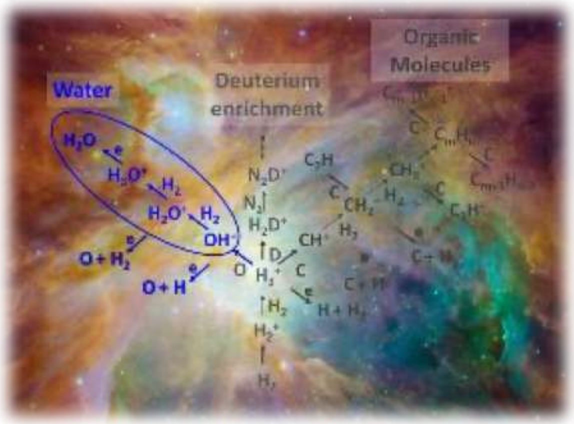


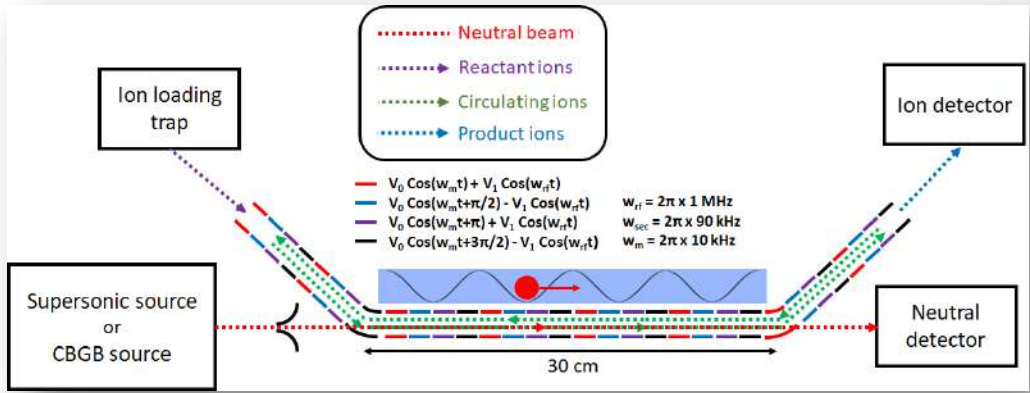
Laser cooling



Figures are from multiple references

Revealing mechanisms of universe evolutions by studying cold ion-radical reactions





- Chain reactions
- Radiative association
- Tunneling resonances
- Collisional resonances
- Discrepancies of reaction dynamics between chemical physics labs and astronomical observatories

Parameters	Expected specifications
Interaction arm length	30 cm
Ion beam velocity	0-1000 m/s
Collision energy range	<0.1 meV to >100 meV
Energy resolution	<0.1 meV
Effective reaction duration	1 s
Detection sensitivity	1 x 10^{-16} $cm^{-3}s^{-1}$