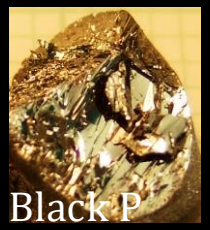
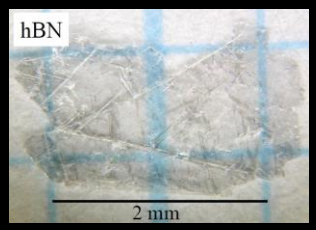
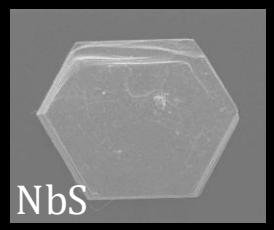
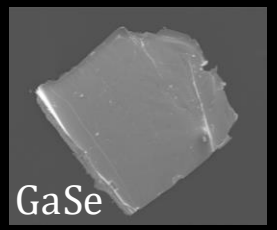
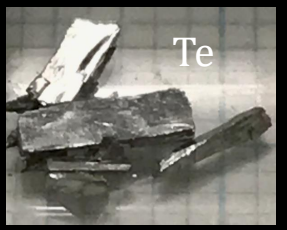
2D Crystals for Science and Applications

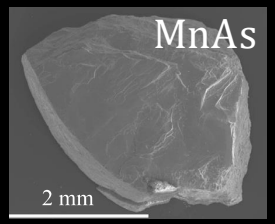


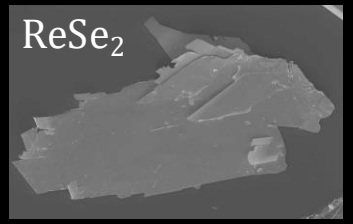


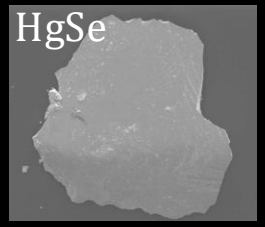


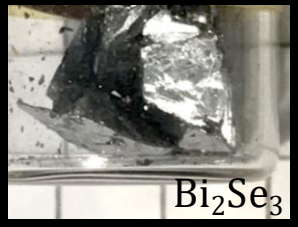


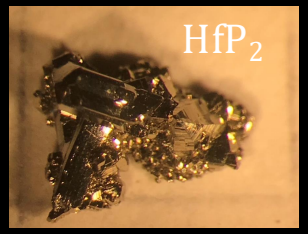


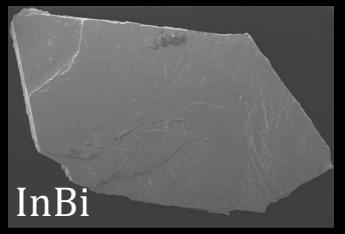


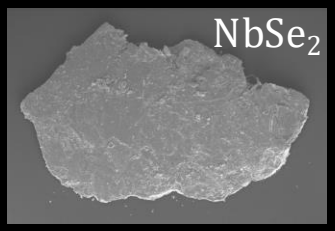


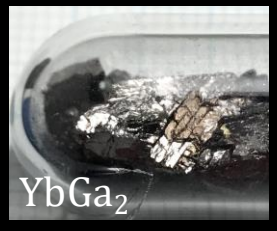


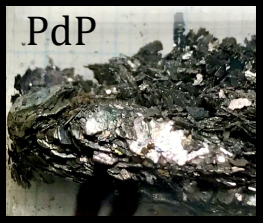


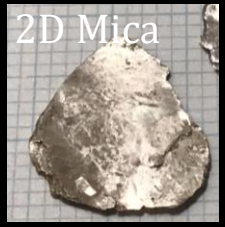


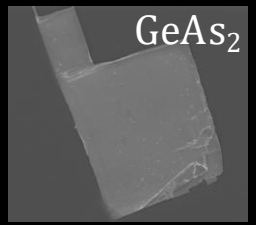


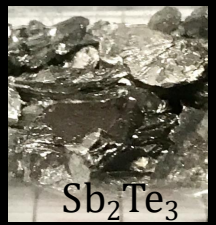


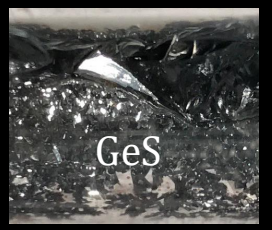








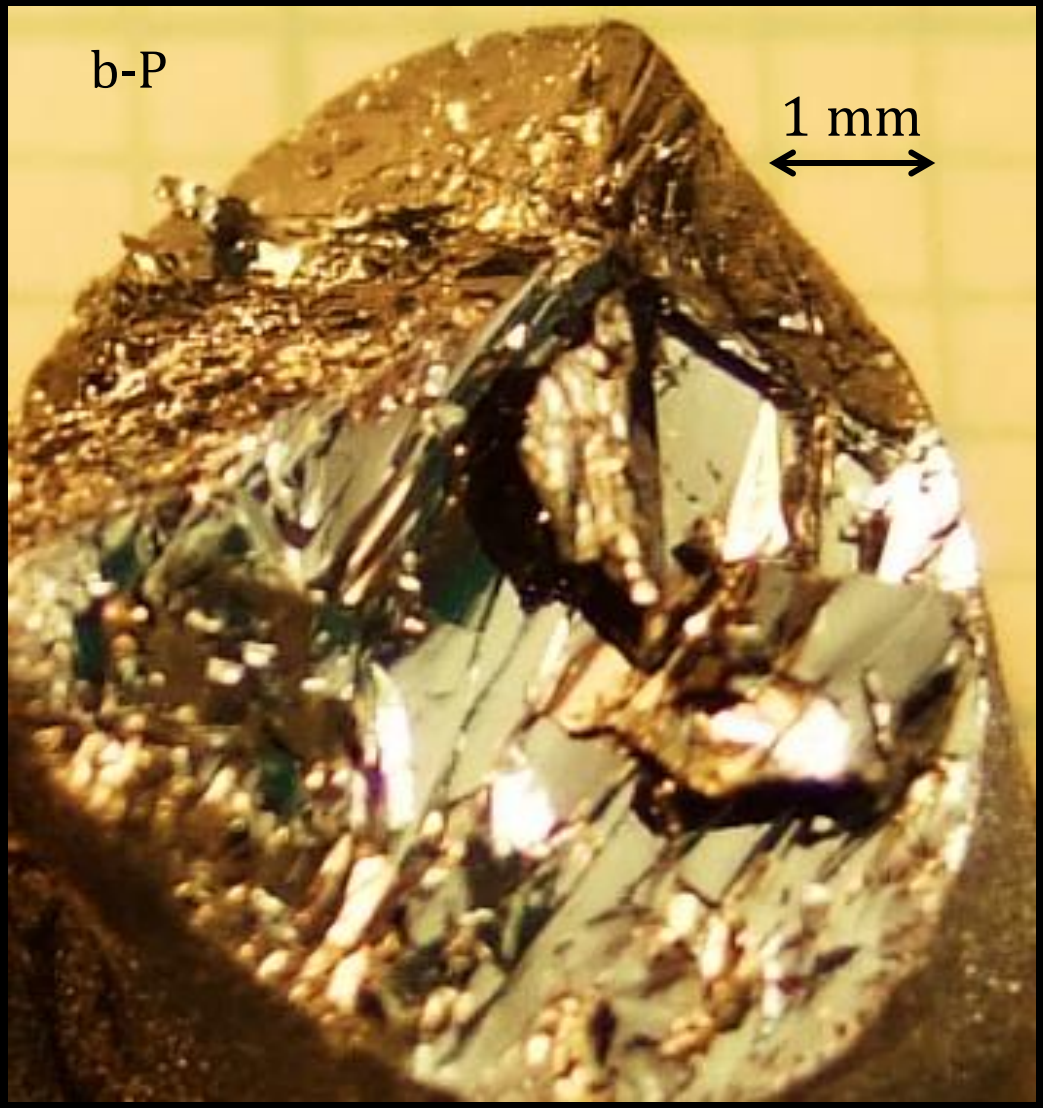




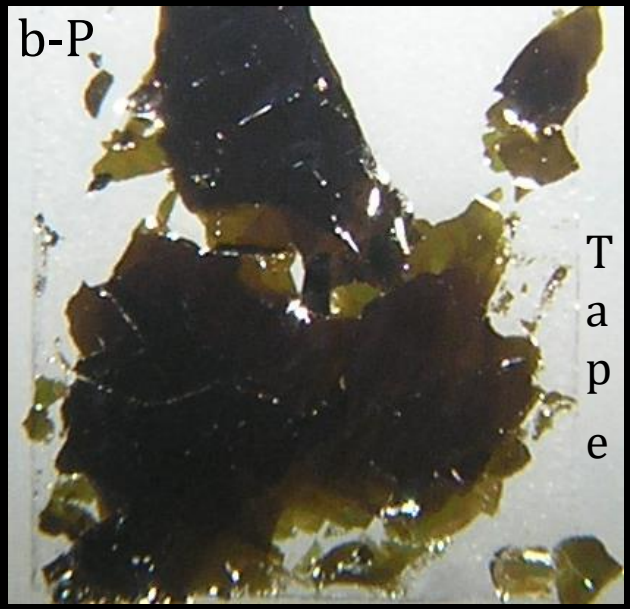
Prices on products are available upon request and depend on various factors such as cost of production, quality, dimensions, etc. Request to: nzhigadlo@gmail.com

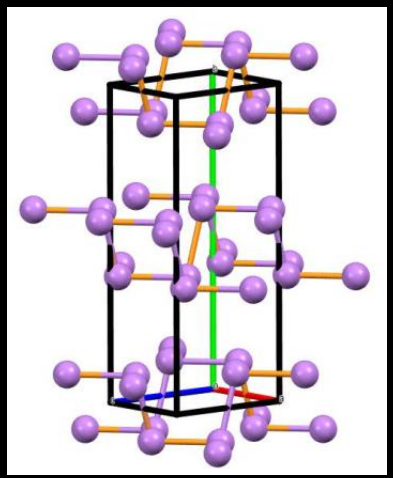
https://crystmat.com

Black Phosphorus



b-P bulk crystals grown at high pressure



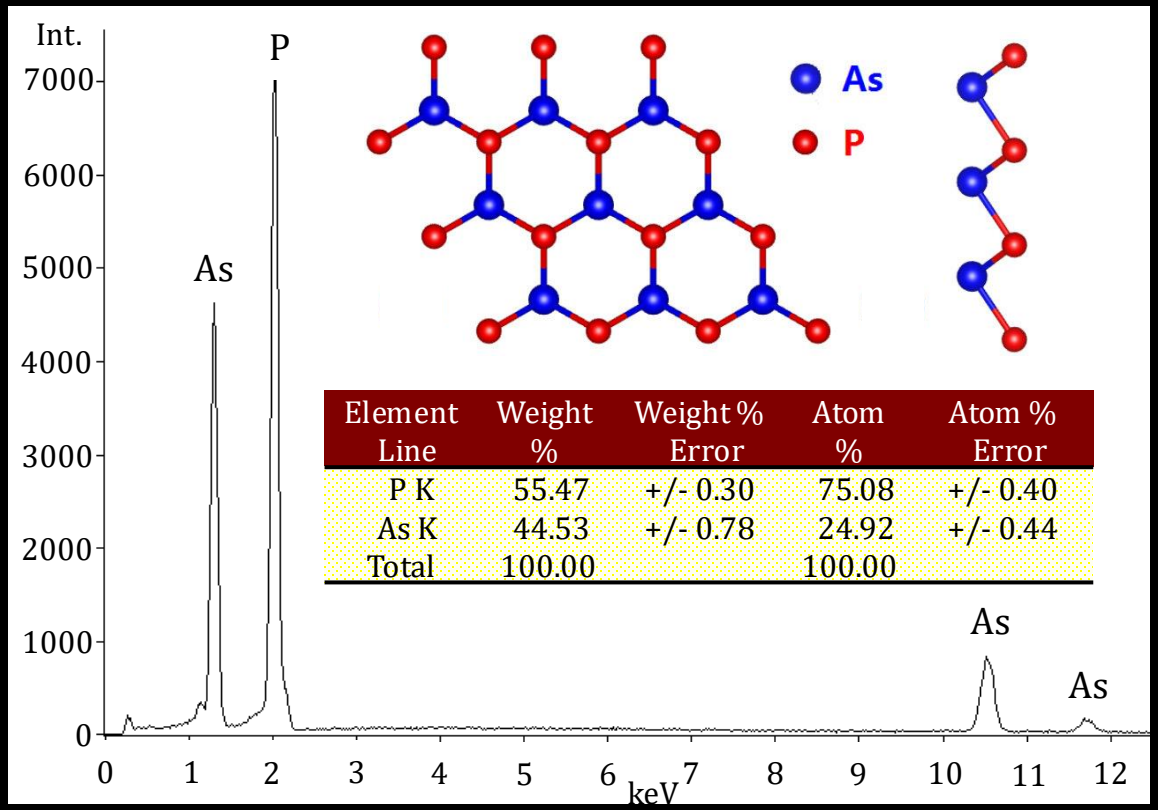


Crystal structure of b-P

Ref.: Nanoscale 2019, 11(39), 18449-18463

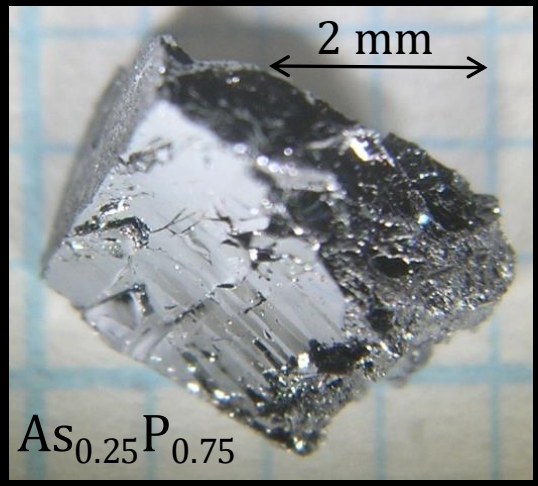
http://crystmat.com

Black b-AsP



Element Line	Weight %	Weight % Error	Atom %	Atom % Error
P K	55.47	+/- 0.30	75.08	+/- 0.40
As K	44.53	+/- 0.78	24.92	+/- 0.44
Total	100.00		100.00	

Crystal structure and EDX analysis of b-AsP crystal



Images of b-AsP crystals

b-AsP are semiconductors with tunable electronic and optical properties via tuning chemical compositions during material synthesis. May find unique applications in electronic and optoelectronic devices operate at infrared regime.

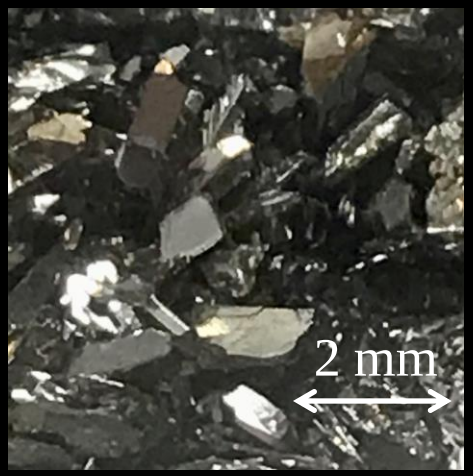
Ref.: Nanoscale 11 (2019) 18449-18463

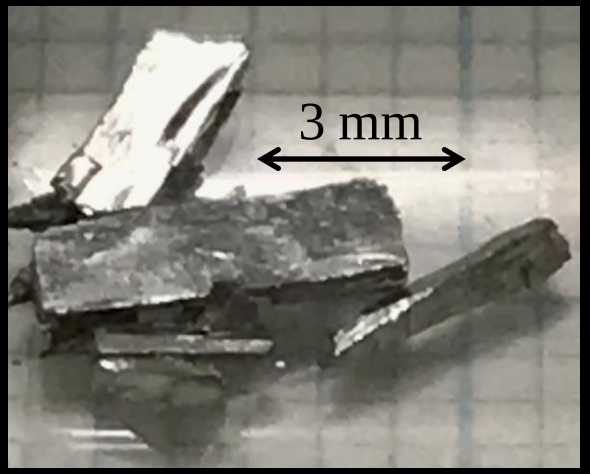
http://crystmat.com

Elemental 2D materials: Tellurium

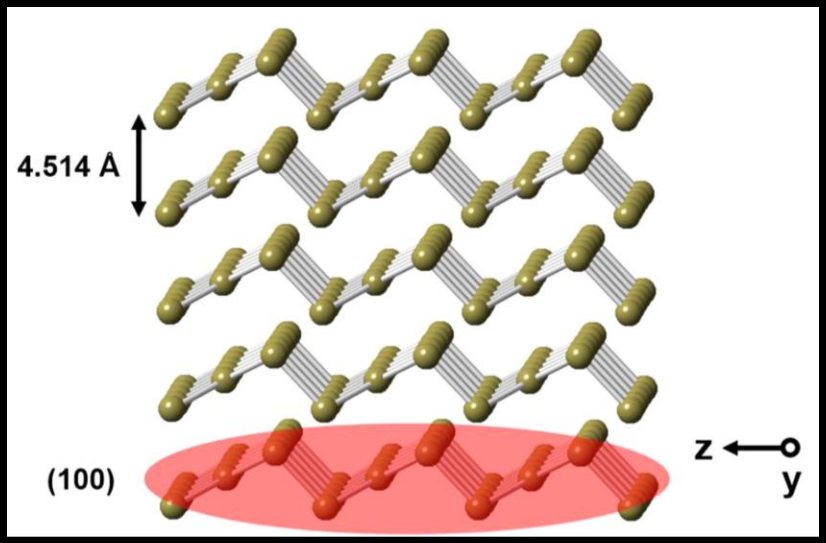
III A	IV A	V A	VI A
5 85 B $2s^2 2p$ 2.04	6 70 C $2s^2 2p^2$ 2.55	N	O
Al	14 110 Si $3s^2 3p^2$ 1.90	15 100 P $3s^2 3p^3$ 2.19	S
31 135 Ga $4s^2 4p^1$ 1.81	32 125 Ge $4s^2 4p^2$ 2.01	As	34 115 Se $4s^2 4p^4$ 2.55
In	50 145 Sn $5s^2 5p^2$ 1.96	51 145 Sb $5s^2 5p^3$ 2.05	52 140 Te $5s^2 5p^4$ 2.1
Tl	Pb	83 160 Bi $6s^2 6p^3$ 2.02	Po

Library of elemental 2D materials
Encycl. of Nanomat. (2023) 1, 138-153





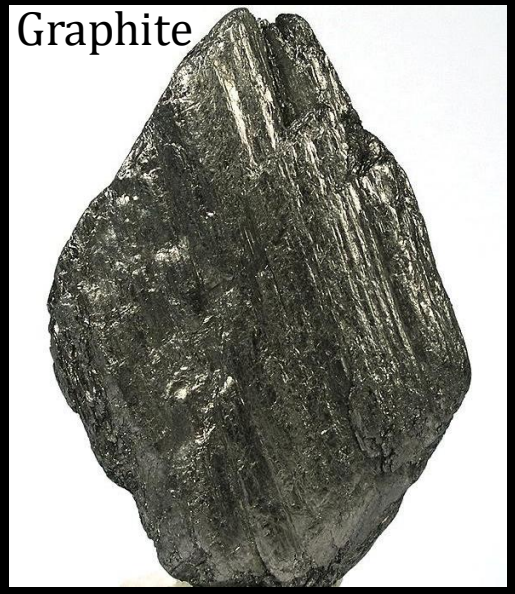
Optical images of Te single crystals

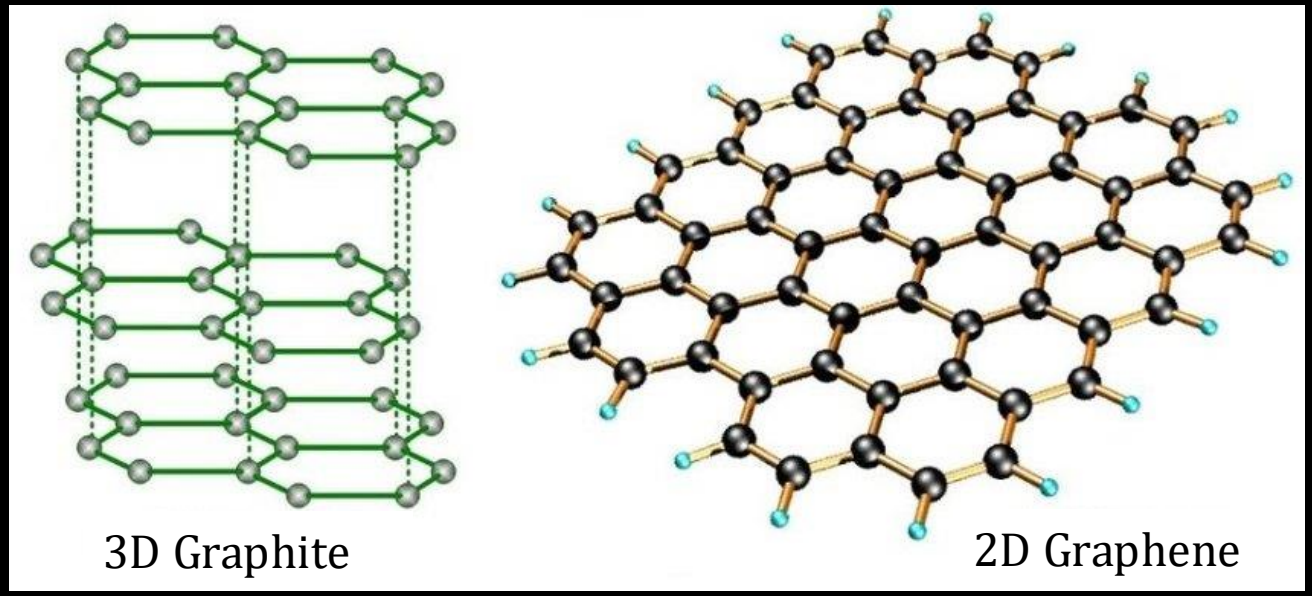


Crystal structure of multilayer tellurene.
Red area represents a monolayer.
J. Hazard.Mat. 423 (2022) 127148

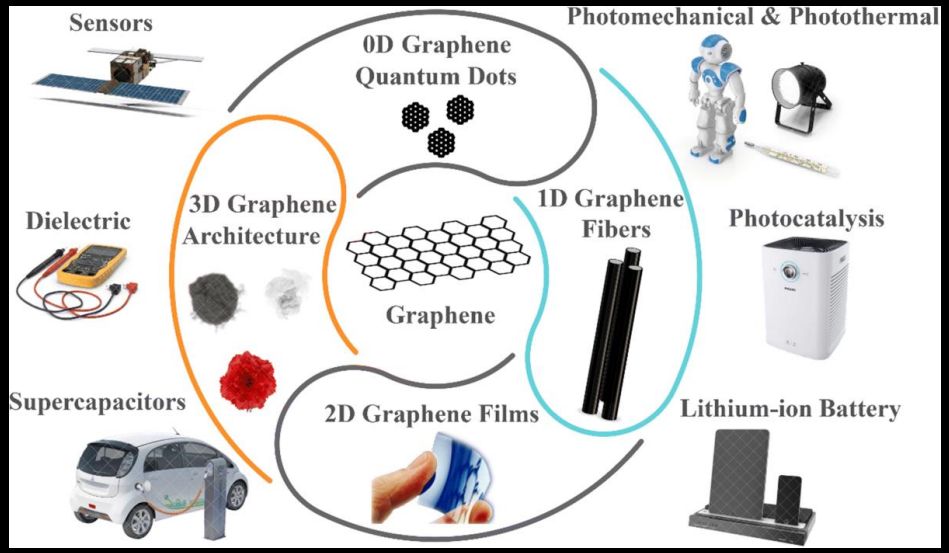
http://crystmat.com

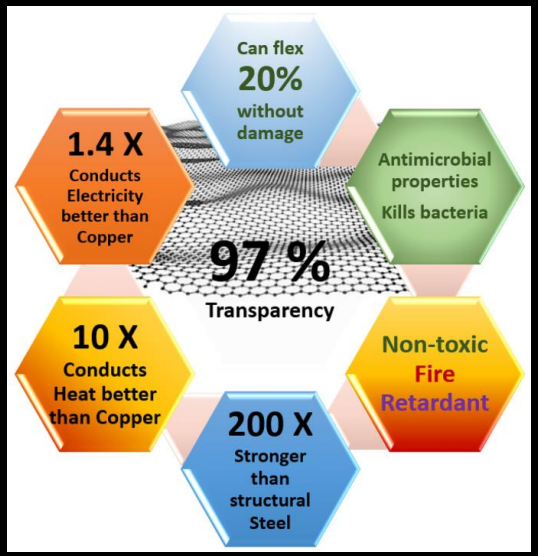
Graphite and Graphene





Graphene is a single layer out of the multiple layers in graphite

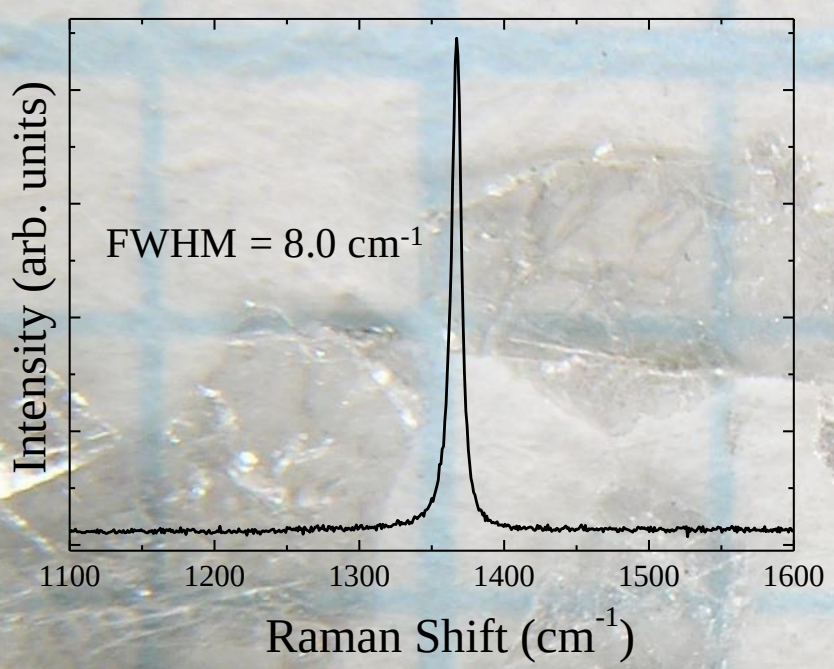




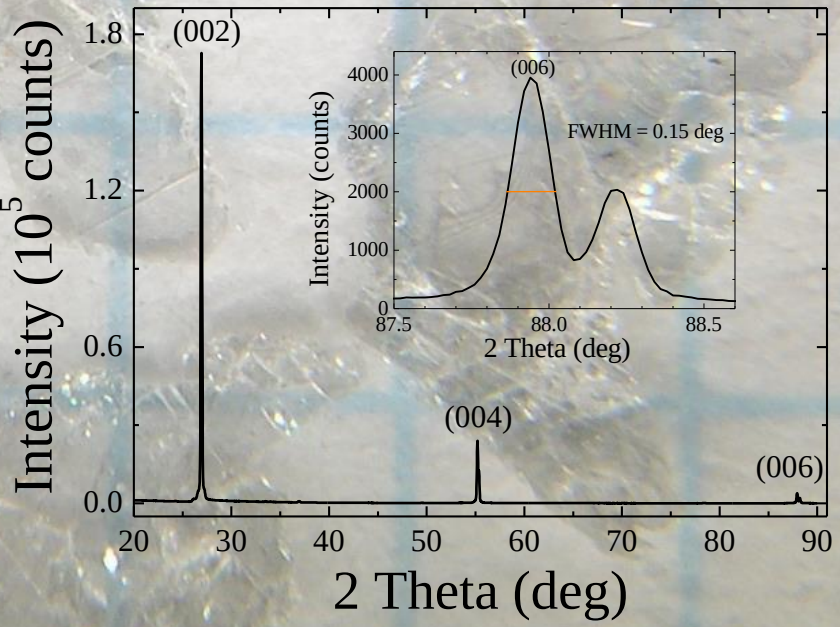
Ref.: Electrochem. Energy Rev. 3, 395 (2020) ; Appl. Comp. Mater. 30, 1737 (2023)

http://crystmat.com

Hexagonal boron nitride hBN



hBN



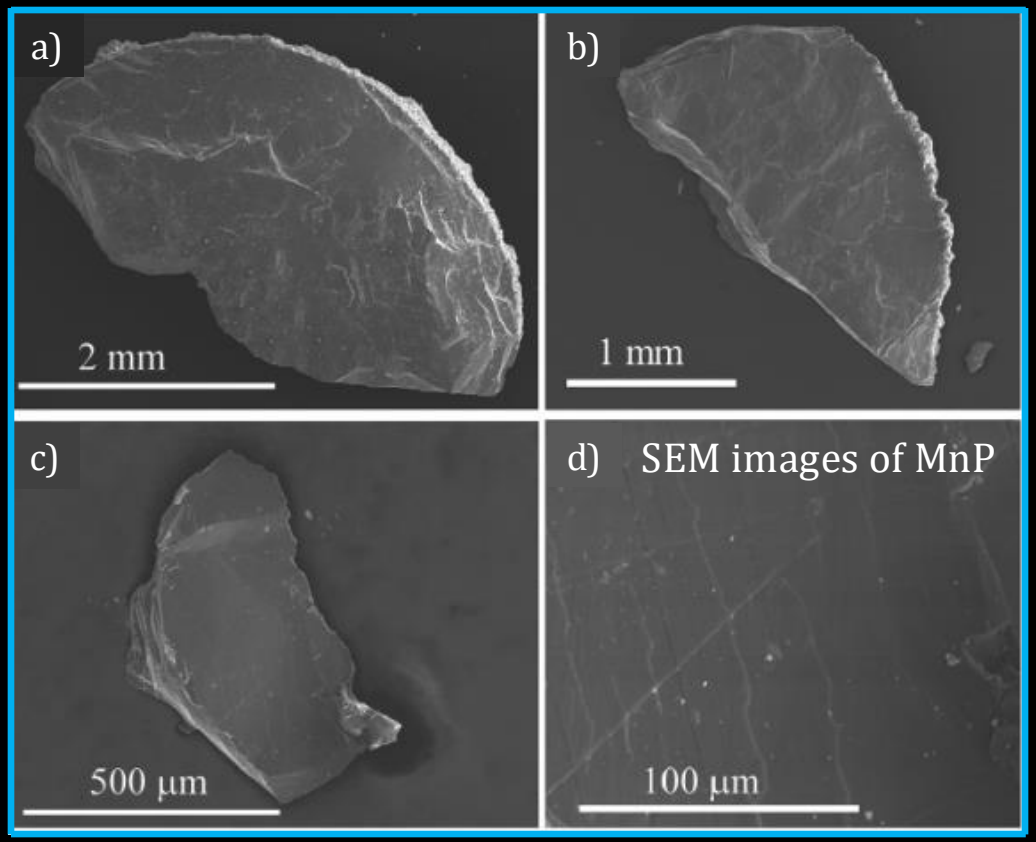
1 mm

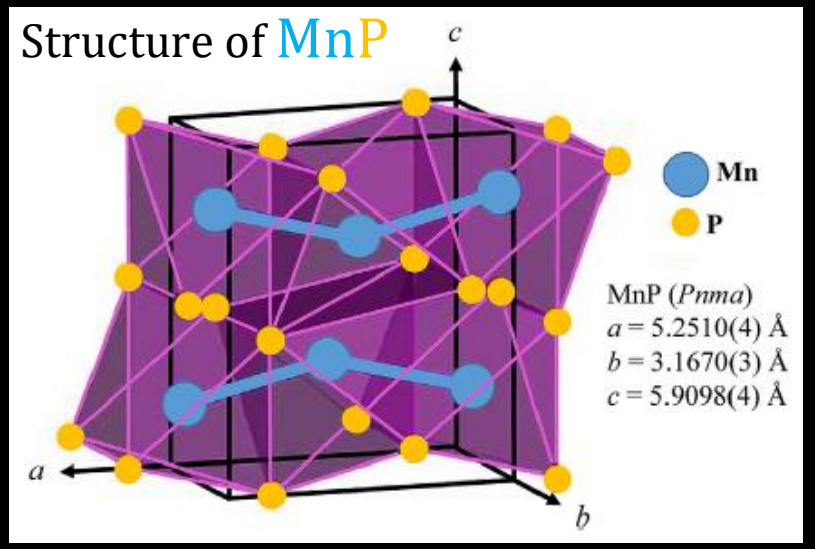
J. Cryst. Growth 402 (2014) 308 ACS Nano 13, 11 (2019) 12372

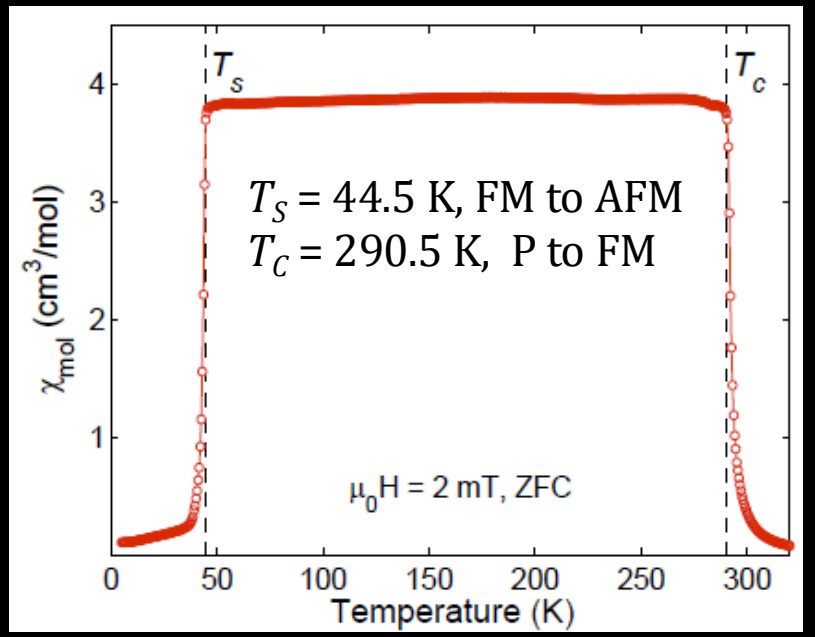
https://crystmat.com

MnP

Potential 2D material for fundamental physics & electronic applications





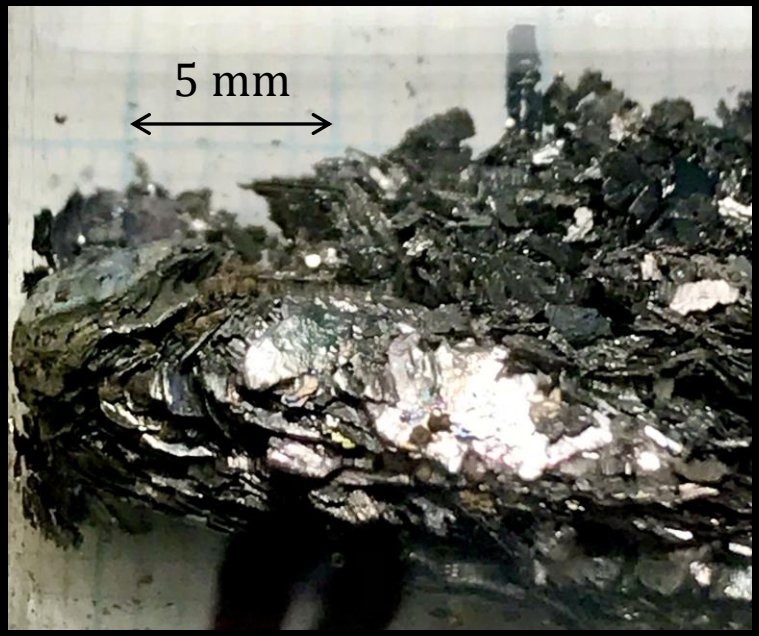


MnP key points: Magnetic properties, strong spin-orbit coupling, topological properties and magnetic skyrmions, thermoelectric and catalytic potential, energy applications.

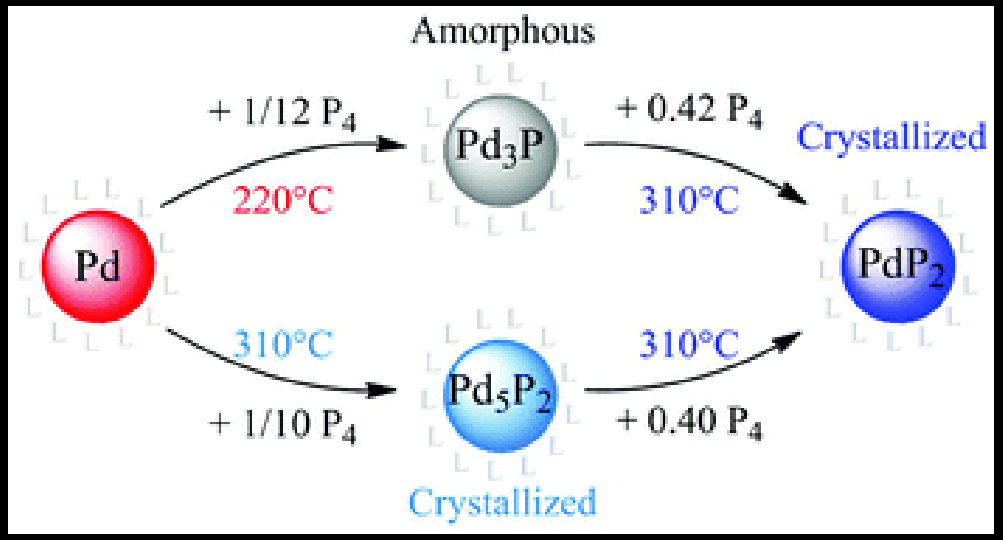
Ref.: J. Alloy Comp. 725 (2017) 1027-1034

https://crystmat.com

Pd_xP_y



Optical image of "Pd_xP_y" 2D crystals

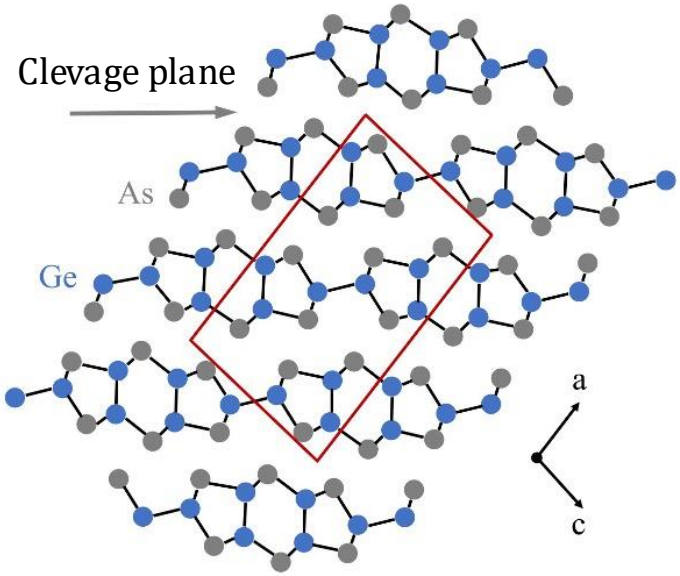


Compounds in the Pd-P system
Ref.: Dalton. Trans. 42, 12667 (2013)

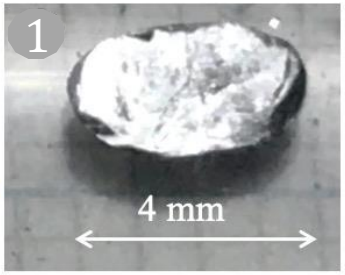
Reactions of Pd with various amounts of P are efficient route to convert them into corresponding Pd phosphides Pd_xP_y. Synthesis of crystalline PdP have proved to be very challenging.

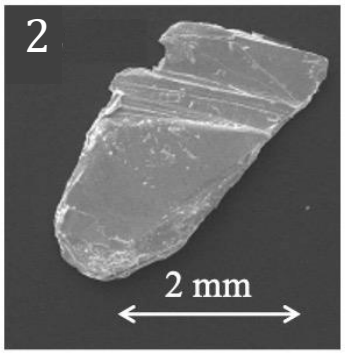
2D Semiconductor GeAs

Could outperform Si-based systems in terms of speed and energy efficiency



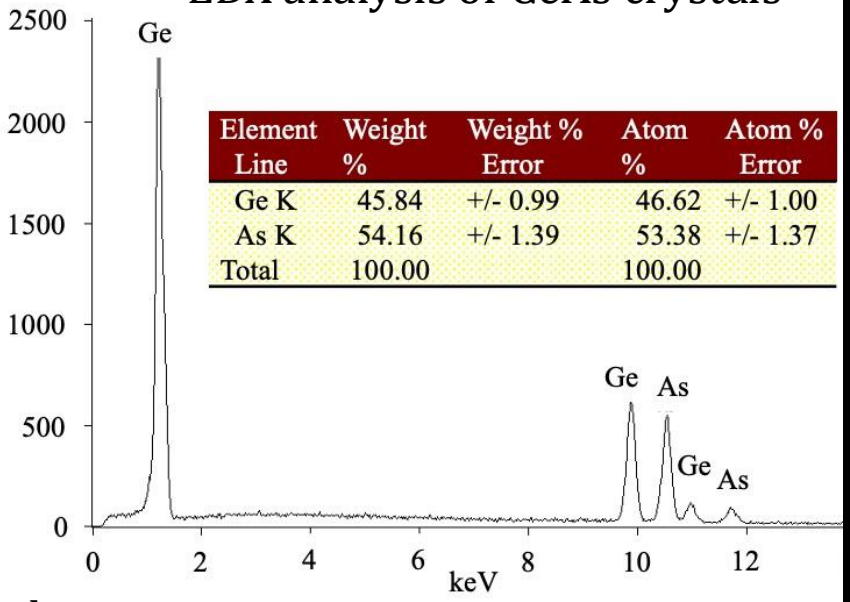
Crystal structure of GeAs



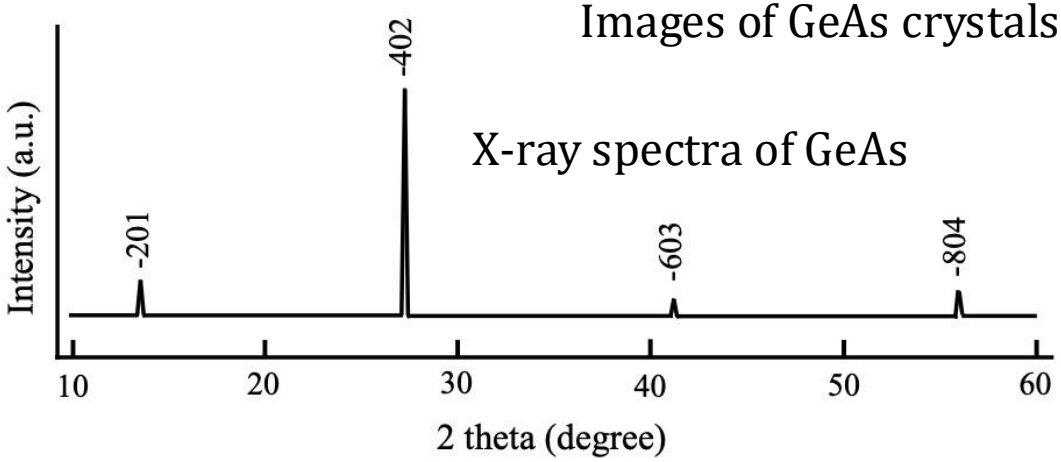


Images of GeAs crystals

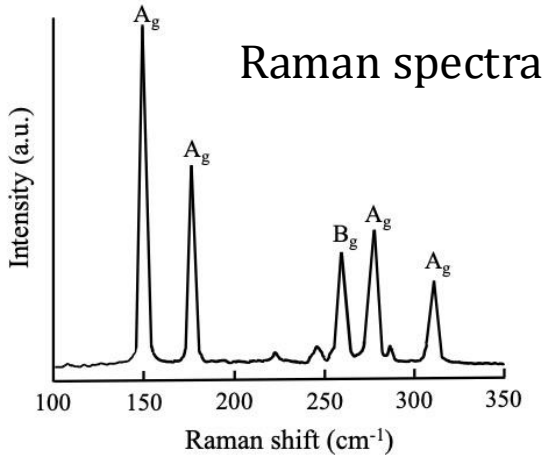
EDX analysis of GeAs crystals



Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Ge K	45.84	+/- 0.99	46.62	+/- 1.00
As K	54.16	+/- 1.39	53.38	+/- 1.37
Total	100.00		100.00	



X-ray spectra of GeAs



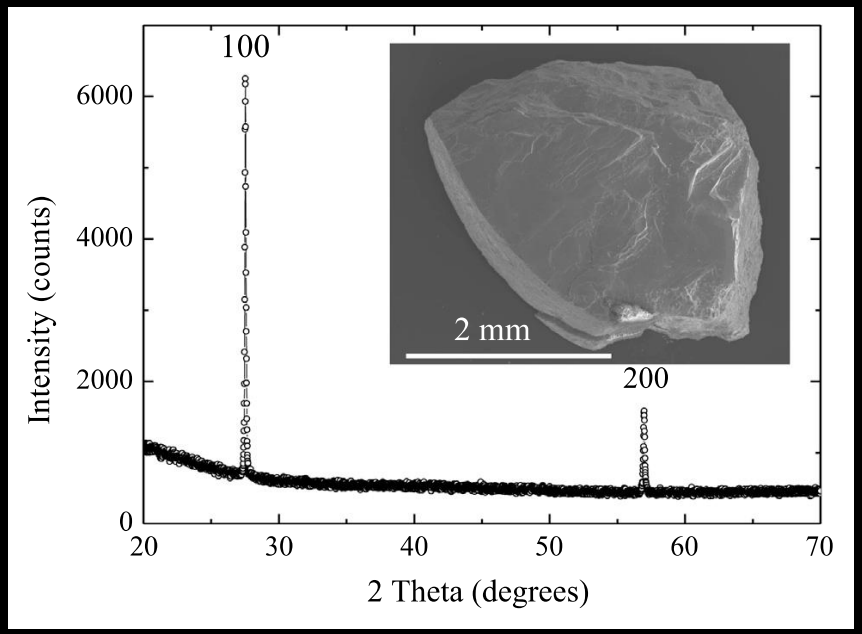
Raman spectra

Used: optoelectronics, solar cells, sensors, radars, integrated circuits, quantum computing

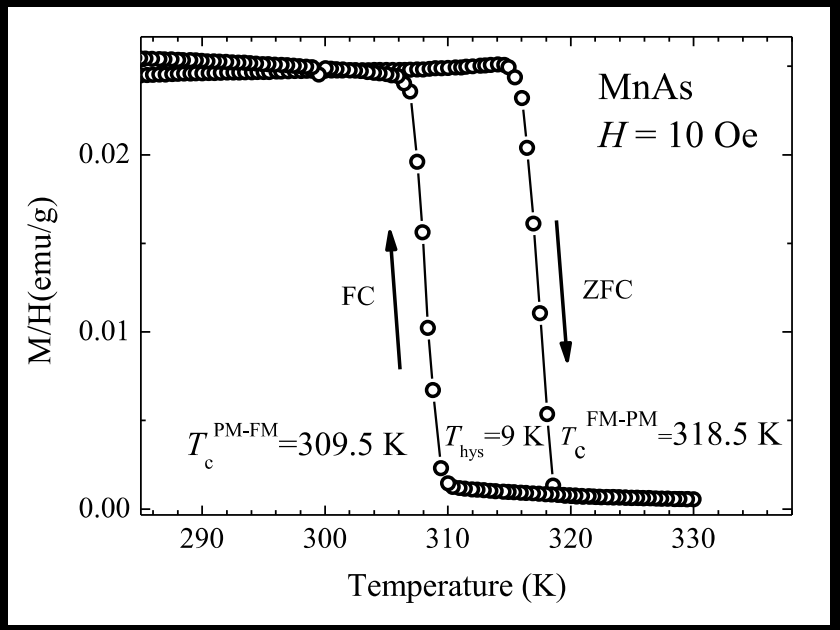
Ref.: J. Cryst. Growth 631 (2024) 127627

https://crystmat.com

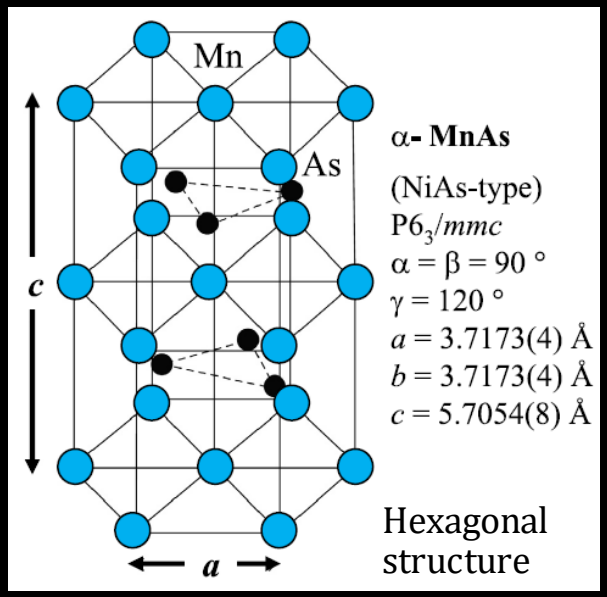
MnAs



XRD with (h00) lines and SEM image



First-order phase transition of MnAs



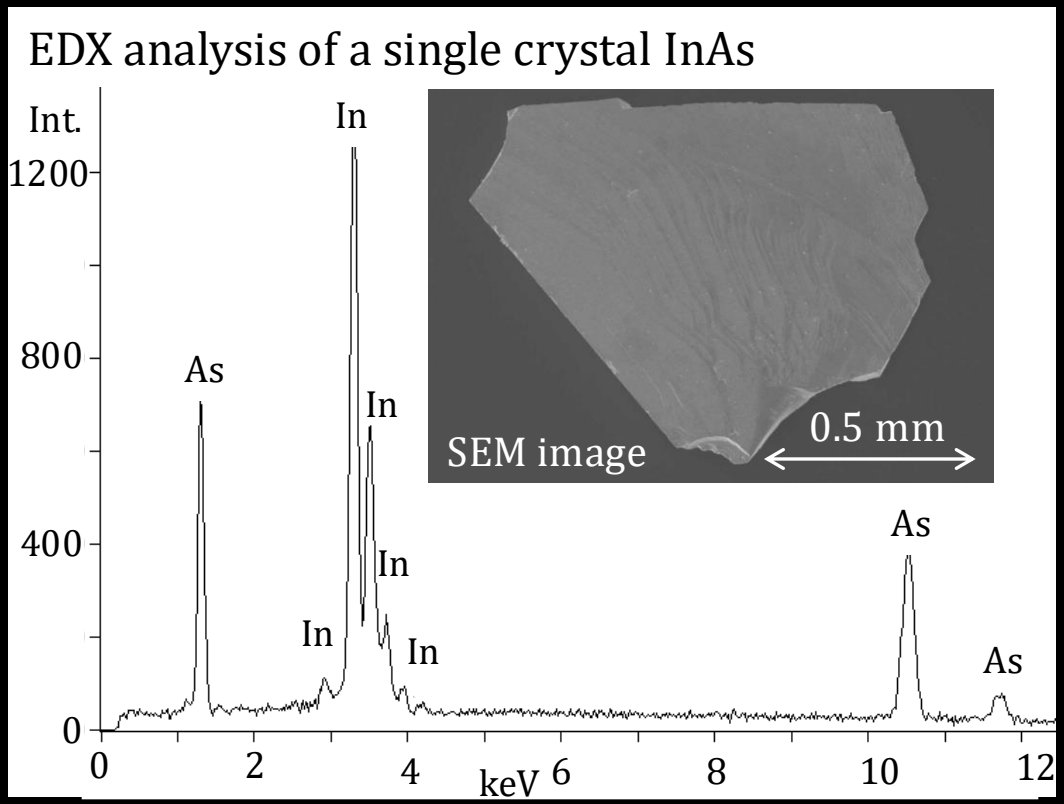
MnAs has potential for exfoliation into thin layers

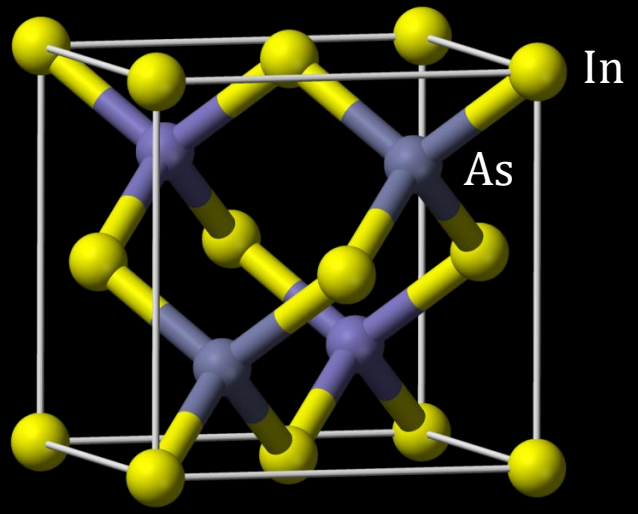
MnAs crystals exhibit a plate-like morphology with flat surfaces. J. Cryst. Growth 480 (2017) 148-153

MnAs is intriguing material because of its unique magnetic properties, phase transitions, and potential for use in cutting-edge technology like spintronics, thermoelectrics, and quantum computing.

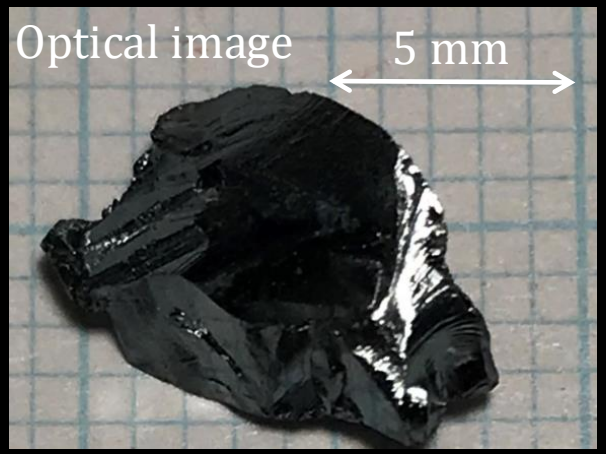
https://crystmat.com

InAs





InAs (Cubic, F-43m, 216)

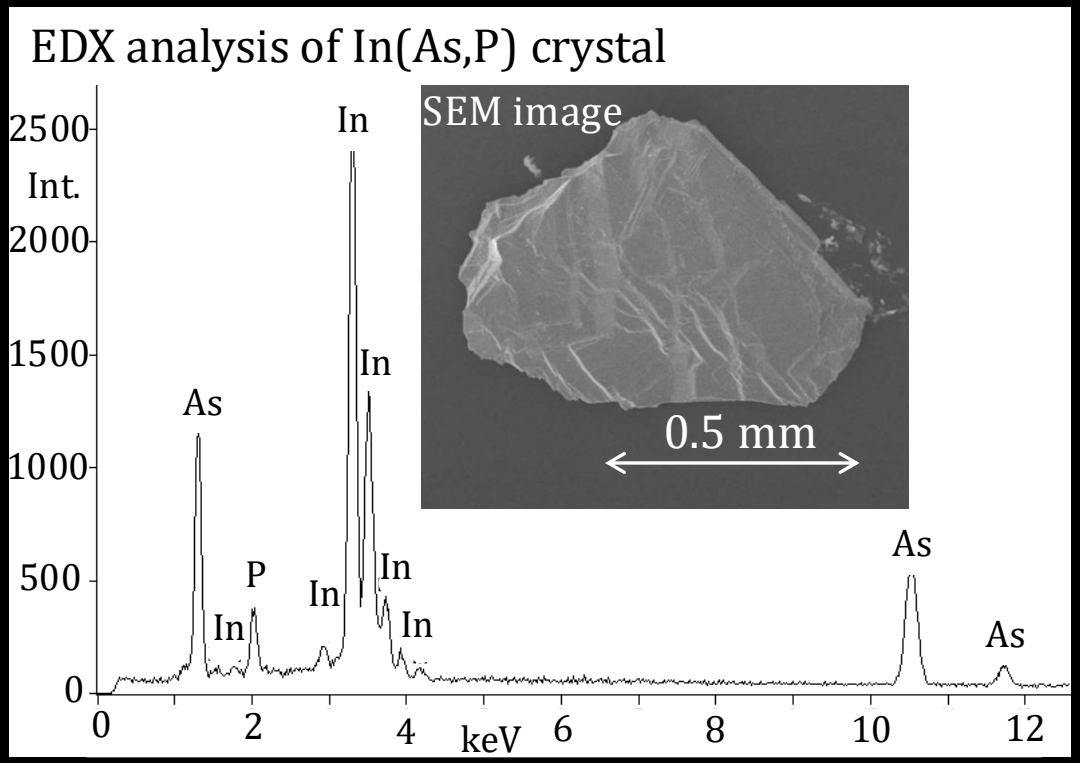


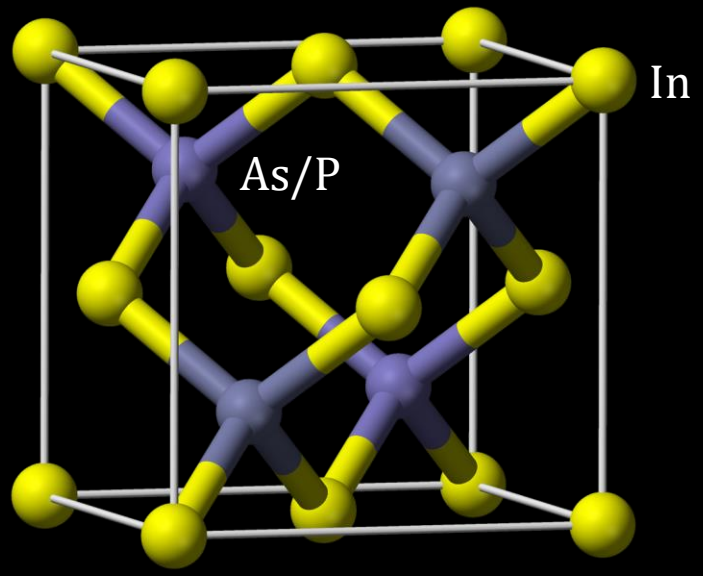
Element Line	Weight %	Weight % Error	Atom %	Atom % Error
As K	42.92	+/- 1.31	53.54	+/- 1.63
In L	57.08	+/- 1.07	46.46	+/- 0.87
Total	100.00		100.00	

Two-dimensional (2D) InAs is a promising for future electronic and optoelectronic applications such as nanoscale transistors, flexible and wearable devices, broadband photodetectors, heterogeneous integration with Si-based electronics.

https://crystmat.com

In(As,P)





In(As,P): (Cubic, F-43m, 216)

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
P K	3.32	+/- 0.35	9.58	+/- 1.02
As K	36.47	+/- 1.69	43.53	+/- 2.02
In L	60.21	+/- 1.53	46.89	+/- 1.19
Total	100.00		100.00	

Key points: bandgap tuning, high-speed electronics and optoelectronics, strain engineering, temperature sensitivity, integration with other materials

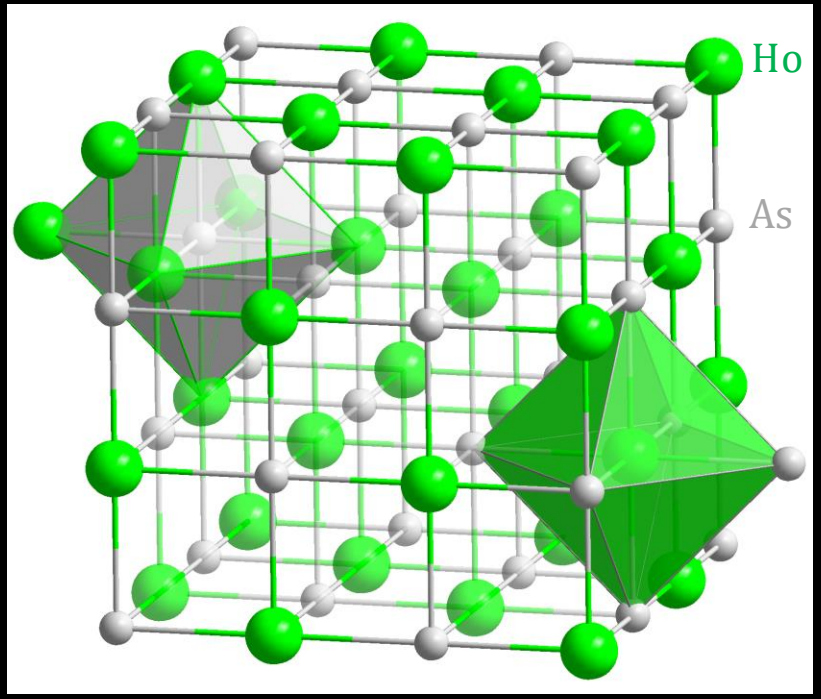
2D In(As,P) is a promising for future electronic and optoelectronic applications such as nanoscale transistors, flexible and wearable devices, broadband photodetectors, heterogeneous integration with Si-based electronics.

https://crystmat.com

Classical antiferromagnet HoAs

Exhibit strong spin-orbit coupling & anisotropic magnetic interactions

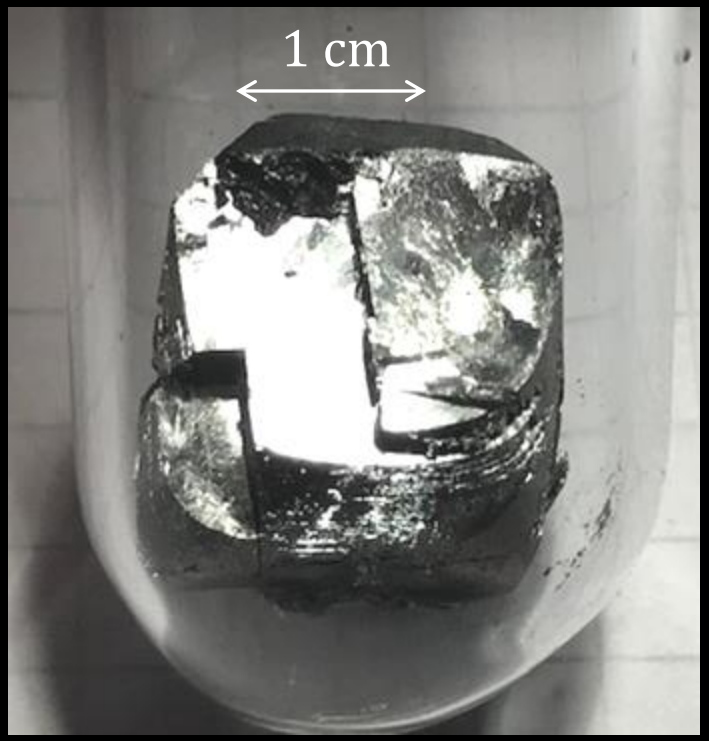
Photo of HoAs crystals. It is unsuitable for exfoliation, yet its morphological appearance offers some hope.



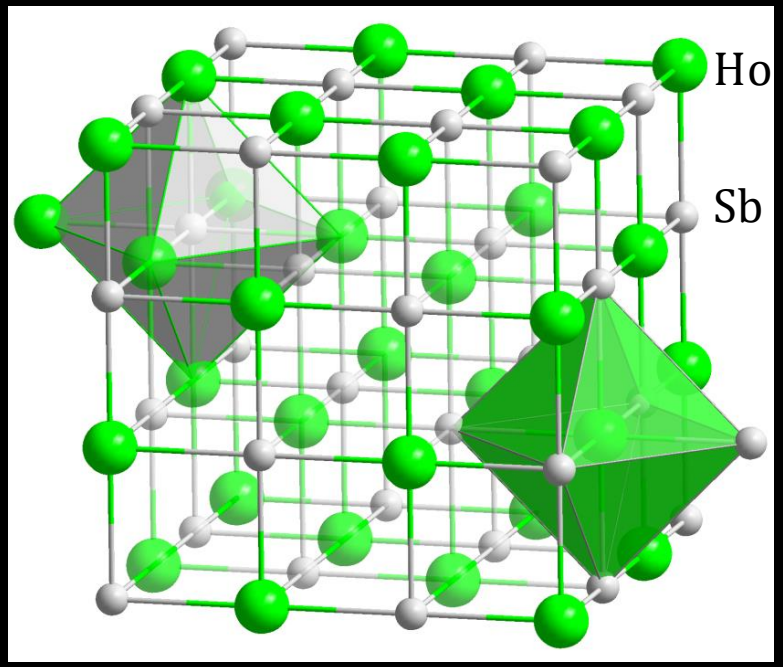
HoAs is rock-salt structured and crystallizes in the cubic *Fm*-3*m* space group

The Neel temperature for HoAs is about 5 K, and the magnetic moments of Ho ions align in opposite directions in neighboring sublattices. Appropriate for studying electronic excited states, charge transport, and bonding interactions.

Magnetic Topological Semimetal HoSb



Optical image of HoSb sample

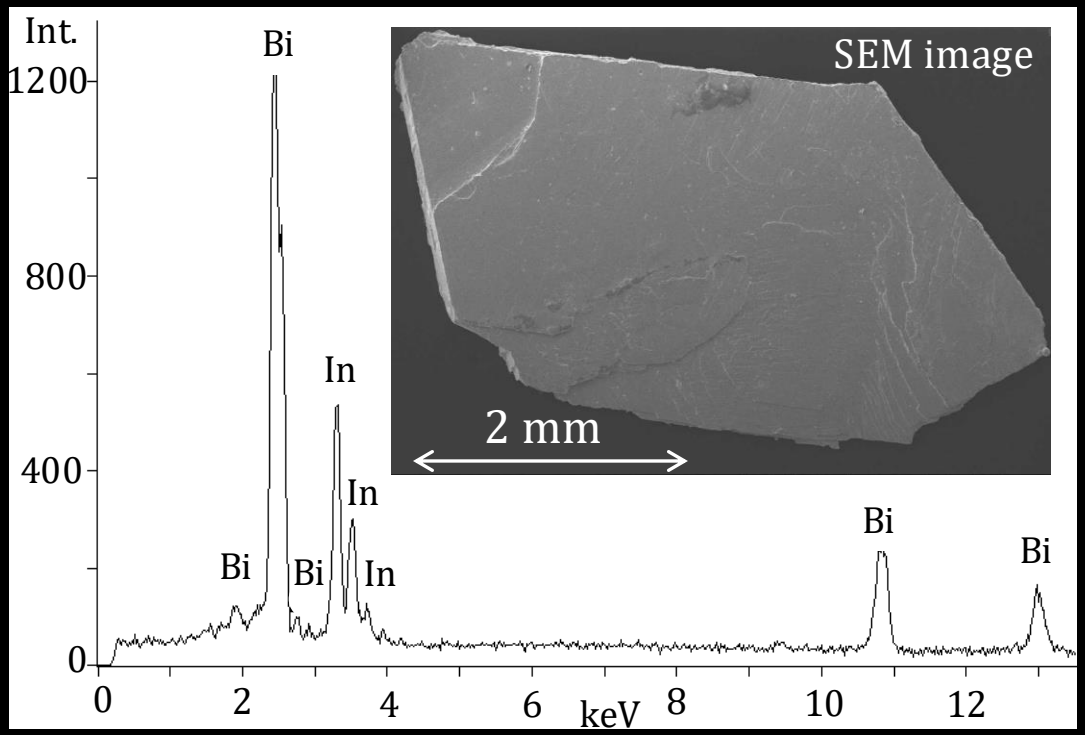


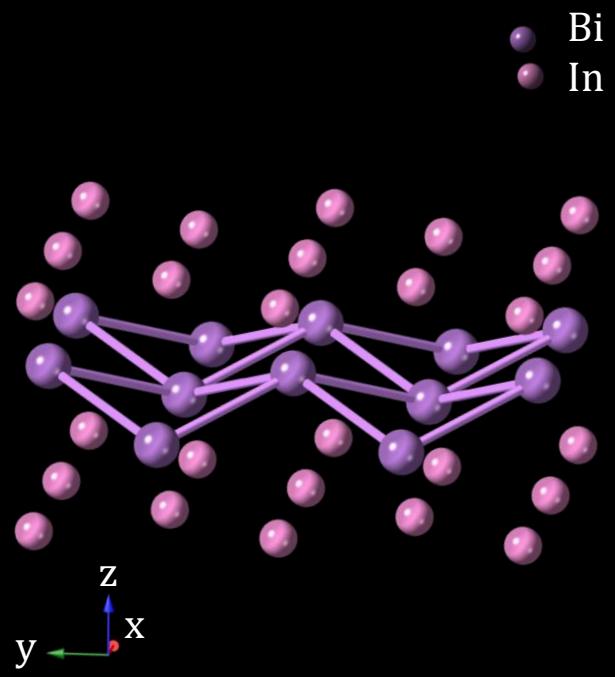
HoSb crystallizes in NaCl structure with space group *Fm*-3*m* and orders AF at ~ 5.7 K

HoSb shows extremely large magnetoresistance (XMR). The Berry phase extracted from Shubnikov-de Haas oscillation indicates the possible nontrivial electronic structure of HoSb in the presence of magnetic field. HoSb offers a unique platform for exploring the interplay between XMR, magnetism and topology in an AFM matrix.

Ref.: Phys. Rev. B 98 (2018) 045137 ; Sci. Rep. 10, 12961 (2020) ; wikipedia

Topological semimetal InBi





InBi (Tetragonal, P4/nmm, 129)

EDX

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
In L	35.51	+/- 1.16	50.05	+/- 1.64
Bi L	64.49	+/- 2.29	49.95	+/- 1.78
Total	100.00		100.00	

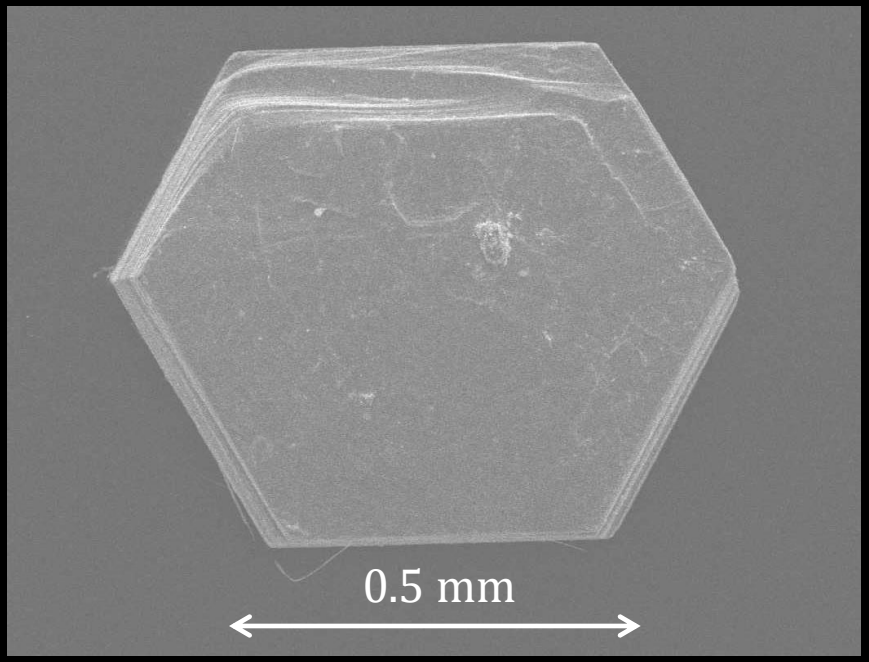
Key points: narrow bandgap, high mobility, strong spin-orbit coupling, quantum effects, thermoelectric applications

Extremely large positive magnetoresistance was found in a nonmagnetic semimetal InBi. Provides a new material platform for study of exotic topological quantum phases.

Ref.: Phys. Rev. B 108, 205107 (2023); New J. Phys. 19, 065007 (2017)

https://crystmat.com

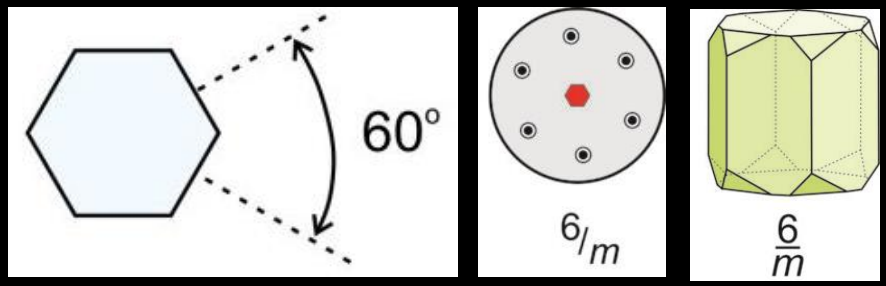
NbS



SEM image of NbS crystal

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
S K	32.20	+/- 0.79	57.92	+/- 1.42
Nb K	67.80	+/- 4.87	42.08	+/- 3.02
Total	100.00		100.00	

EDX analysis of NbS crystal



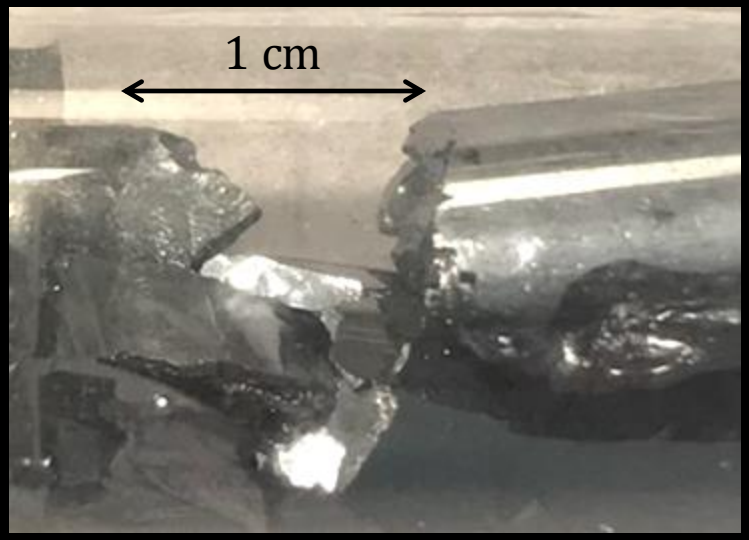
Nice morphological appearance
with 6-fold rotational symmetry

Phase	Homogeneity range, at. %	Chemical formula of sulfide and its formation temp., °C	Structure	Space group	Lattice constants, A			
					a	*b*	*c*	*c/a*
NbS	54,54–47.367	$NbS_{0.9}$>850 $NbS_{1.2}$<850	Hexagonal	$P6_3/mmc$ $P6_3/mmc$	3.33 3,32		6,39 12,92	1,1919 2×1,946

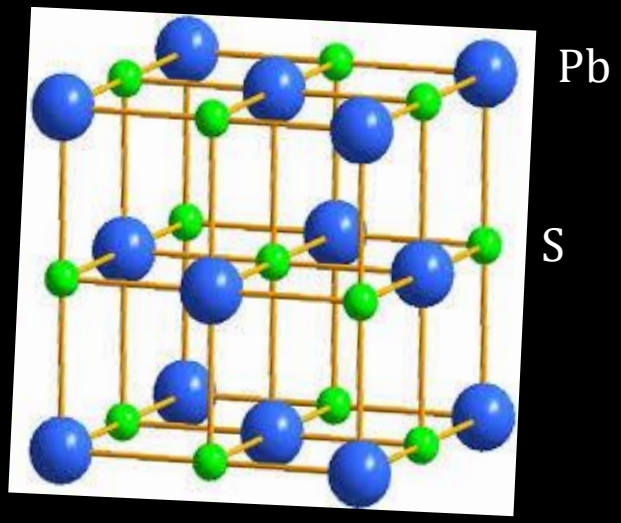
Information about NbS is very limited. Possibly suitable for exfoliation.
Ref.: Poroshkovaya Metallurgiya, 11(35), 9-14, (1965)
https://crystmat.com

PbS

Possibly suitable for creation of thin layers via mechanical exfoliation



Optical image of PbS sample



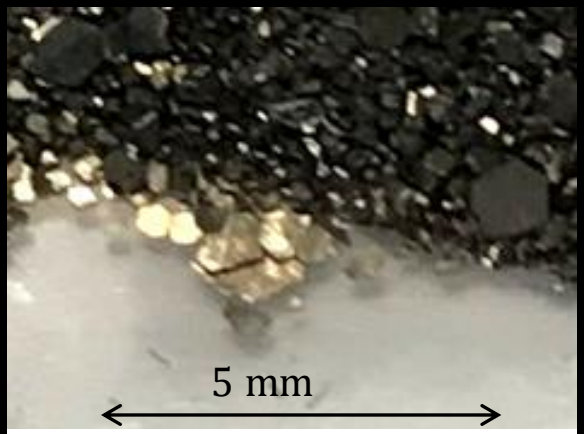
PbS crystallizes in NaCl–type structure (cubic *Fm*-3*m*)

PbS is a semiconductor with a bandgap around 0.41 eV. This small bandgap allows it to absorb and emit infrared light, making it useful in IR detectors and optoelectronic devices.

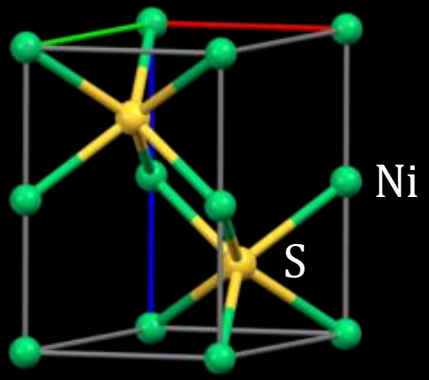
Key interesting points: providing a playground for fundamental studies in condensed matter physics, electron-phono interactions, thermoelectric performance, photophysics and photochemistry, plasmon-exciton coupling, infrared optoelectronics, solar cells.

https://crystmat.com

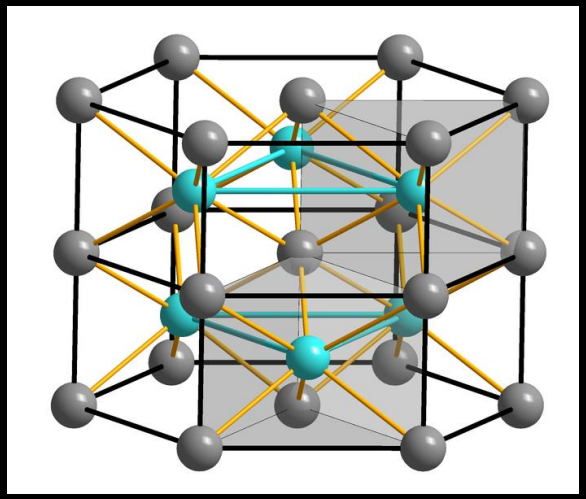
NiS

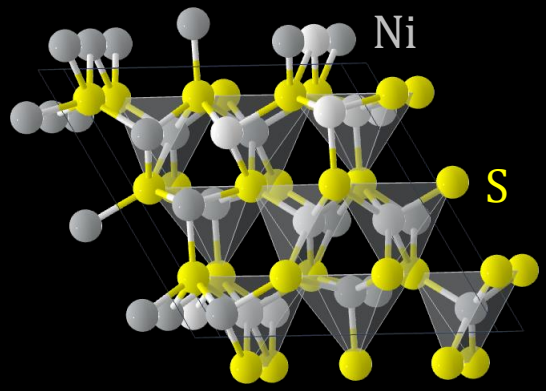


Optical image of NiS crystals



Crystal structure of NiS





NiS crystallizes in trigonal R3m space group. Ni^{2+} is bonded to five S^{2-} atoms to form NiS_5 bipyramids.

NiS has two polymorphs. The α-phase has a hexagonal unit cell, while the β-phase has a rhombohedral cell. Ref.: Wikipedia

2D Semiconductor GeS

Versatile and exciting material for academic research and applications

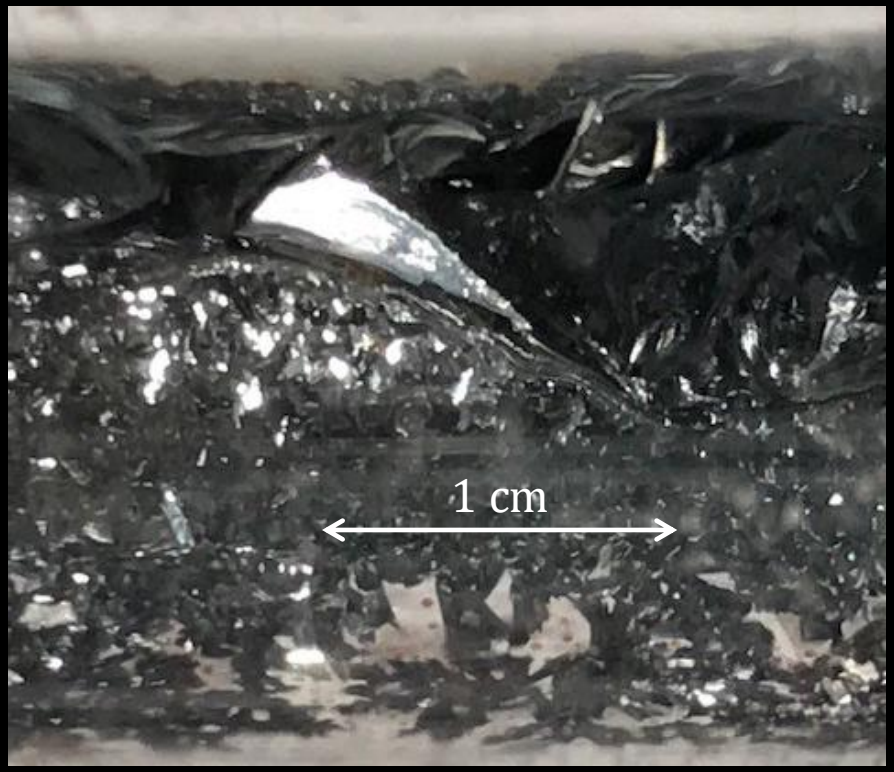
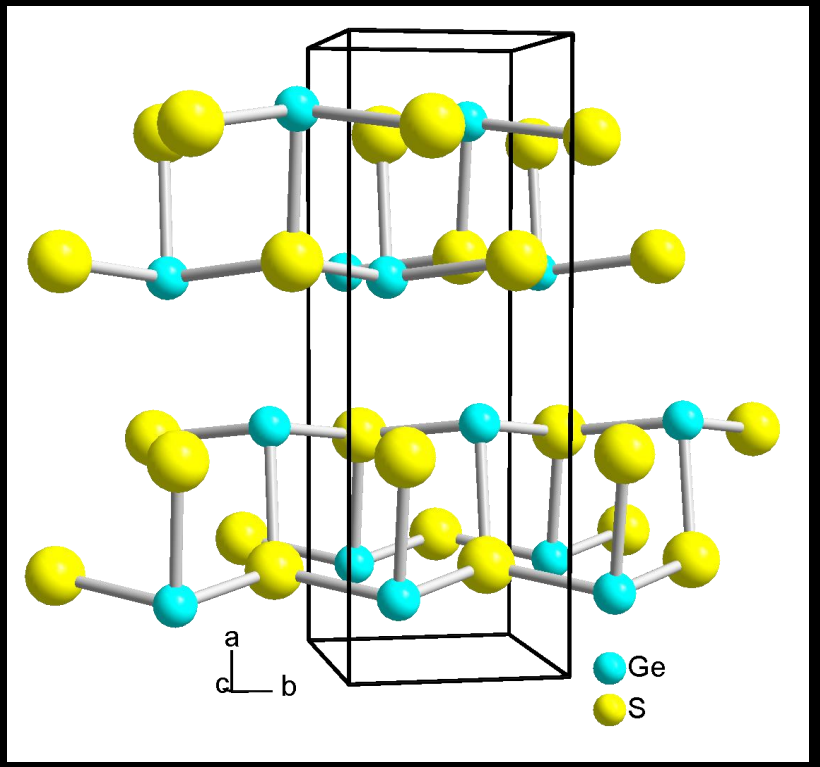


Image of GeS thin flakes captured through the quartz glass ampoule wall



GeS: orthorhombic *Pnma* space group. Structure similar to black phosphorus

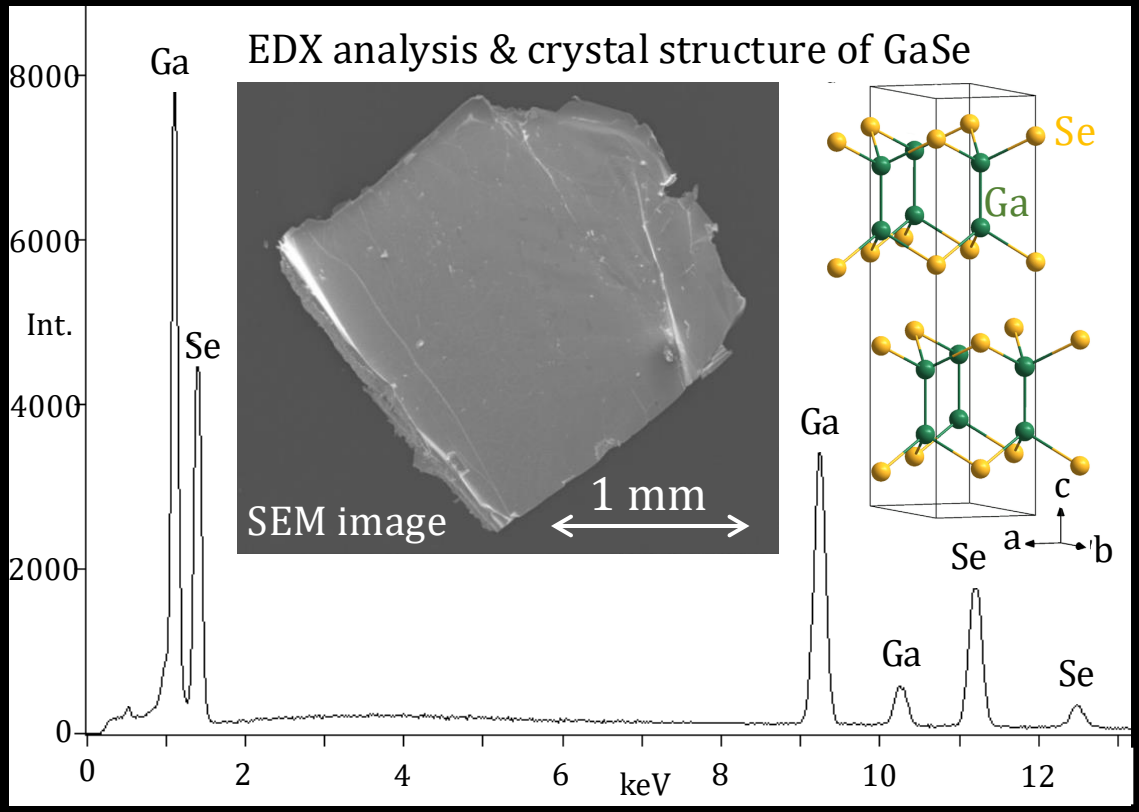
Key Properties: Two-dimensional layered structure, Direct band gap, High electron mobility, Strong photoluminescence, Good conductivity, Nonlinear optical properties

Potentially useful for next-generation high-speed electronics and optoelectronic devices, transistors, where thin, flexible, or even transparent materials are desirable

https://crystmat.com

2D Semiconductor GaSe

Relevant for fundamental science and technological innovations



Optical image of bulk GaSe crystal

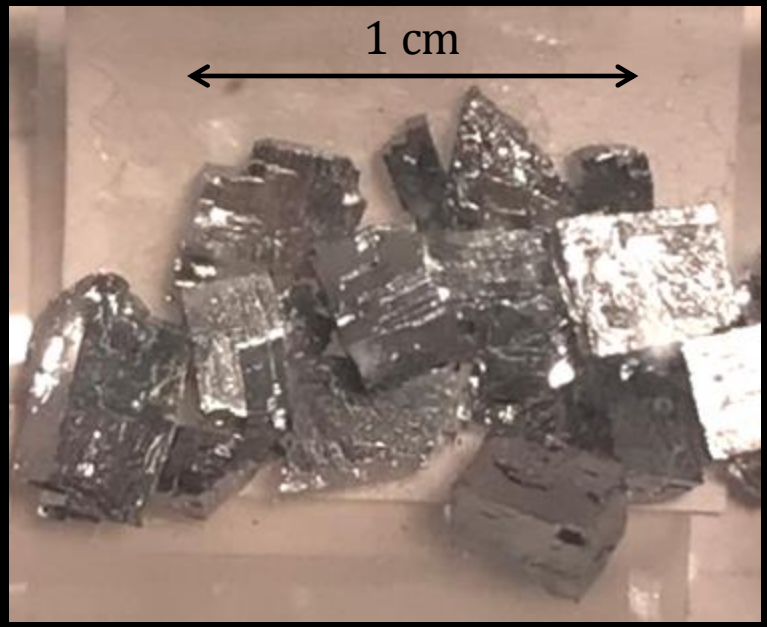
Application: Lasers, photodetectors, sensors, solar cells, displays, FETs, LEDs , quantum computing

Element Line	Weight %	Weight % Error	Atom %
Ga K	48.37	+/- 0.62	51.48
Se K	51.63	+/- 1.01	48.52
Total	100.00		100.00

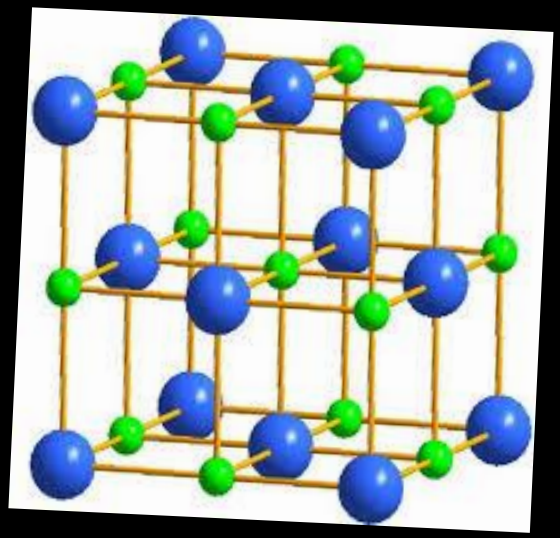
Key points: 1. Layered structure, 2. Nonlinear optical properties, 3. Wide bandgap, 4. Strong light-matter interaction, 5. High carrier mobility, 6. Photovoltaic & thermoelectric potential, 7. Quantum & topological effects, 8. Potential for heterostructures, 9. Mechanical flexibility

https://crystmat.com

PbSe



Optical image of PbSe samples



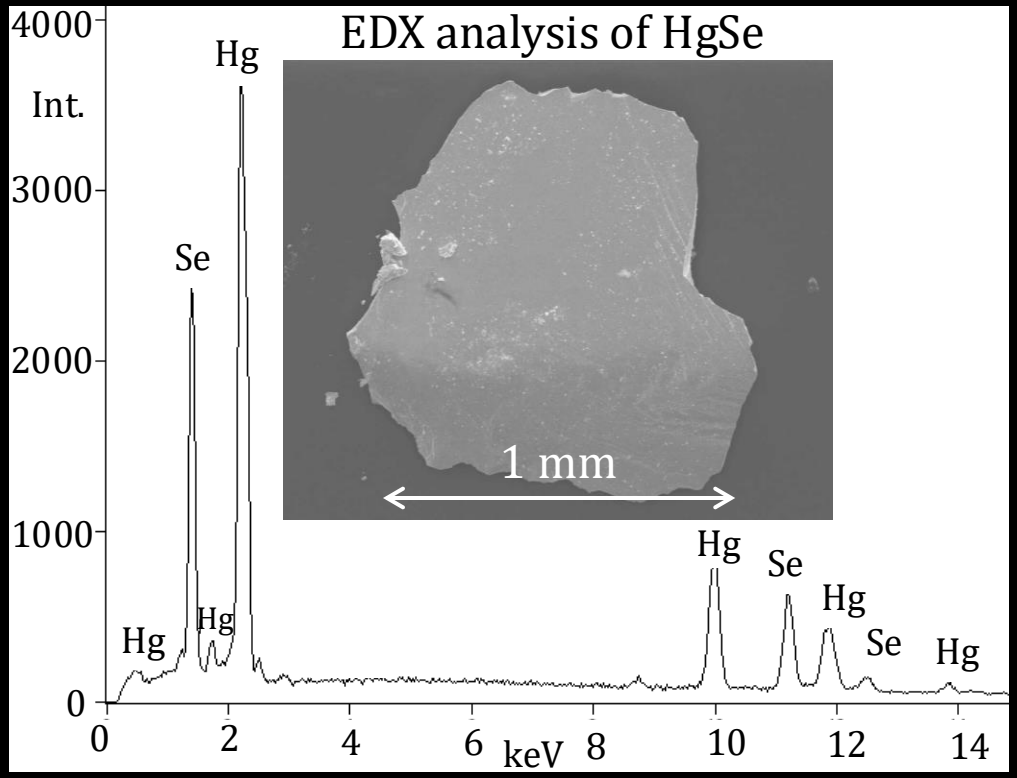
PbSe crystallizes in a NaCl–type structure (cubic, *Fm*-3*m*)

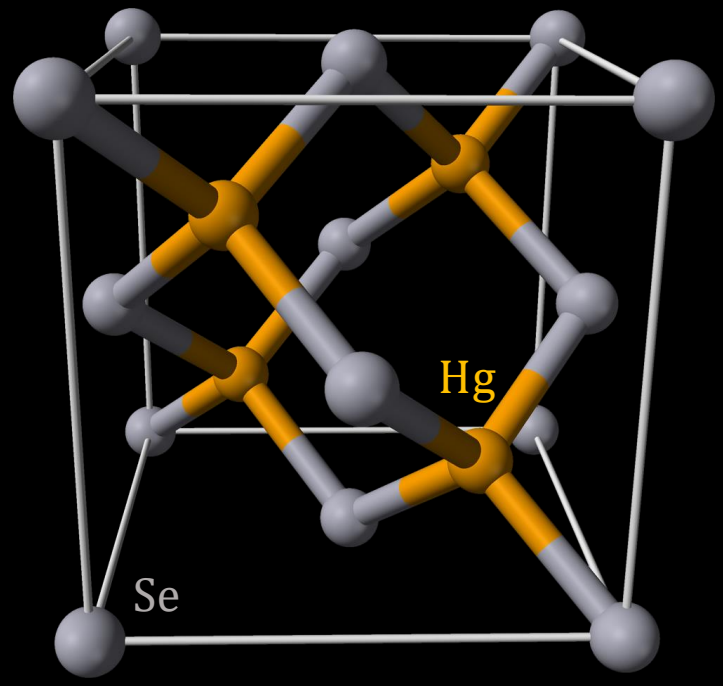
PbSe is a semiconductor material. It has a direct bandgap of 0.27 eV at room temperature. It is used for manufacture of infrared detectors for thermal imaging, operating at wavelengths between 1.5–5.2 μm. Ref.: wikipedia.org

Key areas of interest: high-performance electronics, thermoelectric performance, infrared plasmonic devices (IR sensors, detectors, modulators), plasmon-exciton coupling, solar cells, transistors and flexible electronics, light-emitting diodes.

Topological semimetal HgSe

Exhibit topologically nontrivial Weyl semimetal physics





HgSe belongs to space group *F*-43*m*

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Se K	26.29	+/- 1.13	47.54	+/- 2.04
Hg L	73.71	+/- 2.17	52.46	+/- 1.55
Total	100.00		100.00	

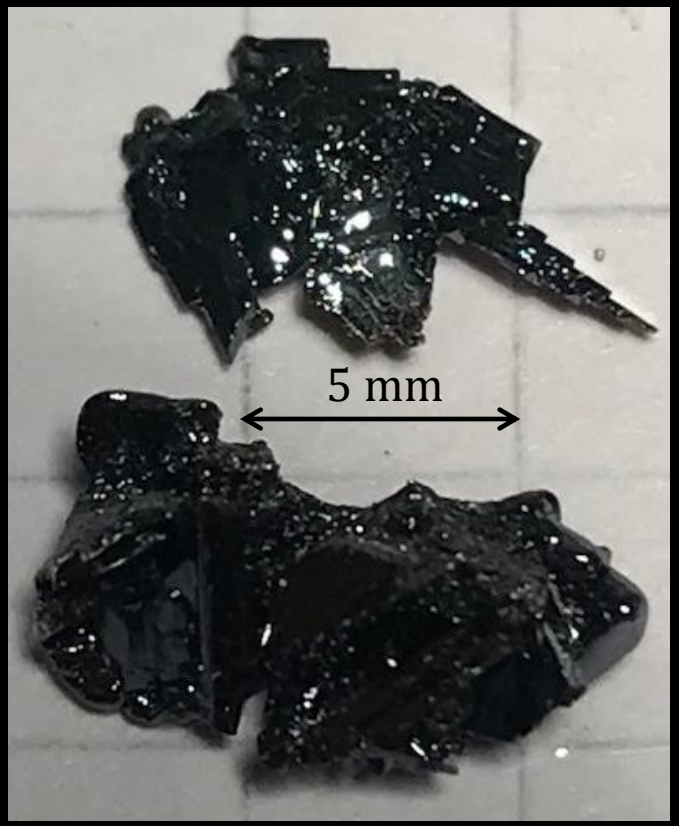
Key Properties: direct bandgap, high carrier mobility, strong spin-orbit coupling, thermoelectric performance, infrared sensitivity, photoconductivity

HgSe is a promising material for potential applications in various fields such as electronics, spintronics, thermoelectrics, quantum computing and laser technologies.

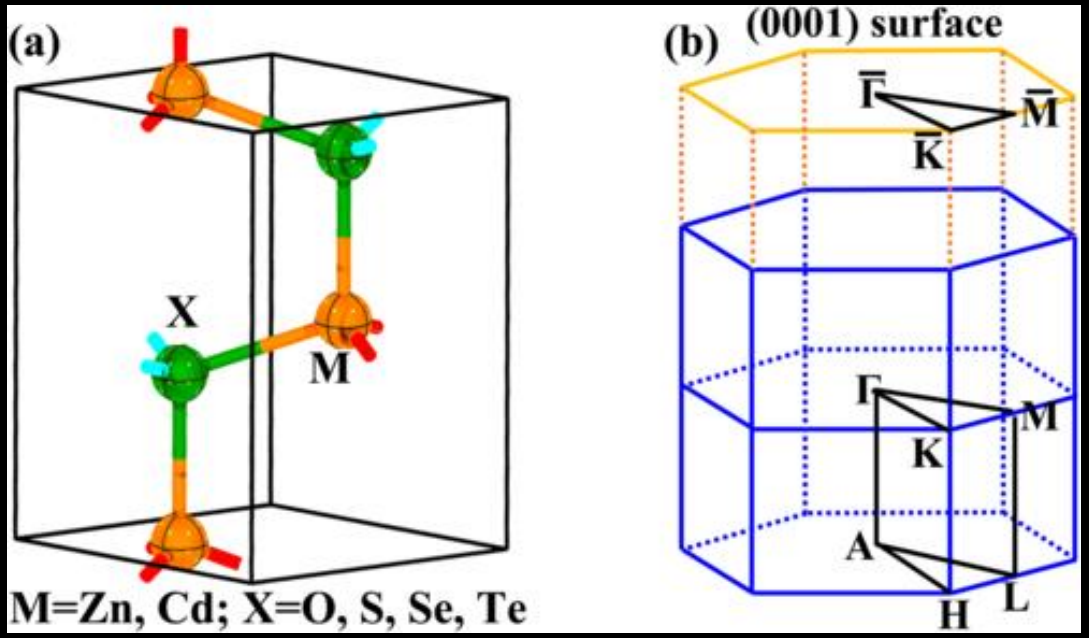
https://crystmat.com

ZnSe

Attractive for applications in flexible and transparent nanoelectronic devices



Optical image of ZnSe samples



(a) Crystal structure of wurtzite MX (where M = Zn and Gd and X = O, S, Se, and Te) chalcogenides. (b) BZ and projected surface BZ for (0001) surface of wurtzite MX chalcogenides.

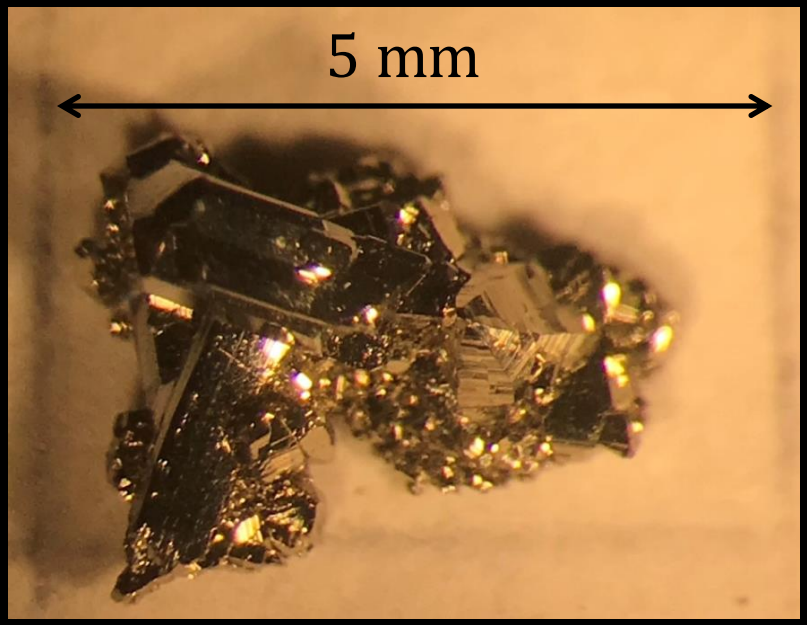
By employing first-principles calculations it was predicted the existence of type-II Weyl phonons in ZnSe, a well-known II-VI semiconductor.

Ref.: J. Mater. Chem. A 2, 17971 (2014); Phys. Rev. B 103, 094306 (2021)

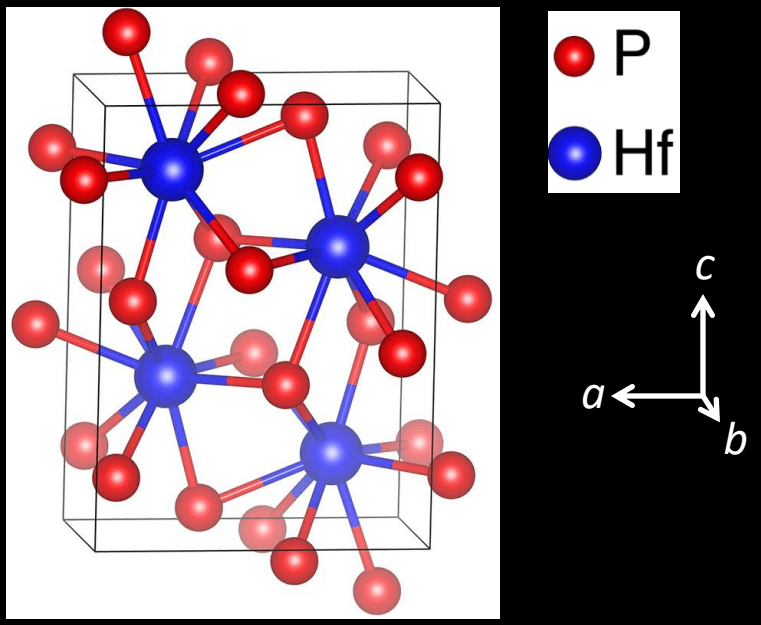
https://crystmat.com

Topological semimetal HfP_2

Potential material for emerging optoelectronic and photovoltaic applications



Optical image of HfP_2 crystals grown by chemical vapor transport method using iodine as transport agent.



HfP_2 crystallizes in the orthorhombic structure with space group *Pnma* (No 62). Hf^{4+} is bonded in a 9-coordinate geometry to nine P^{2-} atoms.

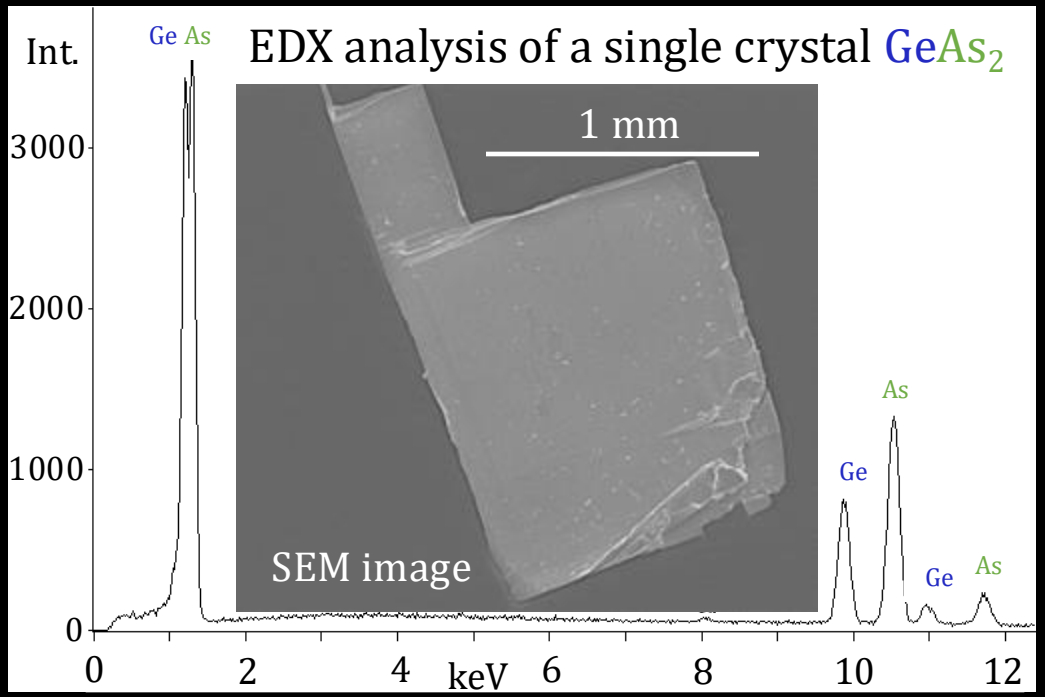
ARPES data show direct observation of topological states in nodal-loop semimetal HfP_2. Ref.: Phys. Rev. Mater. 4, 054201 (2020).

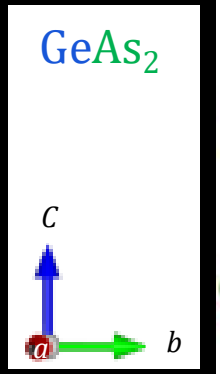
First principles study predicting HfP_2 monolayer as promise candidate for photovoltaic water splitting and produce hydrogen fuel. Ref.: RSC Adv. 12, 11202 (2022)

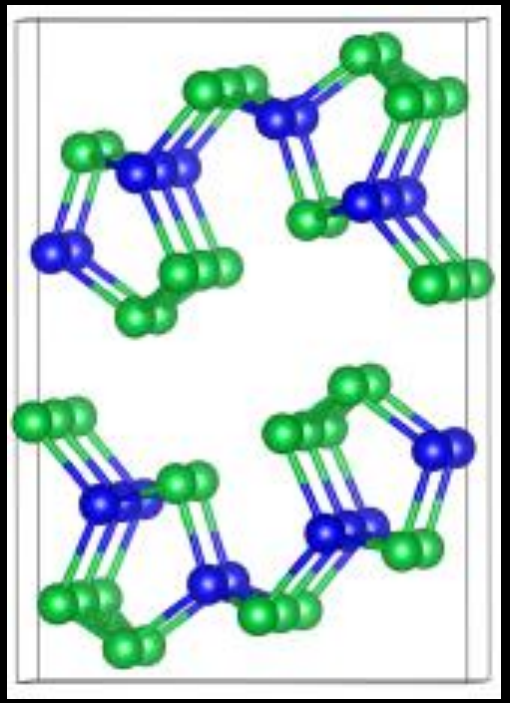
https://crystmat.com

2D Semiconductor $GeAs_2$

Promising candidate for thermoelectric applications







Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Ge K	28.94	+/- 0.58	29.60	+/- 0.60
As K	71.06	+/- 1.02	70.40	+/- 1.01
Total	100.00		100.00	

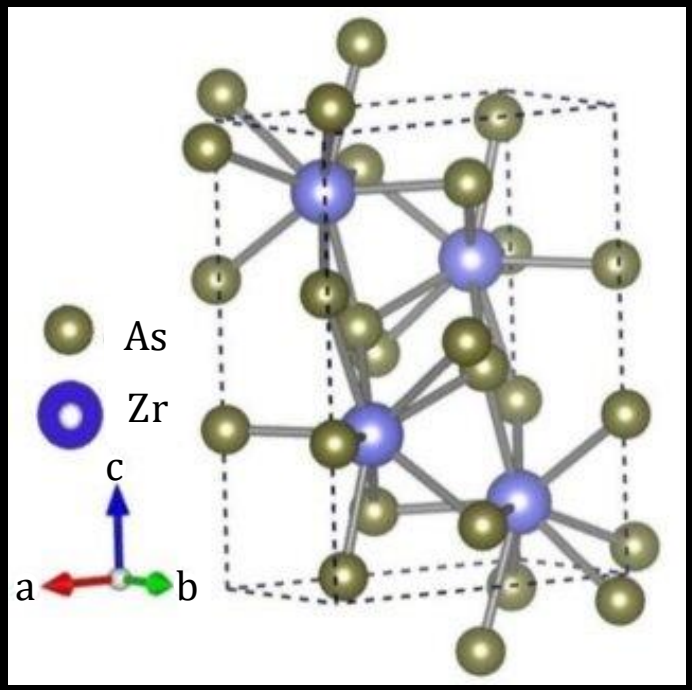
$GeAs_2$ crystallizes in the orthorhombic structure with the space group *Pbam* (No 55).

$GeAs_2$ is a 2D semiconductor with low thermal conductivity and high thermoelectric efficiency. Exfoliation of single-layer $GeAs_2$ is highly feasible and could be carried out by mechanical cleavage. Band-gap: bulk (0.99 eV), monolayer (1.64 eV).

https://crystmat.com

Topological semimetal $ZrAs_2$

Optical image of $ZrAs_2$ crystalline samples



$ZrAs_2$ crystallizes in orthorhombic crystal structure ($PbCl_2$, C23)

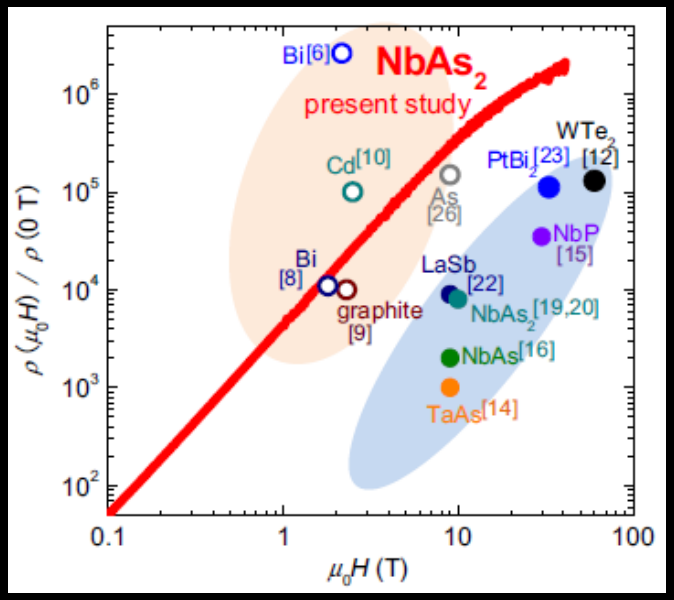
$ZrAs_2$'s topological nature, nodal-line semimetal behavior, high carrier mobility, and potential for quantum phenomena make it a highly intriguing material for researchers studying new types of quantum states.

$ZrAs_2$ exhibits large magnetoresistance properties, it offers a new platform for unveiling interesting physics beyond Weyl semimental and topological insulator systems. Ref.: Phys. Rev. B 110, 035142 (2024) ; B 110, 054114 (2024)

https://crystmat.com

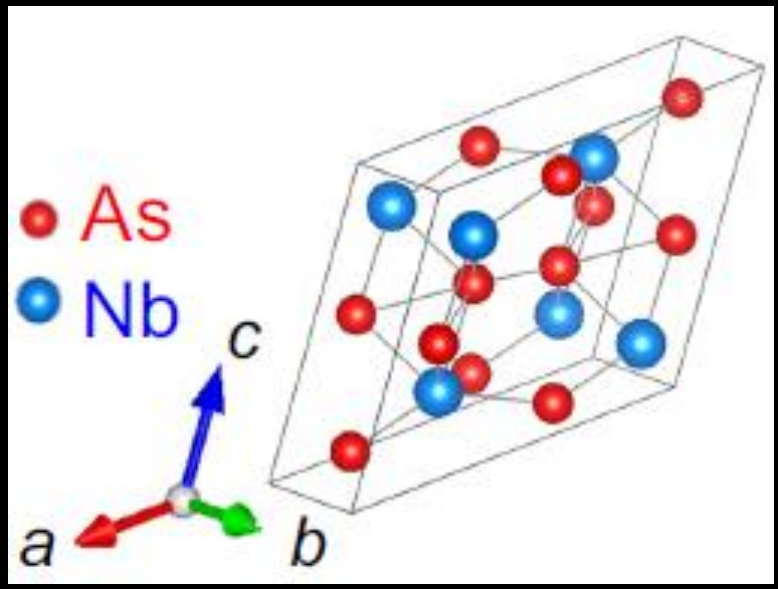
$NbAs_2$

$NbAs_2$ belongs to a large family of transition metal dipnictides MPn_2 (M = V, Nb, Ta, Cr, Mo, and W, Pn = P, As and Sb).



Magnetoresistance of $NbAs_2$, elemental metals and other binary compounds.

Ref.: Phys. Rev. Mat. 2 (2018) 024203



$NbAs_2$ crystallizes in a monoclinic system with the centrosymmetric space group of C12/m1.

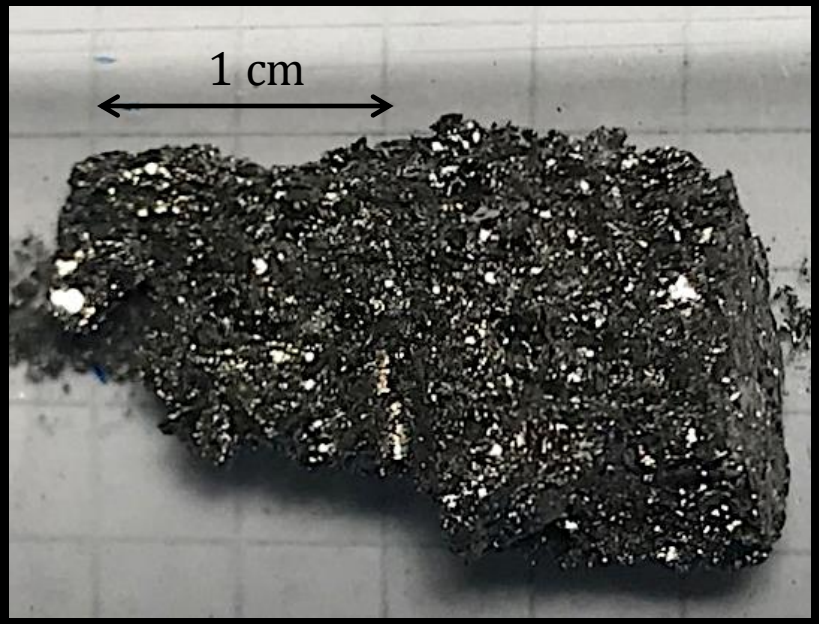
Ref.: Sci. Rep. 8 (2018) 6414

$NbAs_2$ exhibit extremely large magnetoresistance at low temperatures, which is ascribed to an effect for compensation of electrons and holes with large mobilities.

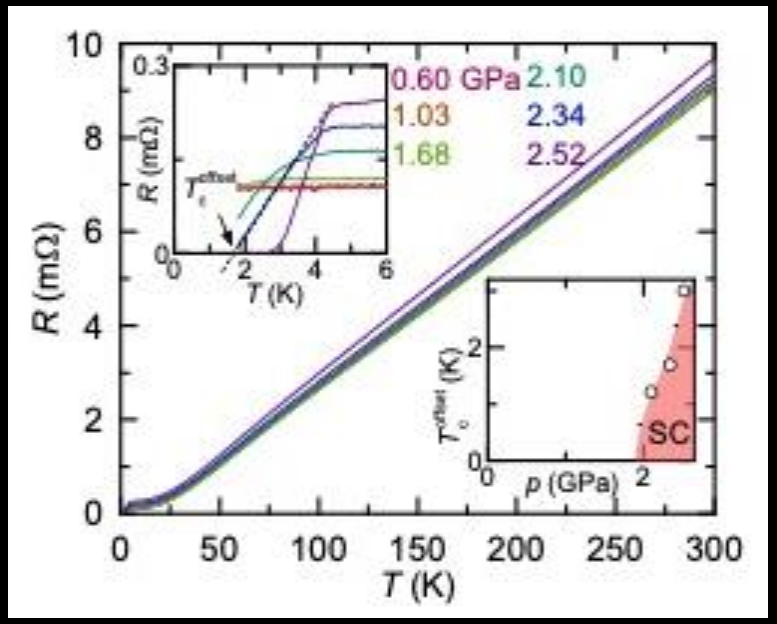
Ref.: Phys. Rev. B 93 (2016) 195119; Phys. Rev. B 93 (2016) 184405

https://crystmat.com

$LaBi_2$



Optical image of $LaBi_2$ sample



Resistance of $LaBi_2$ as a function of T and P

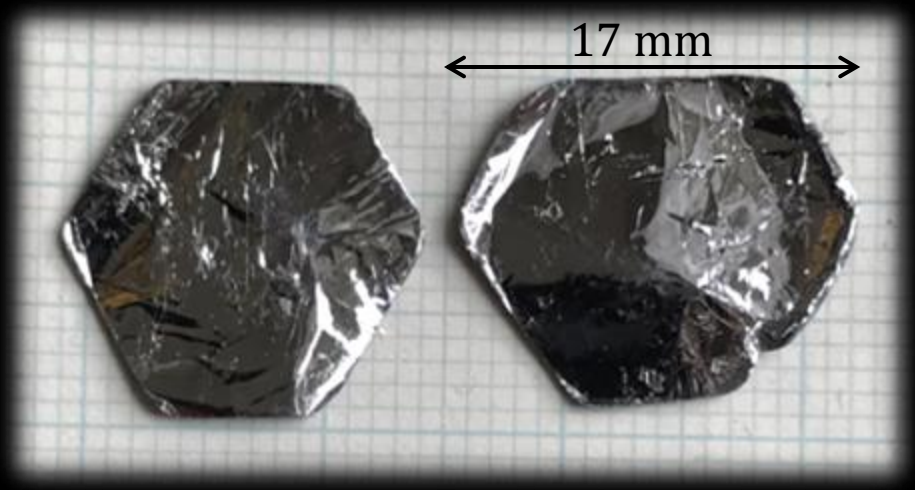
$LaBi_2$ reveals metallic behavior without indications of magnetic ordering. Superconductivity appears at high pressure, but its origin is not clarified yet.
Ref.: Phys. Rev. Materials 3, 095006 (2019)

Key points of interest: combination of topological properties, strong spin-orbit coupling, potential for Majorana fermions, thermoelectric applications, quantum computing, spintronic devices, transistors, sensors, energy harvesting.

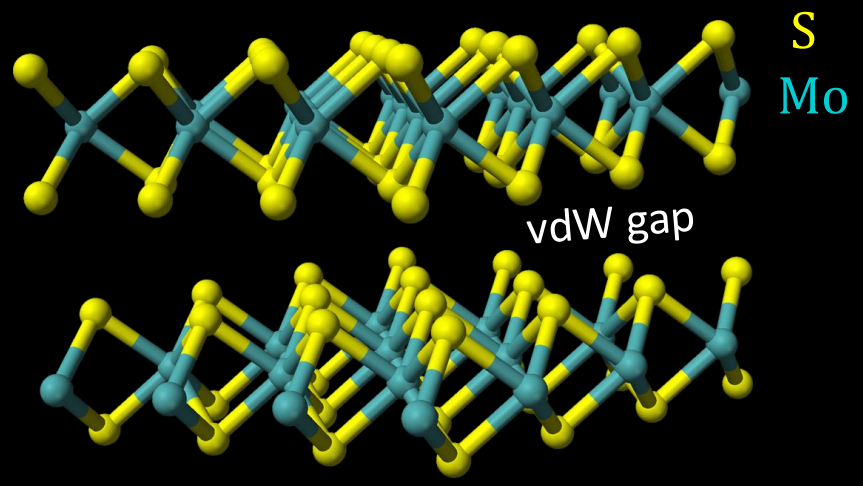
https://crystmat.com

2D Semiconductor MoS_2

MoS_2 plays an important role in condensed matter physics research



Optical image of MoS_2 single crystals. 2D MoS_2 monolayers can be produced by exfoliating bulk crystals.



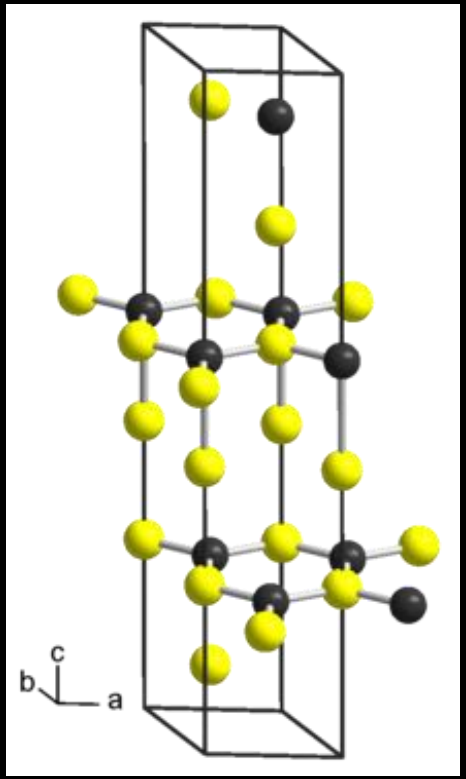
MoS_2: hexagonal *P*6_3/*mmc* space group. Monolayer is a layer of Mo atoms sandwiched between two layers of S atoms.

Bulk MoS_2 has an indirect gap of 1.2 eV. MoS_2 monolayers have a direct gap of 1.8 eV. Under an electric field MoS_2 monolayers have been found to superconduct at 9.4 K.

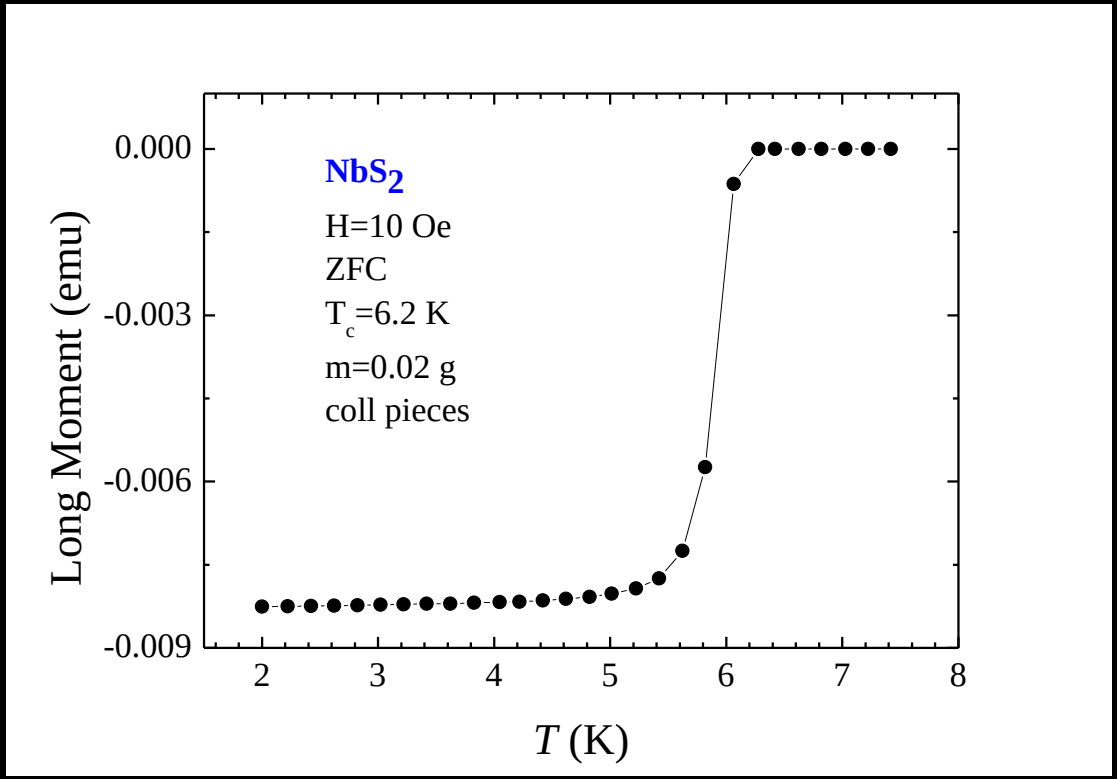
Applications: Field-effect transistors; Photodetectors; Solar cells; Chemical sensors; Supercapacitors & batteries; Spintronics; Valleytronic devices.

https://crystmat.com

NbS_2



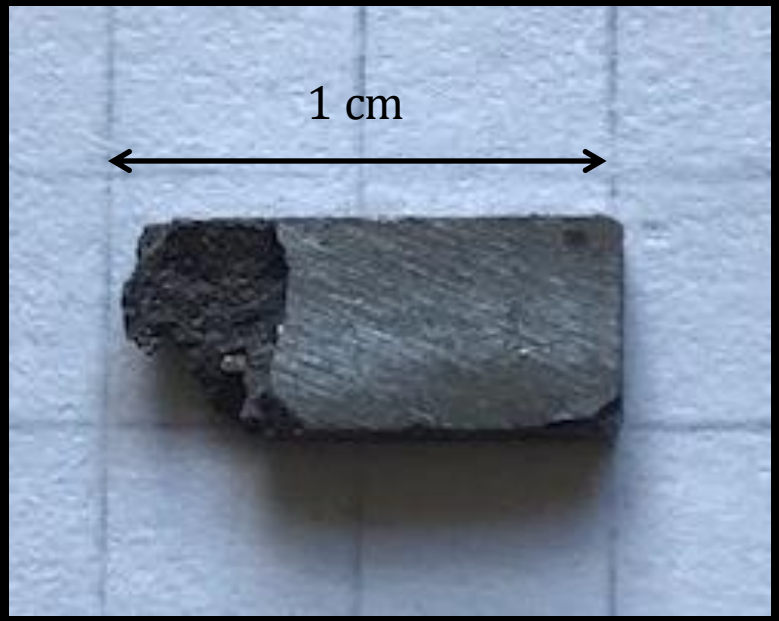
Crystal structure of NbS_2



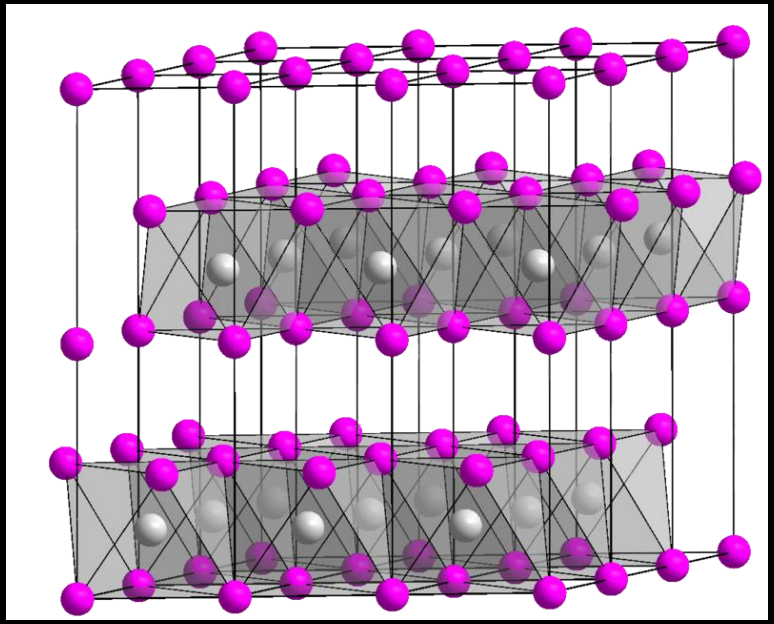
Superconducting transition of NbS_2

NbS_2 can be exfoliated into ultrathin grayish sheets similar to other transition metal dichalcogenides. These layers exhibit superconductivity, where the transition temperature increases from ca. 2 to 6 K with the layer thickness increasing from 6 to 12 nm, and then saturates with thickness.

PtS_2



Optical image of PtS_2 sample

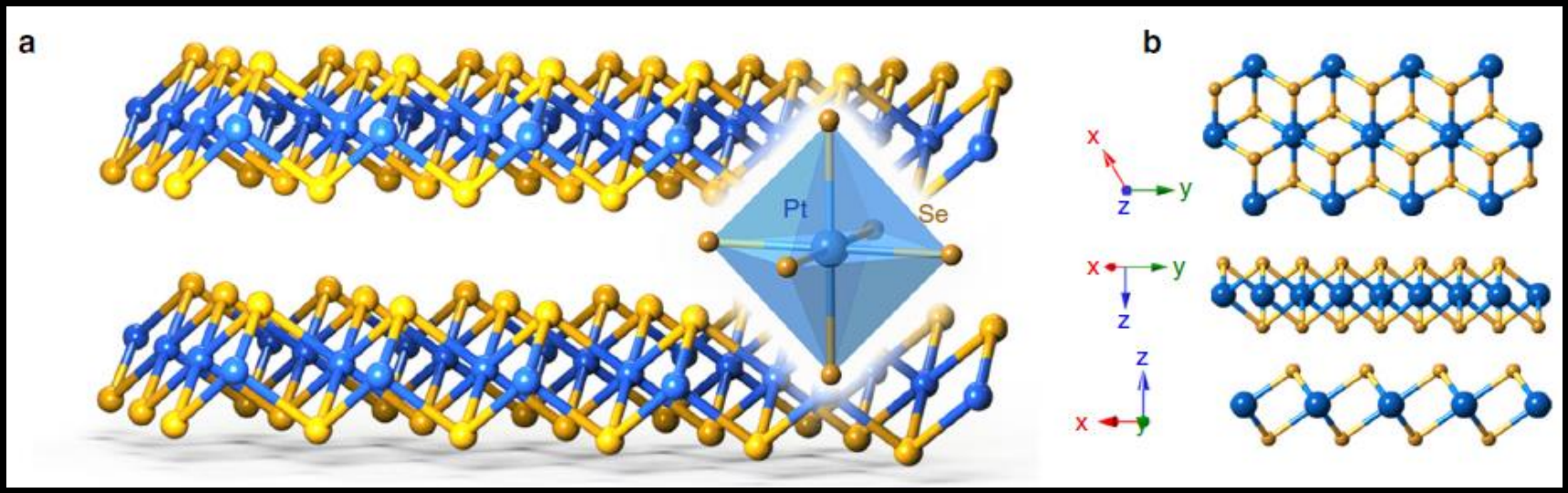


PtS_2 crystallizes in the *P*-3*m*1 space group of the trigonal system. Ref.: Wikipedia

PtS_2 semiconductor: bandgap of 0.25 eV for bulk and 1.6 eV for monolayers

Key points of interest: 2d layered material, semiconductor, spin-orbit coupling, topological properties, high carrier mobility, thermal stability, catalysis potential, form heterostructures, flexible nanoelectronics, quantum devices.

$PtSe_2$



$PtSe_2$ crystal possesses a 1*T*-type hexagonal crystal structure with *P*-3*m*1 space group, as show in Fig. (a) and (b).

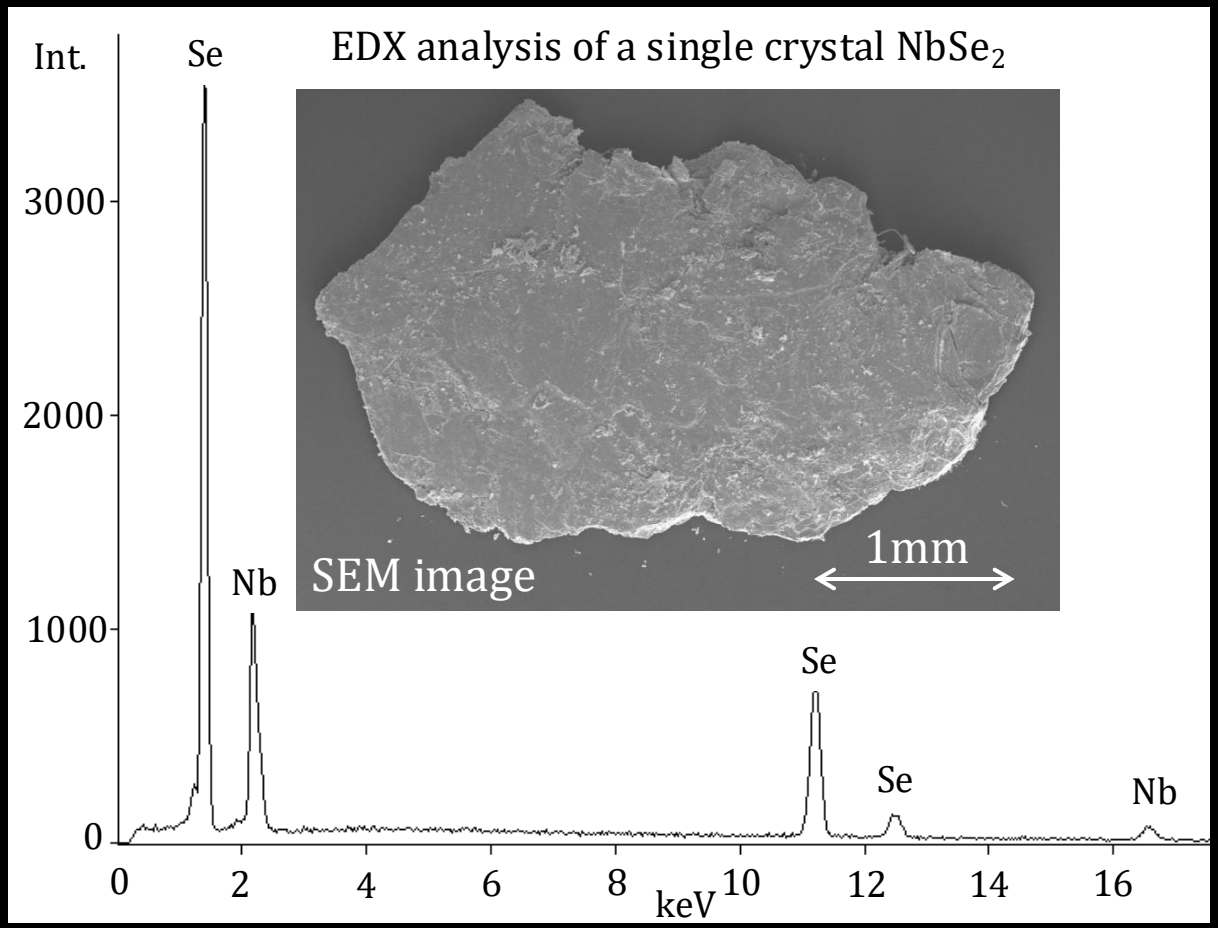
$PtSe_2$ is semimetallic, but when reduced to few layers it becomes a semiconductor. The band gap is calculated as 1.2 eV for monolayer, and 0.2 eV for bilayers. For a trylayer or thicker the substance loses a bandgap and becomes semimetalic.

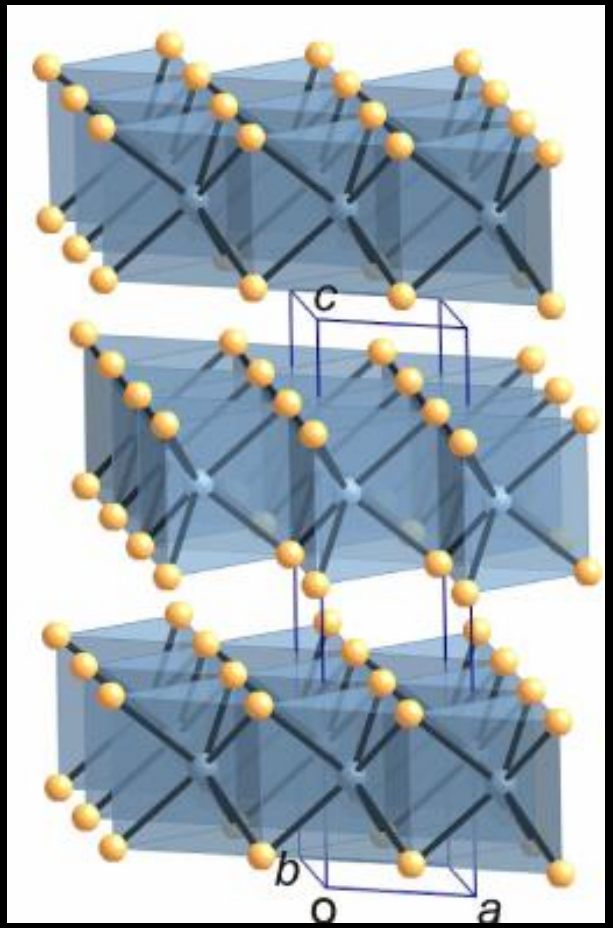
Monolyers of $PtSe_2$ show helical spin texture, which is not expected for centrosymmetric materials such as this. This property could be due to a local dipole induced Rashba effect. It means that $PtSe_2$ is a potential spintronics material. Ref.: Wikipedia

https://crystmat.com

2D Layered $NbSe_2$

$NbSe_2$ is fascinating material because of its layered structure, superconductivity, charge density wave phase, and capacity to host topologically intriguing states.





Element	Weight %	Weight % Err.	Atom %	Atom % Err.
Se K	61.73	+/- 1.18	65.49	+/- 1.25
Nb K	38.27	+/- 3.10	34.51	+/- 2.79
Total	100.00		100.00	

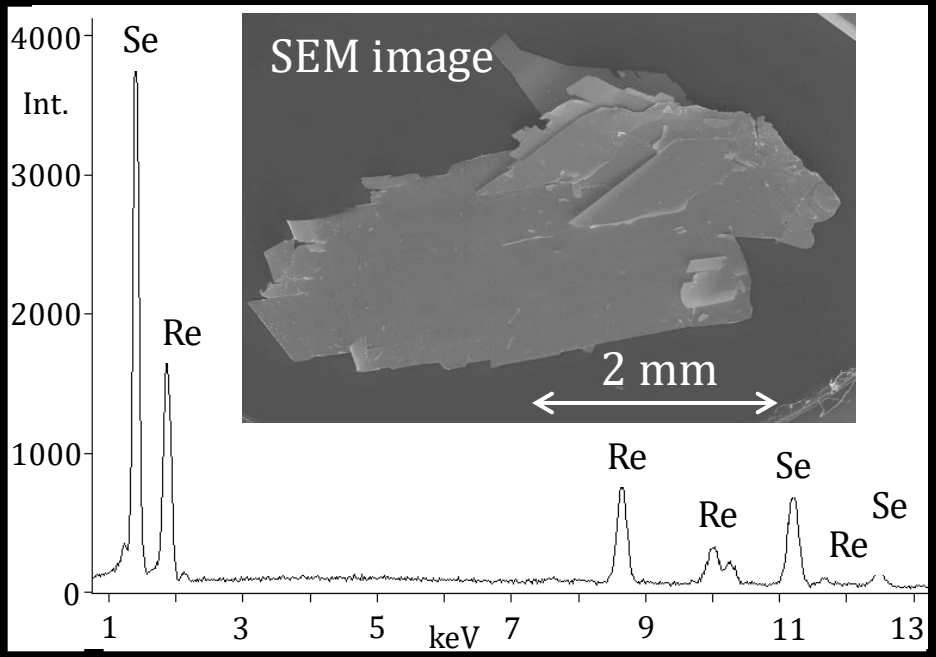
$NbSe_2$: $P6_3/mmc$ space group

Ref.: 2D Mater. 3 (2016) 035028

https://crystmat.com

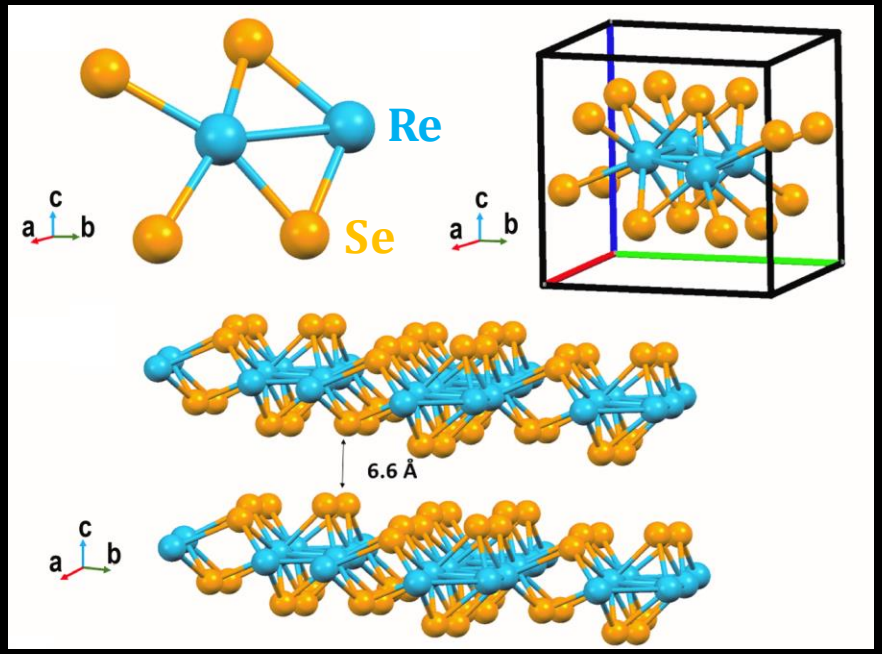
2D Semiconductor $ReSe_2$

May exhibit novel quantum states under strain, electric or magnetic fields, such as exotic phases or topologically protected edge states



EDX analysis of a single crystal $ReSe_2$

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Se K	46.13	+/- 1.09	66.88	+/- 1.58
Re L	53.87	+/- 1.14	33.12	+/- 0.70
Total	100.00		100.00	



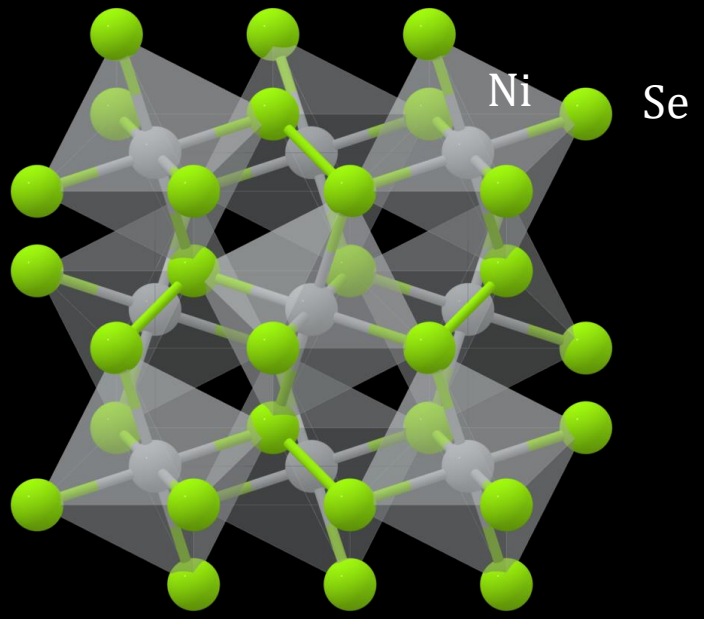
Unit cell of $ReSe_2$, which crystallizes in a distorted triclinic structure with a P-1 space group. Ref.: J. Phys. D: Appl. Phys. 50 (2017) 044001

Possible applications: in flexible and stretchable electronics, optoelectronics, and thermoelectrics (photodetectors, sensors, lasers, transistors, displays).

https://crystmat.com

$NiSe_2$

Optical image of $NiSe_2$ sample



$NiSe_2$ crystallizes in orthorhombic *Pbca* space group. Ni^{2+} is bonded to 6 Se^{1-} atoms to form $NiSe_6$ octahedra.

$NiSe_2$ can be exfoliated into 2D layers. Exhibit much better catalytic performance than well-studied MoS_2 and WS_2-based catalysts.

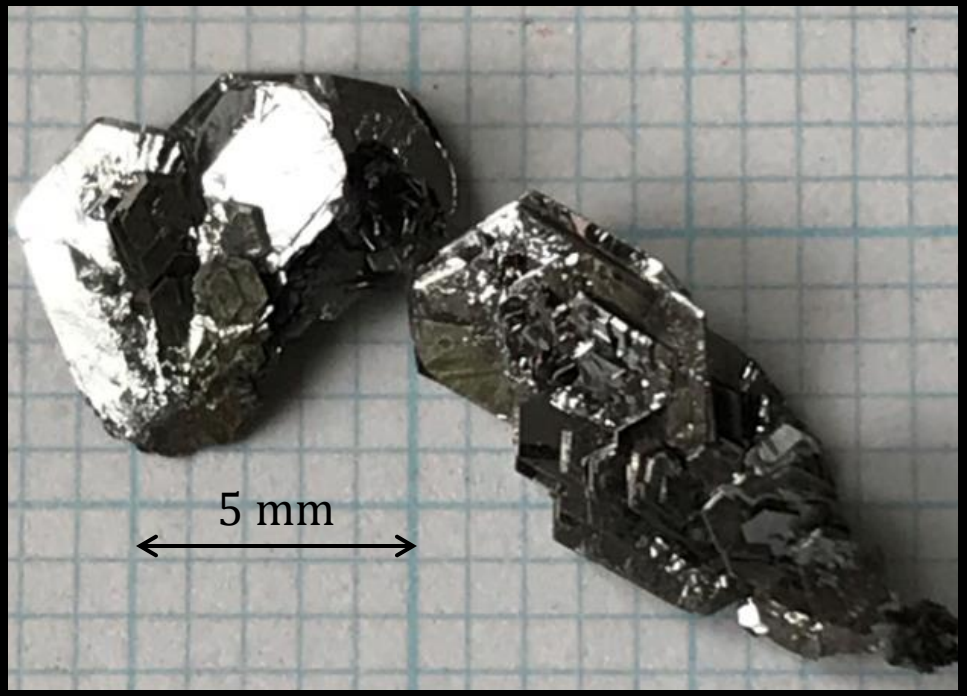
$NiSe_2$ key interesting points: promising topological and thermoelectric material, superconductivity, catalytic activity (alternative to Pt-based catalysts in fuel cells and batteries), creating heterostructures with other 2D materials.

https://crystmat.com

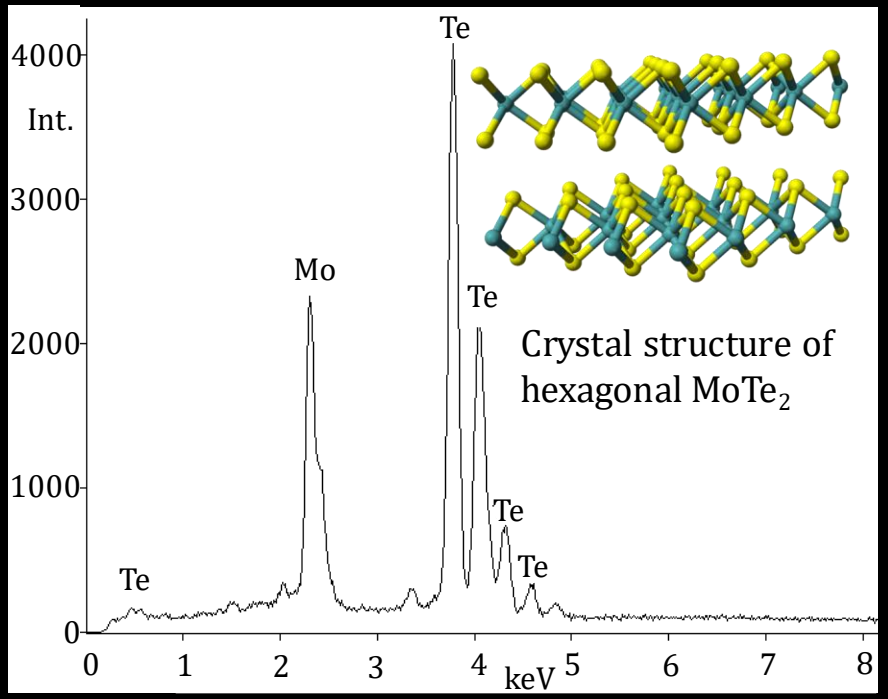
$MoTe_2$

Material for numerous functionalities

Optical image of $MoTe_2$ single crystals



EDX analysis of a single crystal $MoTe_2$

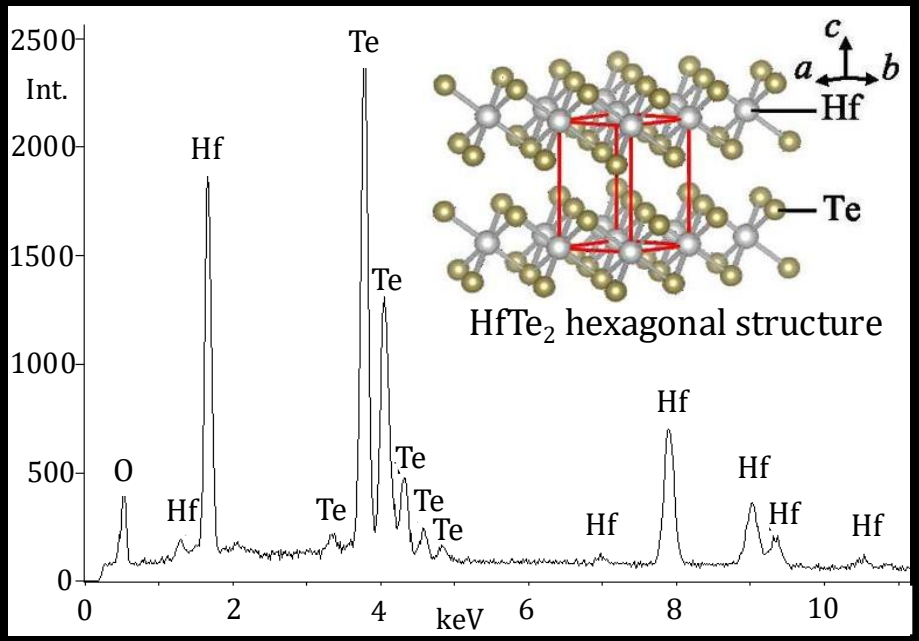


Applications of $MoTe_2$: Energy storage (batteries, supercapacitors), catalysis, sensors, solar cells, photodetectors, field-effect transistors, etc.

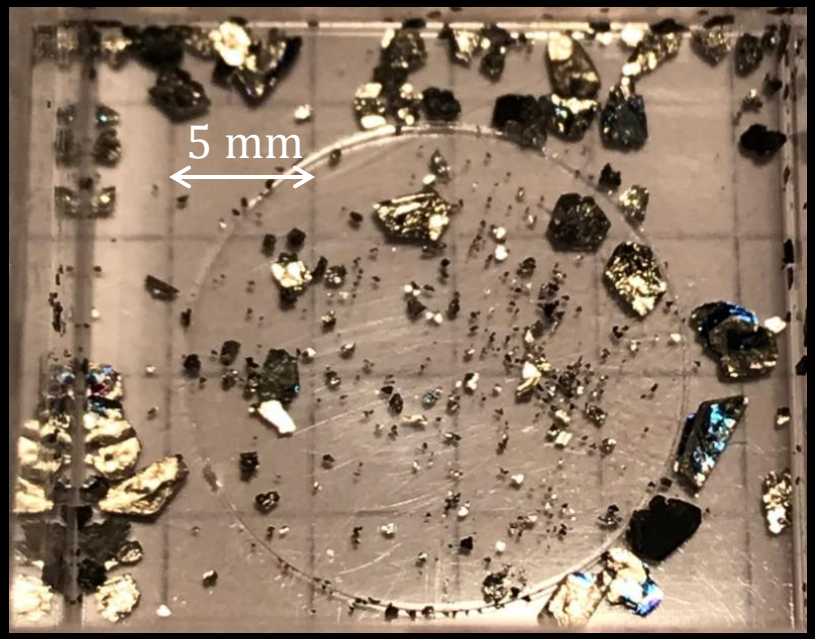
Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Mo L	28.08	+/- 0.46	34.18	+/- 0.56
Te L	71.92	+/- 0.71	65.82	+/- 0.65
Total	100.00		100.00	

$MoTe_2$ sheets can be thinned down to monolayers that are flexible and almost transparent. Mechanically adjustable and opto-electronically tunable $MoTe_2$ has potential for wearable and flexible electronic devices. Ref.: Wikipedia

2D Semimetal $HfTe_2$

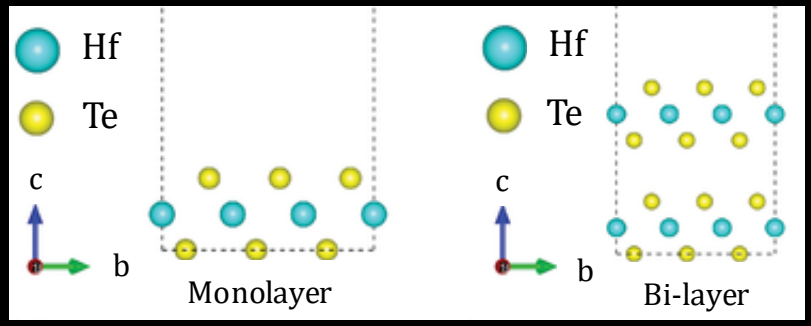


EDX analysis of a single crystal $HfTe_2$



Optical image of $HfTe_2$ single crystals

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Te L	58.82	+/- 0.81	66.65	+/- 0.92
Hf L	41.18	+/- 0.98	33.35	+/- 0.80
Total	100.00		100.00	



$HfTe_2$ key points: layered structure and topological characteristics, candidate for Weyl semimetal, strong spin-orbit coupling, anomalous magnetoresistance, possible superconductivity, tuning via strain & dimensionality, potential for thermoelectrics.

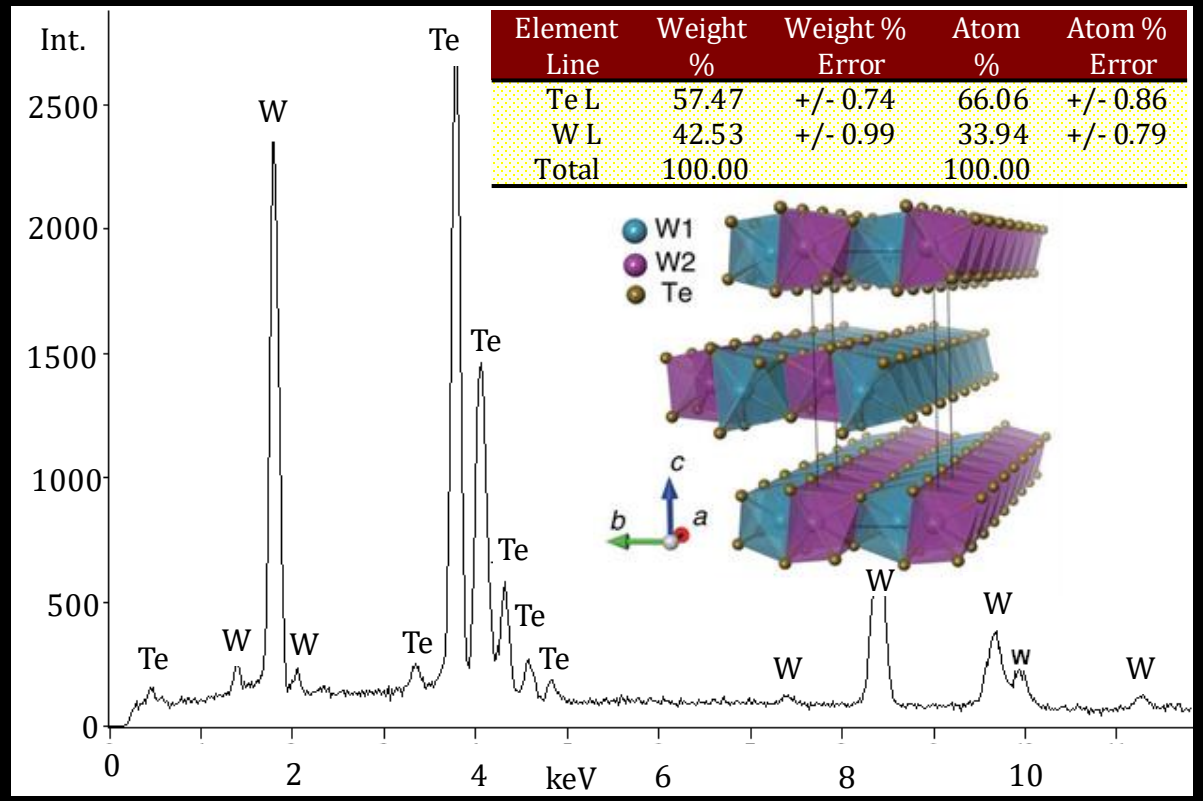
https://crystmat.com

2D Semimetal WTe_2

Material for cutting-edge science

Image of WTe_2 crystals

Crystal structure of WTe_2



EDX analysis of WTe_2

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Te L	57.47	+/- 0.74	66.06	+/- 0.86
W L	42.53	+/- 0.99	33.94	+/- 0.79
Total	100.00		100.00	

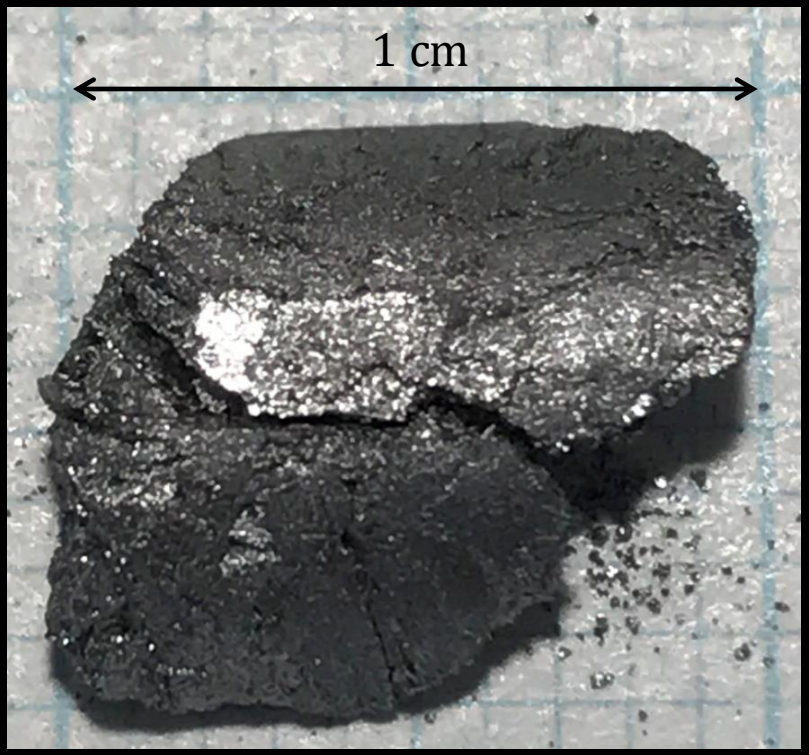
WTe_2 is a type-II Weyl semimetal. Bulk crystal reveals large magnetoresistance and pressure-driven superconductivity. Electrons in a WTe_2 flake can exhibit hydrodynamic behaviour, exhibiting traits similar to those of classical fluids.

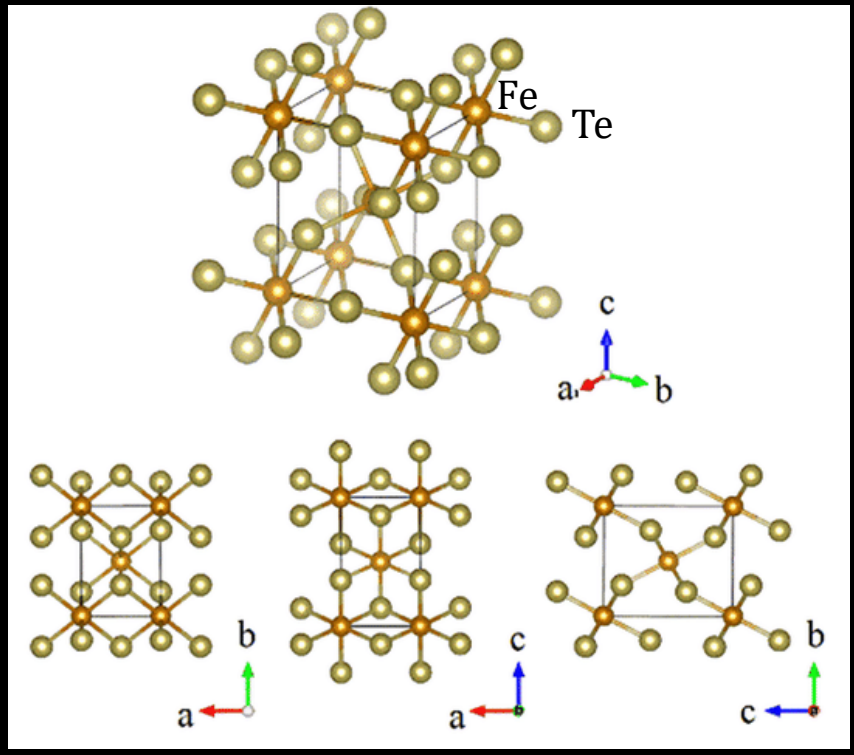
Refs.: Wikipedia ; Nat. Physics 17 (2021) 1216

https://crystmat.com

$FeTe_2$

Material with promises for applications that relatively unstudied experimentally





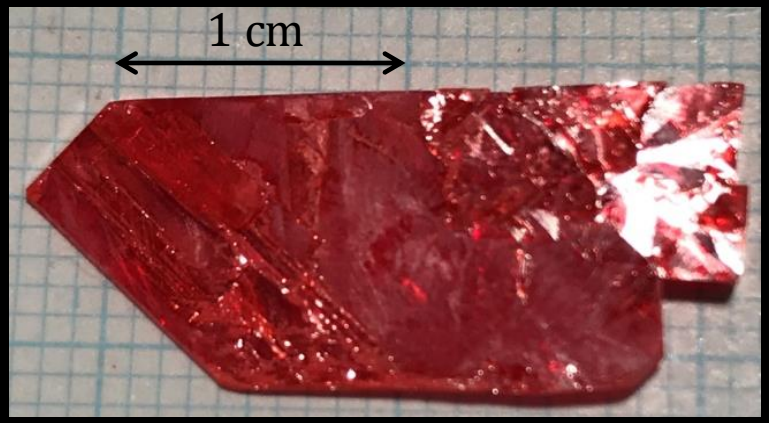
$FeTe_2$ was synthesized from high purity elements employing evacuated silica tube technique. Specimen was heated, reground and annealed at 450 °C several times until complete.

$FeTe_2$ crystallizes in orthorhombic structure with space group *Pnnm*. Cooling down to 2 K, paramagnetic to AF and then FM phase transitions were observed at 79 K and 35 K.

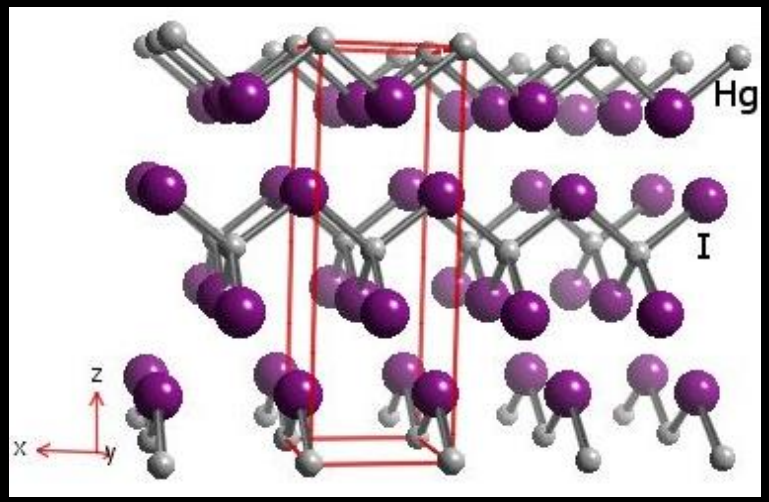
Ref.: J. Phys.: Condens. Matter 32, 035808 (2020); ACS Omega 6, 10537 (2021)

https://crystmat.com

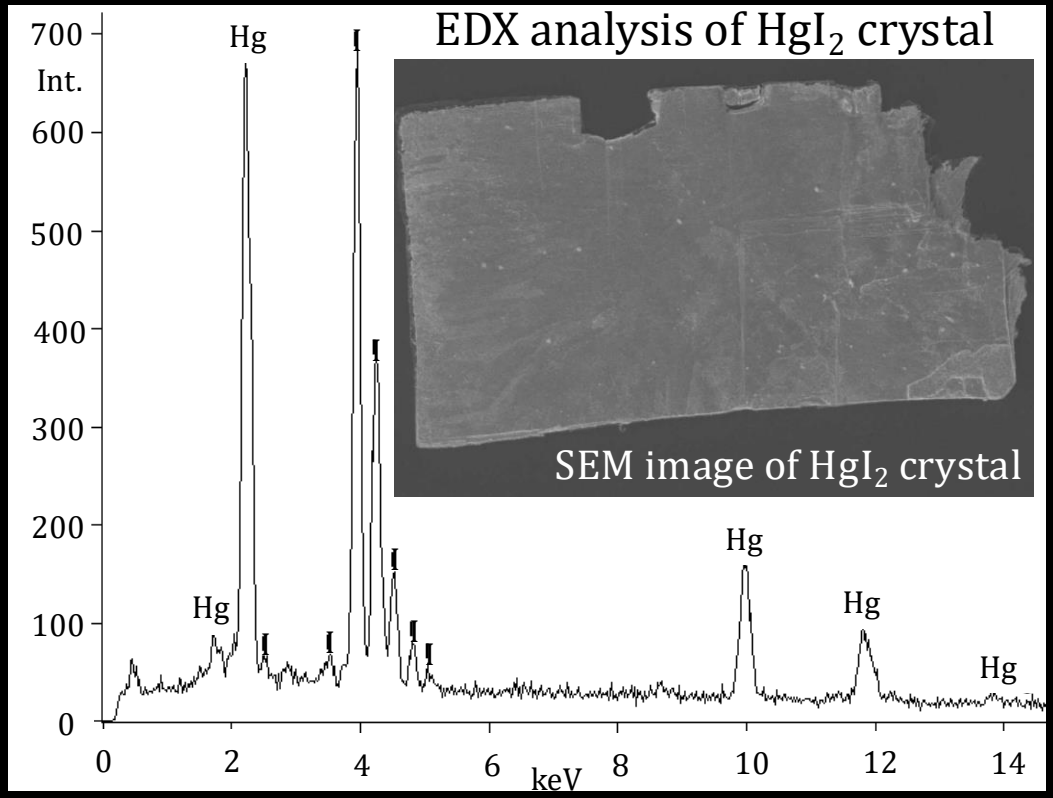
2D Semiconductor α-HgI_2



Optical image of HgI_2 layered crystal



Crystallizes in *P*4_2/*nmc* space group



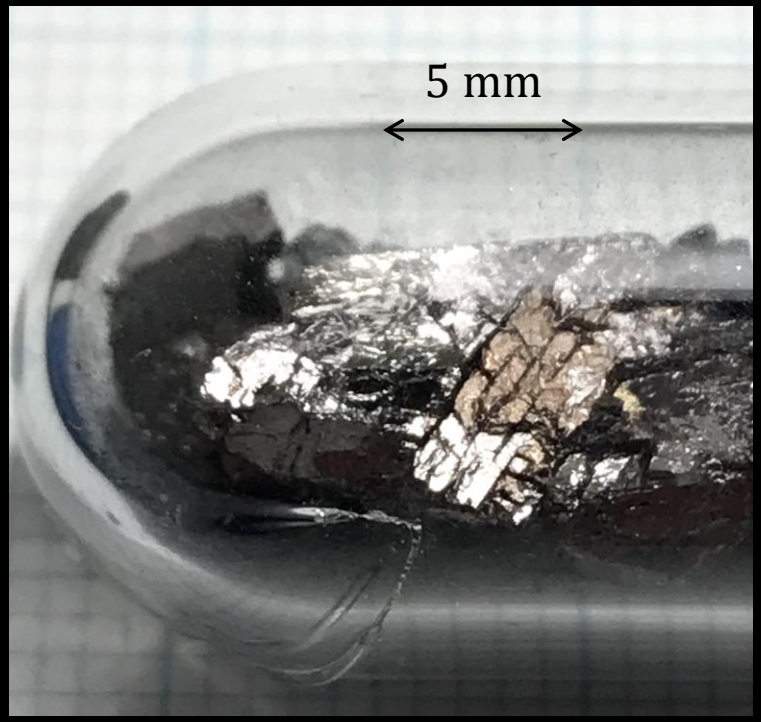
Element Line	Weight %	Weight % Error	Atom %	Atom % Error
I L	54.07	+/- 1.42	65.05	+/- 1.71
Hg L	45.93	+/- 2.46	34.95	+/- 1.87
Total	100.00		100.00	

HgI_2 is a semiconductor for construction of X- and **γ**-ray detectors for digital medical imaging. HgI_2 has a wide optical band-gap (2.1 eV) and high photon absorption coefficient for high-energy radiation.

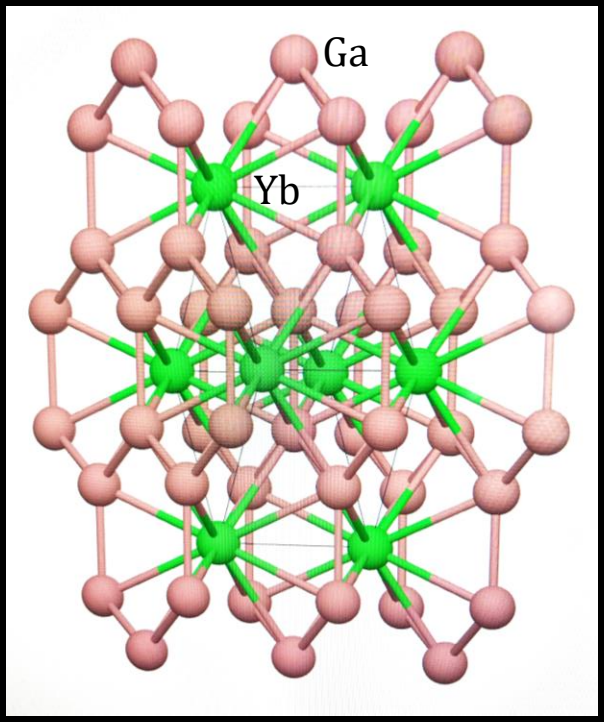
https://crystmat.com

$YbGa_2$

Predicted as potential topological electronic material



Optical image of $YbGa_2$ crystals



Hexagonal *P*6_3/*mmc* space group

$YbGa_2$ key aspects: Yb valence state, potential for quantum criticality and superconductivity, magnetic properties, heavy fermion behavior, quantum technologies, low-dimensionality, electronic band structure, high pressure effects

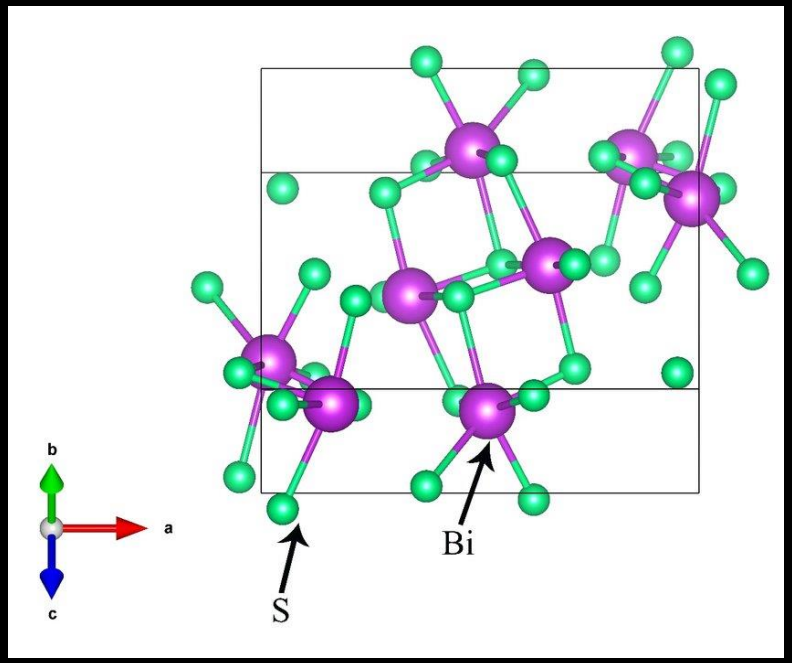
At pressure above 22 GPa, $YbGa_2$ undergoes structural phase transition and Yb increase oxidation state from 2+ to 3+. Ref.: ZAAC 627, 2249 (2001)

https://crystmat.com

Bi_2S_3

Bi_2S_3 has lamellar structure and can be exfoliated down to monolayers through standard mechanical exfoliation technique.

Image of Bi_2S_3 crystals

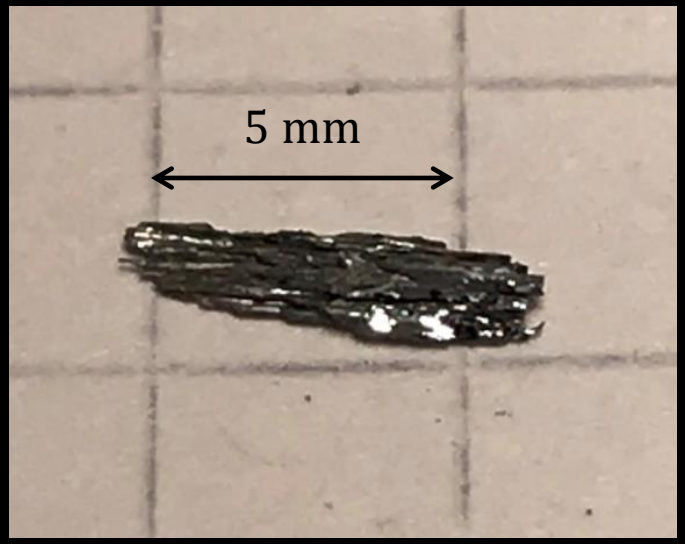


Crystal structure of Bi_2S_3

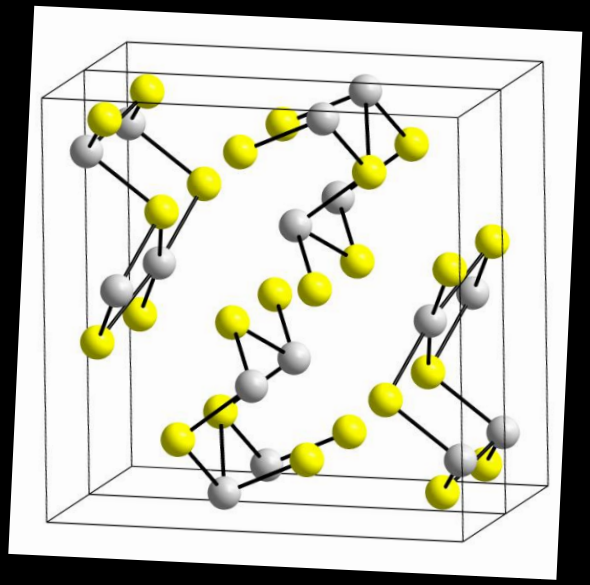
Bi_2S_3 is crystallized in orthorhombic structure (space group *Pnma*) and has semiconducting behaviour with band gap ~1.3 eV and large absorption coefficient of 105 cm-1. Interesting candidate for thermoelectrics, photodetectors, solar cells and supercapacitors.

Sb_2S_3

Topological insulator, high mobility 2D semiconductor



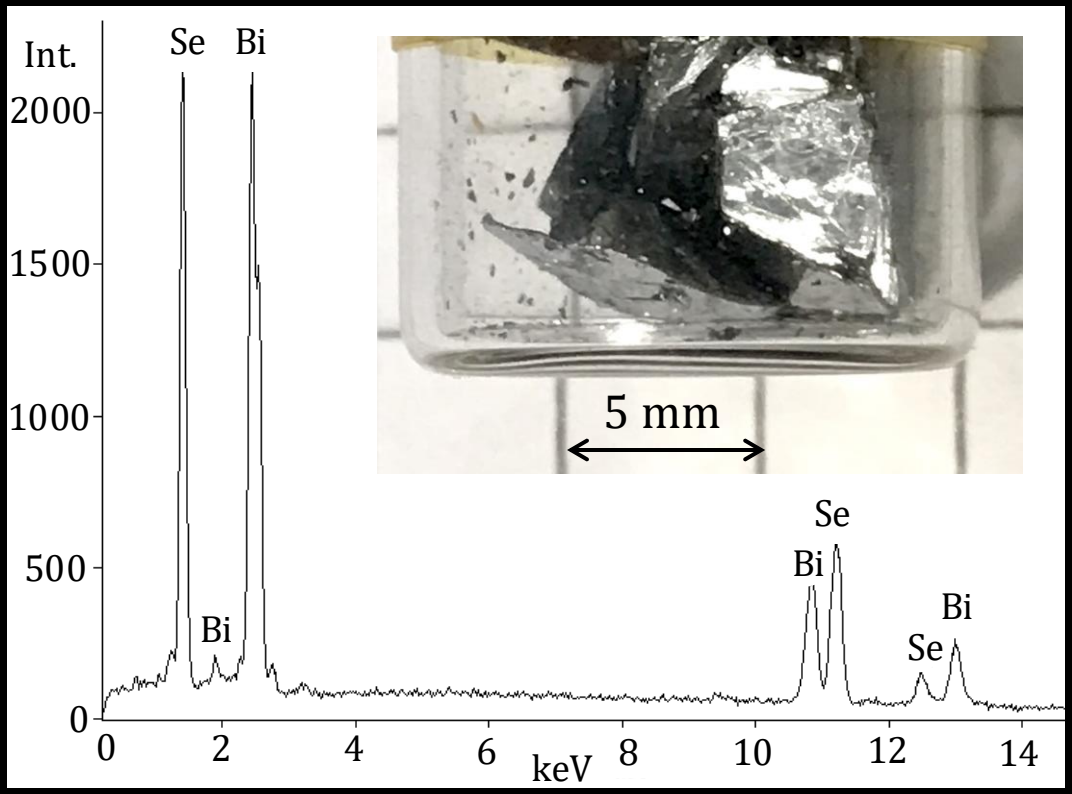
Optical image of Sb_2S_3 crystal

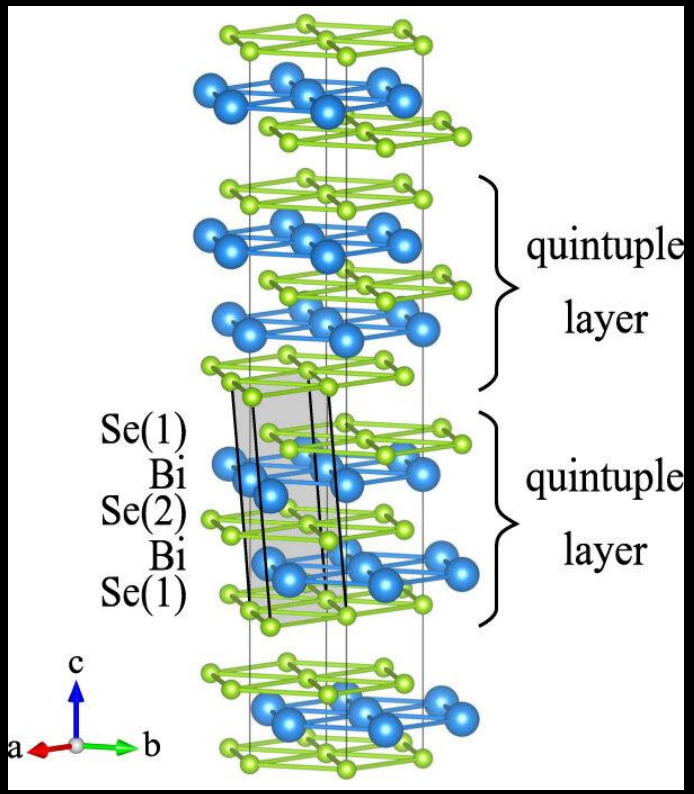


Sb_2S_3 crystallizes in orthorhombic structure, space group *Pbnm* (a = 11.23 Å, b = 11.31 Å, c = 3.84 Å, Z = 4). Ref.: Wikipedia

Sb_2S_3 is a promising photovoltanic material. With band gap of 1.7-1.8 eV it has been considered as a perfect component for top sub cell in Si-based tandem solar cells. Ref.: Nat. Commun. **10**, 4540 (2019); Joule **2**, 857-878 (2018)

2D topological insulator Bi_2Se_3





EDX

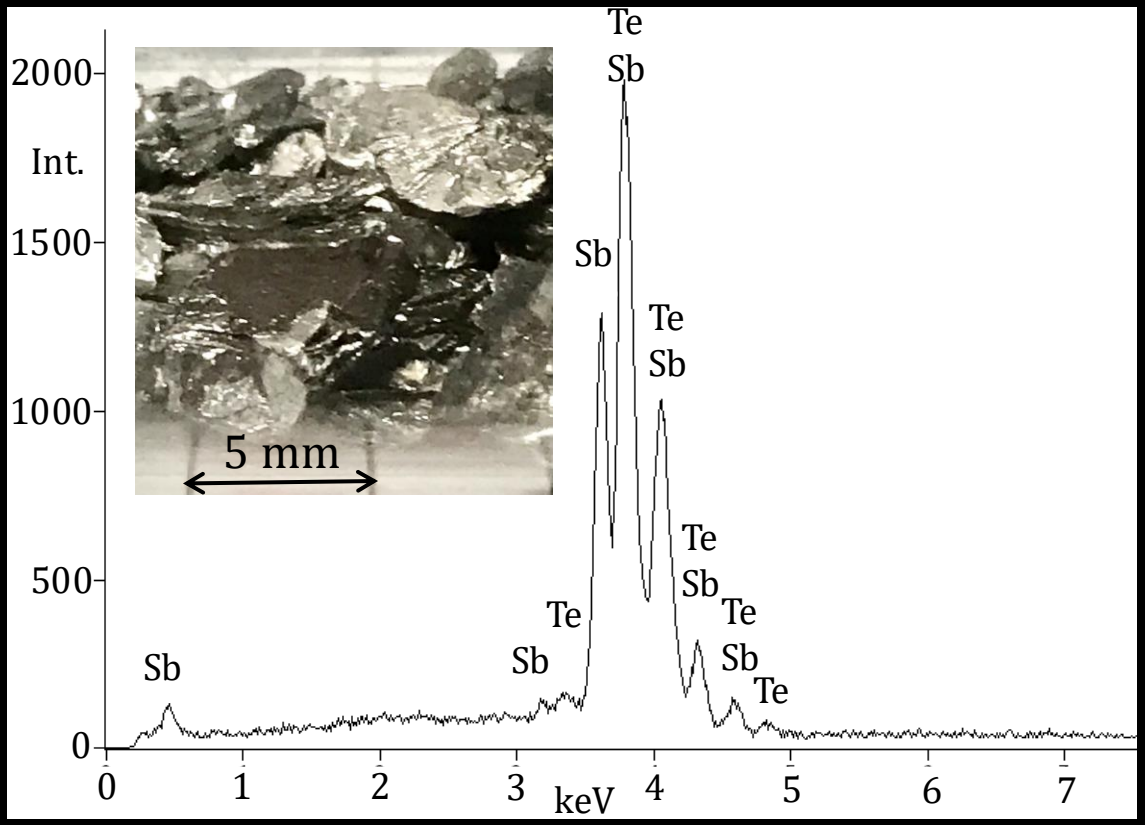
Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Se K	36.23	+/- 1.07	60.06	+/- 1.77
Bi L	63.77	+/- 1.83	39.94	+/- 1.15
Total	100.00		100.00	

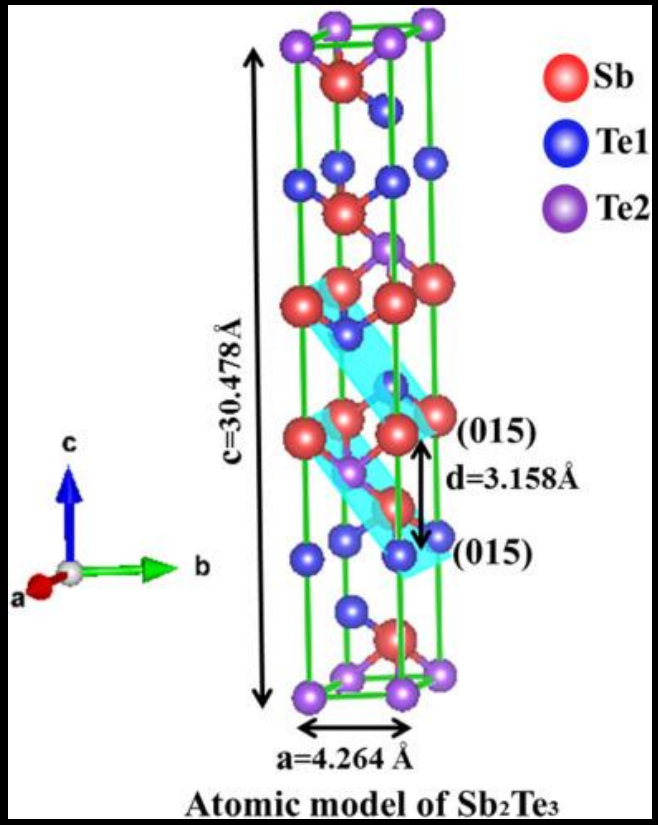
Bi_2Se_3 crystallizes in rhombohedral structure with space group *R-3m*
Ref.: J. Phys.: Condens. Matter. 33, 065501 (2020)

Bi_2Se_3 is an intriguing material due to its topological insulating properties, potential for quantum computing, spintronic applications, and thermoelectric capabilities. Its distinct electronic structure and 2D surface states make it a crucial material for advancing both fundamental physics and cutting-edge technologies.

https://crystmat.com

2D Topological insulator Sb_2Te_3





EDX

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Sb L	40.40	+/- 1.54	41.53	+/- 1.58
Te L	59.60	+/- 2.16	58.47	+/- 2.12
Total	100.00		100.00	

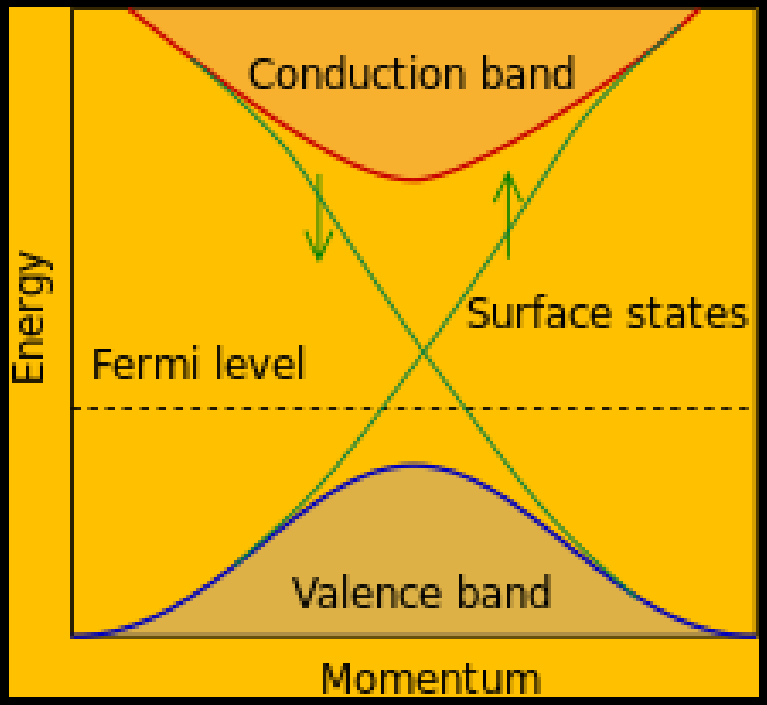
Crystallizes in rhombohedral structure with *R-3m* space group. Ref.: J. Alloy Comp. 858, 157732 (2021)

Key interesting points: thermoelectric, quantum computing, spintronics, lasers, infrared detectors, non-volatile memory, data storage technology.

https://crystmat.com

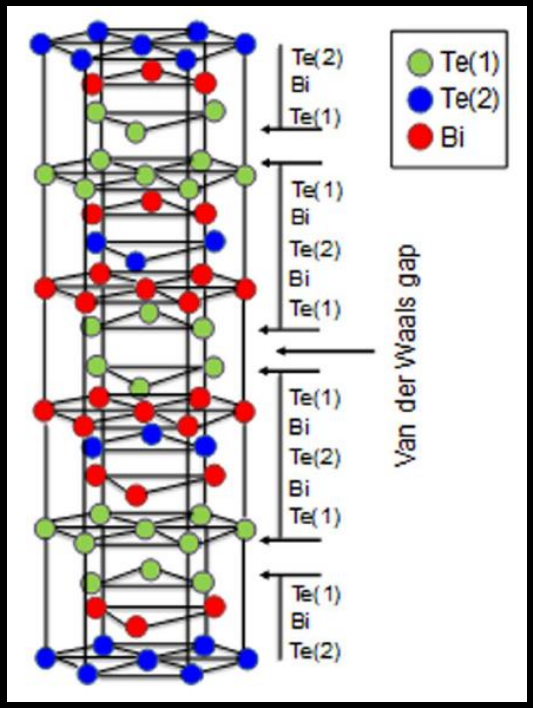
2D Topological insulator Bi_2Te_3

Bi_2Te_3 is a topological insulator. It is an efficient thermoelectric material for refrigeration or portable power generation. The layers are stacked together via van der Waals interactions and can be exfoliated into thin 2D layers.



An idealized band structure for a topological insulator. Fermi level falls within bulk band gap which is traversed by topologically-protected spin-textured Dirac surface states.

Ref.: Ann. Rev. Cond. Mat. Phys. 2: 55 (2011)

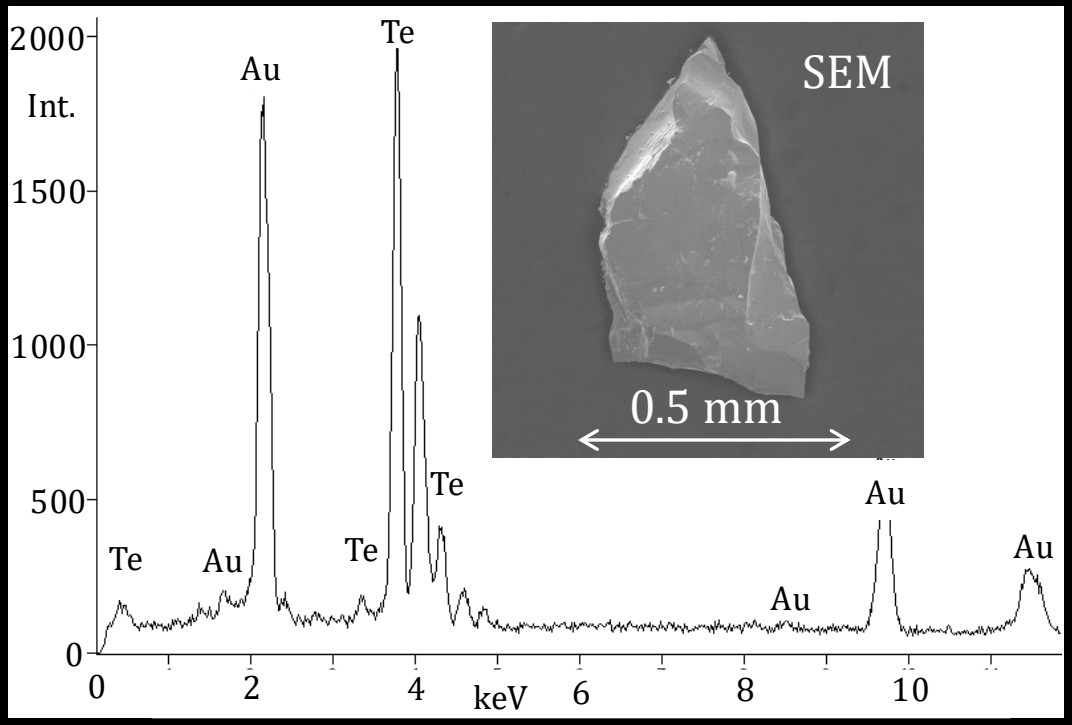


Bi_2Te_3 crystallizes in a rhombohedral structure with the space group *R-3m*, and is described by a hexagonal unit cell.

Ref.: Sci. Rep. 9: 10790 (2019)

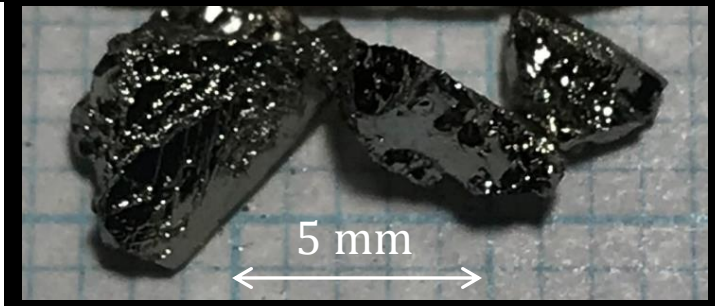
Au_2Te_3

Heavy elements such as Au and Te have potential to form compounds with strong spin-orbit coupling and narrow band gaps. Little is known about Au_2Te_3 compound.

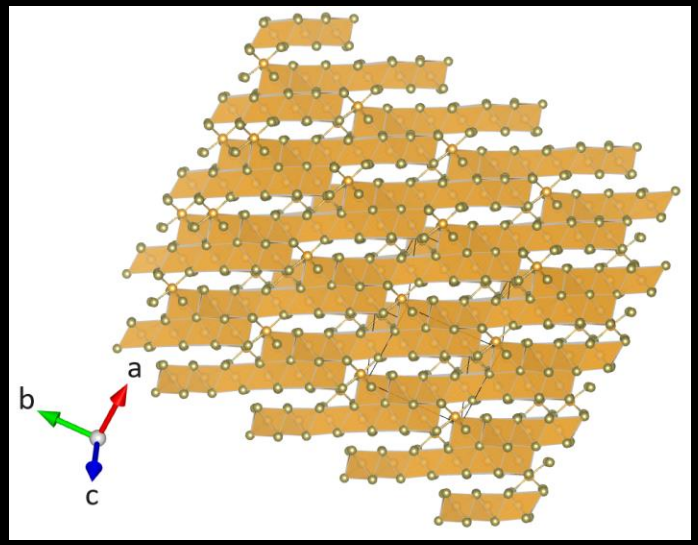


EDX analysis of a single crystal Au_2Te_3

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Te L	49.98	+/- 0.76	60.67	+/- 0.92
Au L	50.02	+/- 1.33	39.33	+/- 1.05
Total	100.00		100.00	



Optical image of Au_2Te_3

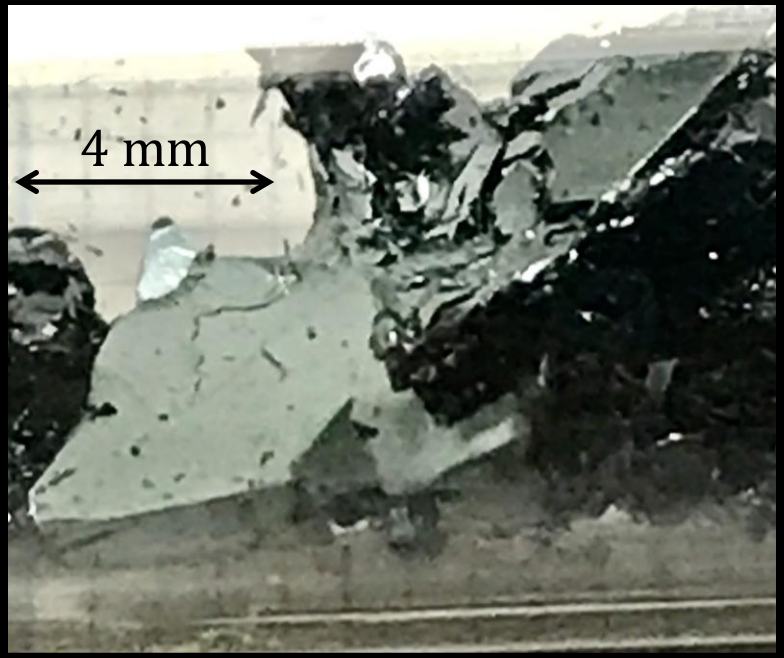


Te atoms form octahedra around Au atoms, creating displaced double layers

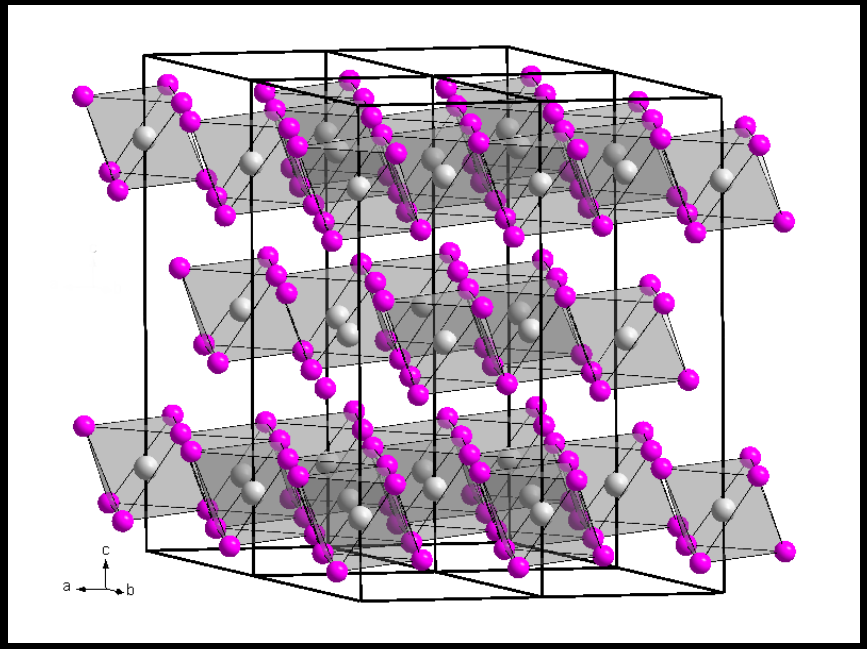
Ref.: Wikipedia; Science 145 (3632), 581-583 (1964); Nat Phys Sci 231, 67-68 (1971)

https://crystmat.com

2D Helimagnet ferric chloride $FeCl_3$



Optical image of $FeCl_3$ single crystals



$FeCl_3$: hexagonal structure *R*_3, No 148

A neutron diffraction study found a helimagnetic structure for $FeCl_3$ below 15 K. A field induced magnetic transition was also observed in $FeCl_3$.

Ref.: Crystals 7 (2017) 121

$FeCl_3$ layers can be intercalated with graphite. This van der Waals system combines frustration and disorder, due to intercalation, and may be hosting topologically non-trivial magnetic phases. Ref.: Phys. Rev. B 105 (2022) 054418

Bi_2Se_2S

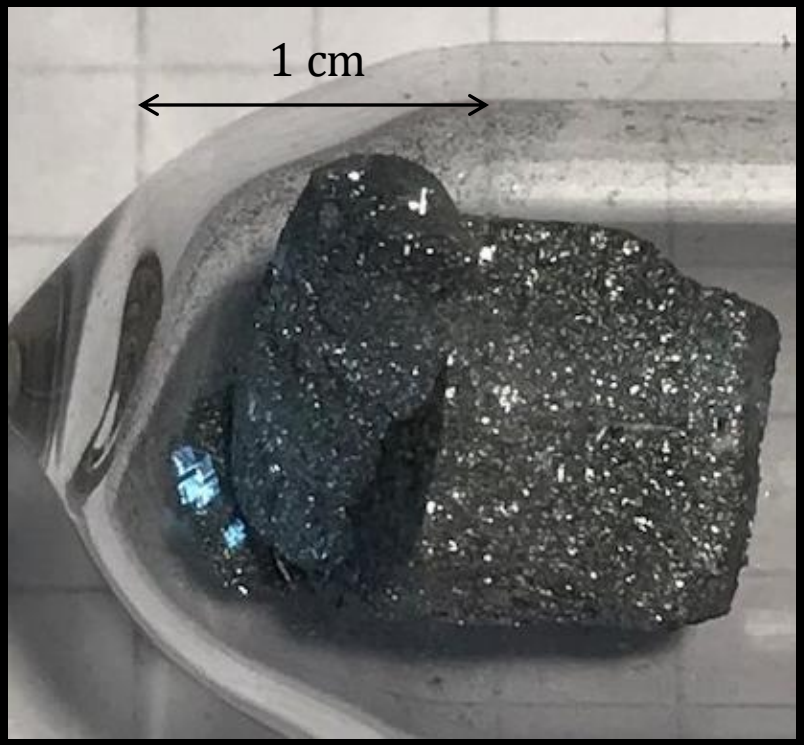
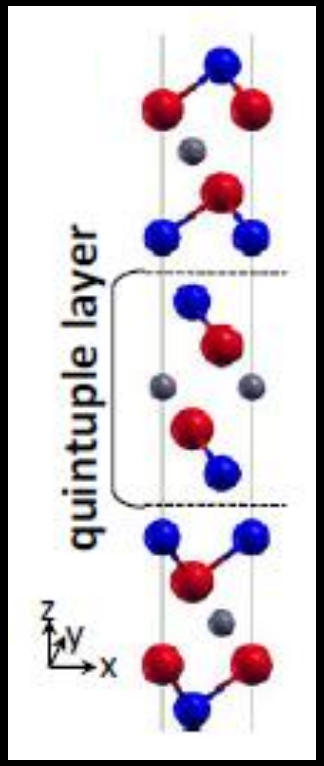


Image of Bi_2Se_2S sample



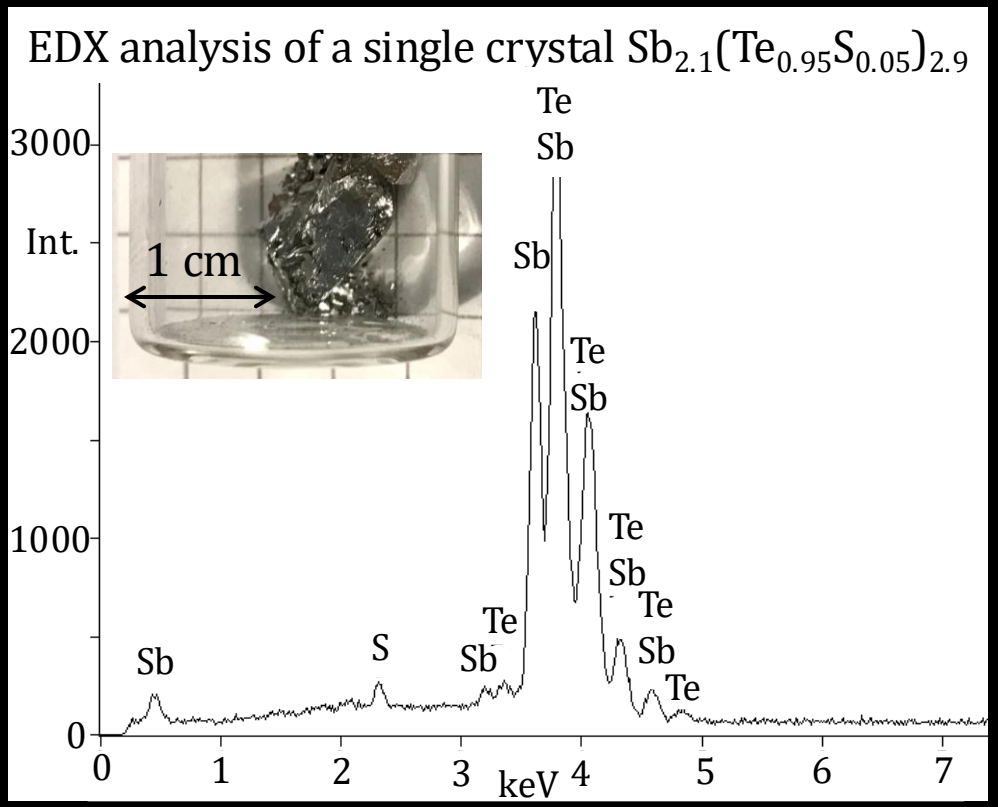
The crystal structure of the tetradymite M_2Xe_2Y

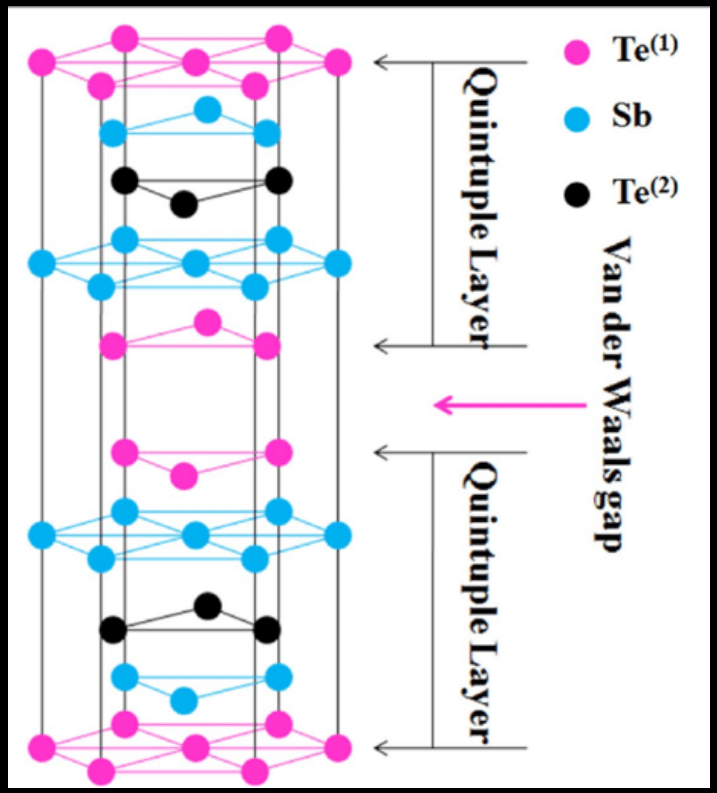
Ref.: New J. Phys. 13, 095005 (2011)

The ternary tetradymite-like compouds M_2Xe_2Y (M = Bi or Sb; X and Y = S, Se or Te) are variations of binary compounds Bi_2Se_3 and Bi_2Te_3. They are predicted to have an isolated Dirac cone on their naturally cleaved surface.

https://crystmat.com

2D topological insulator $Sb_{2.1}(Te_{0.95}S_{0.05})_{2.9}$





Element Line	Weight %	Weight % Error	Atom %	Atom % Error
S K	1.17	+/- 0.07	4.41	+/- 0.27
Sb L	41.64	+/- 1.17	41.37	+/- 1.17
Te L	57.19	+/- 1.65	54.22	+/- 1.56
Total	100.00		100.00	

$Sb_{2.1}(Te_{0.95}S_{0.05})_{2.9}$ crystallizes in rhombohedral structure with *R-3m* space group. Ref.: Nanoscale Res. Lett. 16, 22 (2021)

Key interesting points: thermoelectric, quantum computing, spintronics, lasers, infrared detectors, non-volatile memory, data storage technology.

https://crystmat.com

$HgTe/Sb_2Te_3 = Sb_{2.8}Hg_{0.2}Te_{3.95}$

Perspective topological insulator material

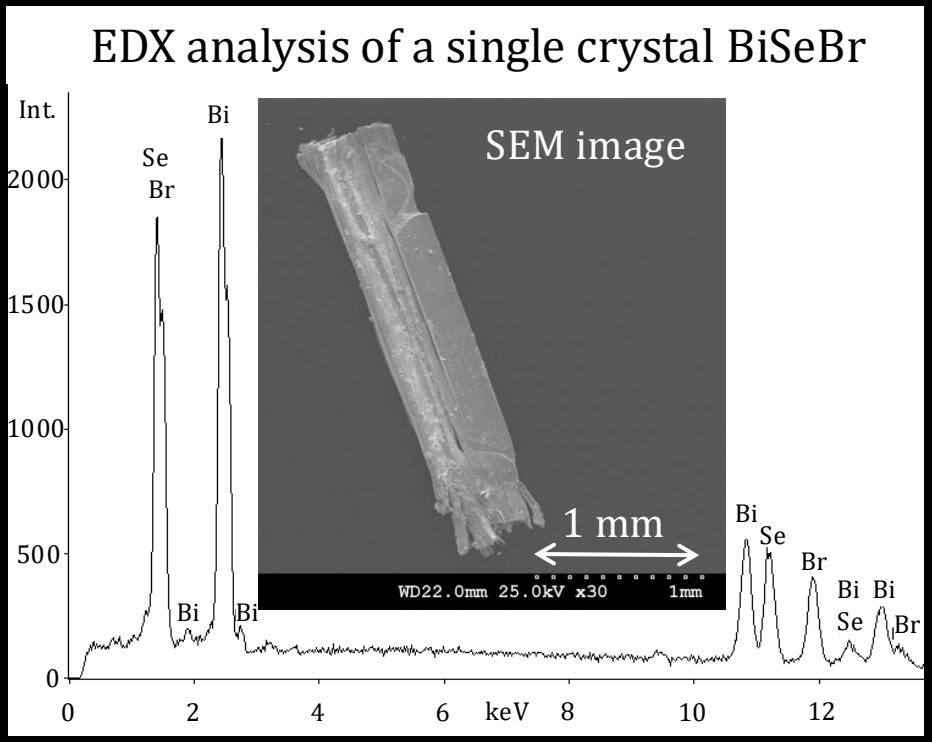
Optical image of $Sb_{2.8}Hg_{0.2}Te_{3.95}$ crystalline sample

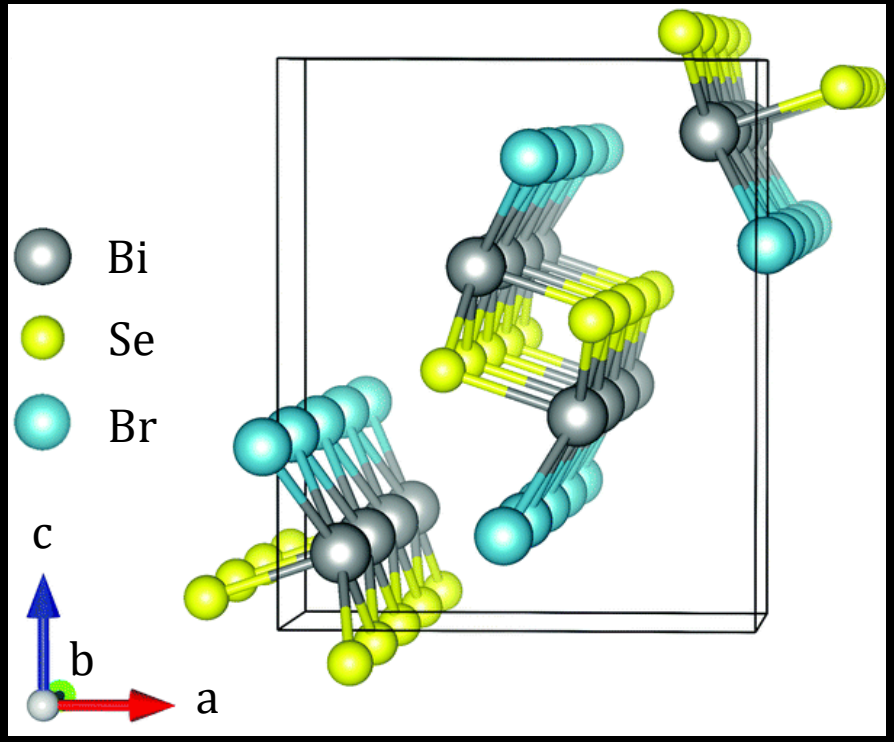
Mutual solubility of HgTe and Sb_2Te_3 is insignificant

https://crystmat.com

2D Semiconductor BiSeBr

Offers a new avenue for research, spintronic applications & quantum computing





Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Se K	21.94	+/- 0.84	33.61	+/- 1.29
Br K	22.69	+/- 0.61	34.34	+/- 0.92
Bi L	55.37	+/- 1.12	32.05	+/- 0.65
Total	100.00		100.00	

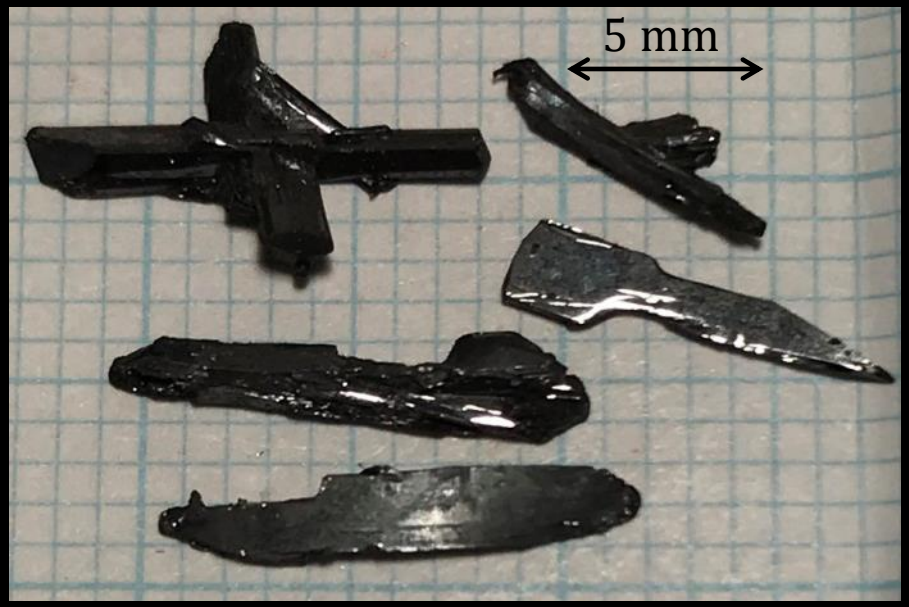
BiSeBr crystallizes in the orthorhombic *Pnma* space group. Ref.: CrystEngComm 24 (2022) 1094 . It can be easily exfoliated into mono- and a few-layer materials.

Key properties: Topologically protected surface states (Dirac fermions, quantum spin Hall effect), strong spin-orbital coupling, high-temperature stability, layered structure.

https://crystmat.com

BiSeI

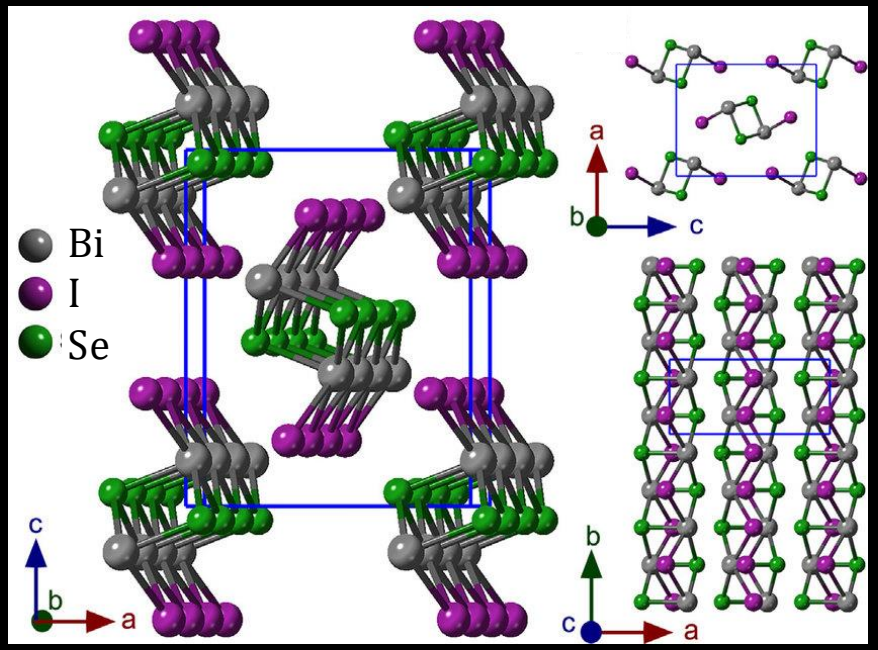
Topological Insulator ● Thermoelectric ● Quantum Computing & Spintronics



Optical image of BiSeI single crystals

Element Line	Weight %	Weight % Error	Atom %	Atom % Error
Se K	19.25	+/- 0.82	33.65	+/- 1.43
I L	30.45	+/- 0.65	33.12	+/- 0.71
Bi L	50.31	+/- 1.51	33.23	+/- 0.99
Total	100.00		100.00	

EDX analysis of a single crystal BiSeI



BiSeI crystallizes in orthorhombic *Pnma* space group. It can be exfoliated into thin layers. J. Cryst. Growth 517 (2017) 7-11

Application: solar cells, photodetectors, thermoelectrics, catalysis, sensors, LEDs, nonlinear optics, lasers, LEDs

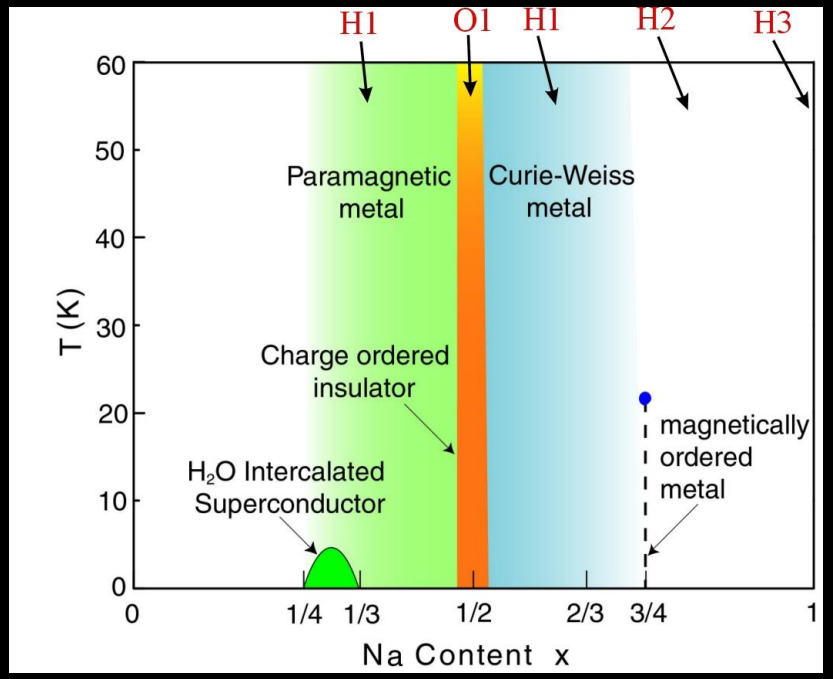
Key points of interest: tunability of bandgap, ultrathin thickness, intrinsic anisotropic characteristics, potential for integration with metal oxide semiconductors.

https://crystmat.com

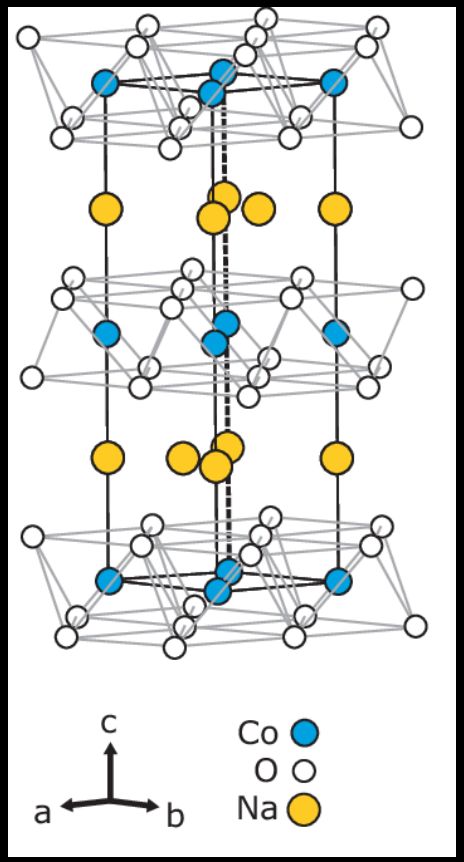
Non-superconducting Na_xCoO_2

Quasi-2D material consisting of triangular 2D CoO_2 layers with Na atoms in between

Image of Na_xCoO_2 single crystal



Phase diagram of Na_xCoO_2
Phys. Rev. B 70, 184110 (2004)

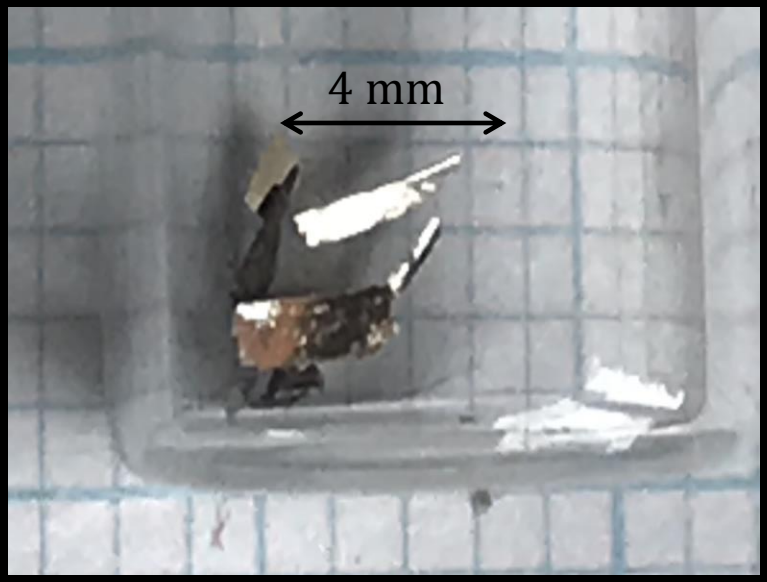


Hexagonal *P*6_3/*mmc* space group

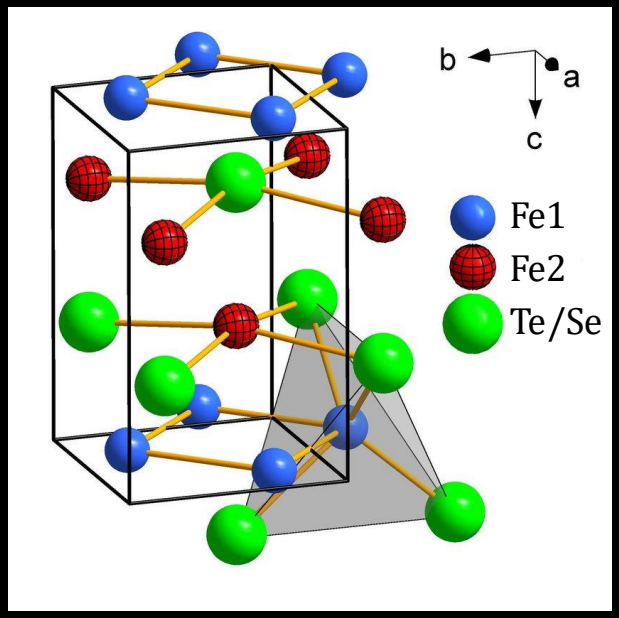
Na_xCoO_2 key points: superconductivity and thermoelectric properties, unique crystal structure, strong correlations, sodium intercalation (tunability), energy storage and battery applications, potential for new phases and new physics.

https://crystmat.com

2D non-superconducting $FeTe_{0.65}Se_{0.35}$



Optical image of $FeTe_{0.65}Se_{0.35}$ single crystals grown under high pressure



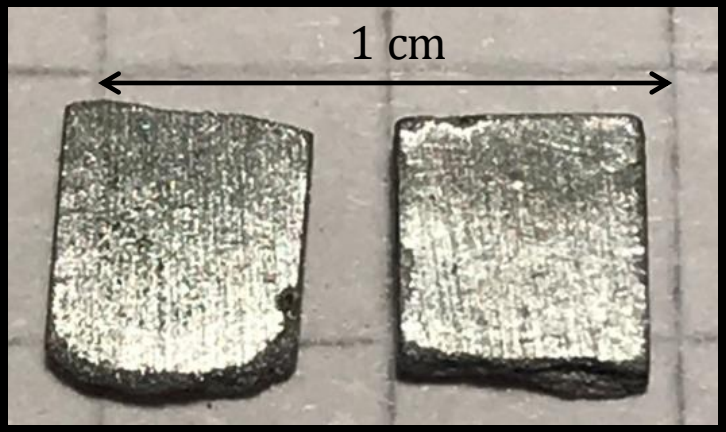
Crystal structure of $FeTe_{0.65}Se_{0.35}$

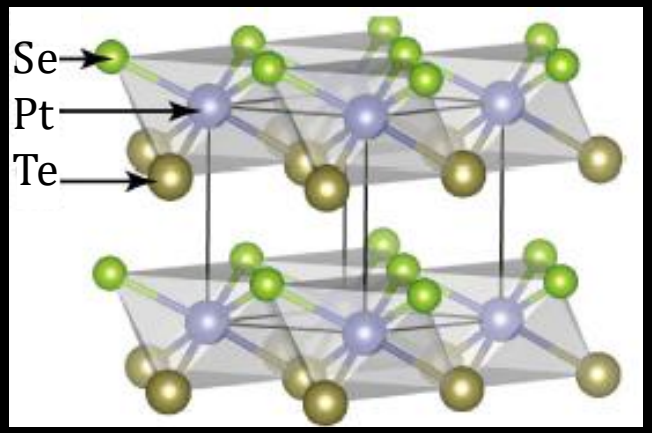
Crystal structure of $FeTe_{0.65}Se_{0.35}$ demonstrating tetrahedral coordination of Fe1 ions in 2a positions by anions of Se and Te and interstitial Fe2 ions in 2c position in anion plane. Atoms in Fe2 position are at interstitial sites between Te/Se atoms. Fe1 atoms are itinerant, Fe2 type atoms are localized with a magnetic moment of 2.5 μ_B and are destructive for superconductivity.

Homogeneous $FeTe_{0.6}Se_{0.4}$ crystals without excess of Fe2 and without variation in composition is non-superconducting. Ref.: J. Cryst. Growth 432 (2015) 95

https://crystmat.com

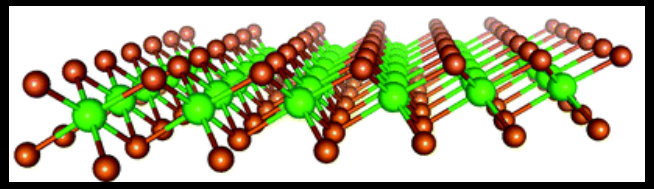
2D Janus compound PtSeTe





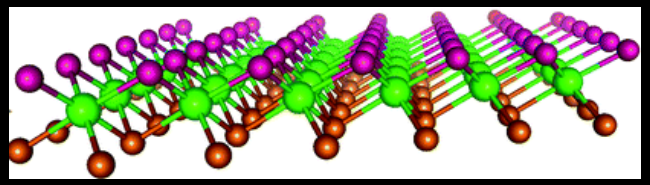
Crystal structure of PtSeTe

Photos of PtSeTe polycrystalline samples



PtS_2
$PtSe_2$
$PtTe_2$

Monolayer PtX_2



PtSSe
PtSTe
PtSeTe

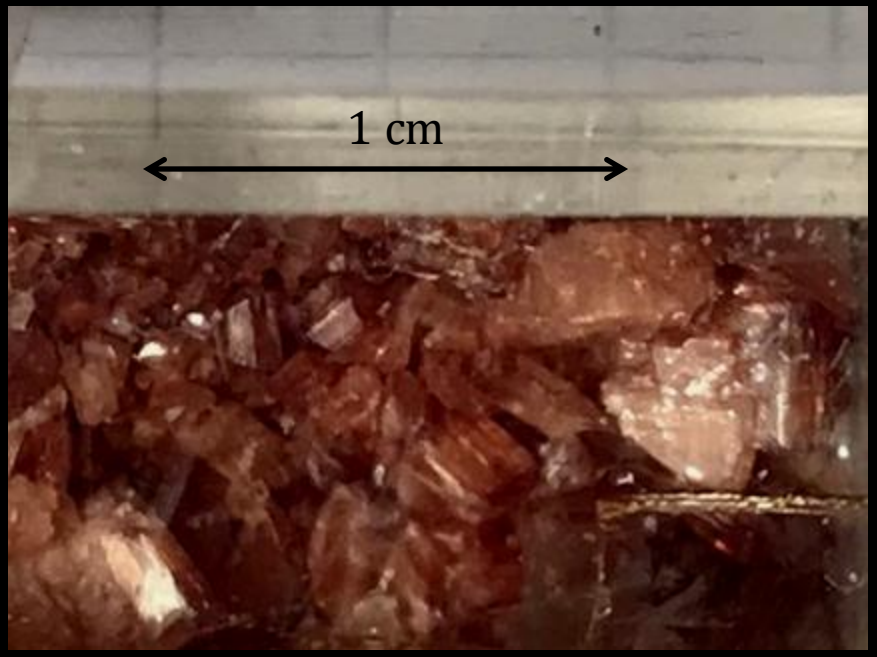
Monolayer Janus PtXY

From PtX_2 monolayers to Janus PtXY

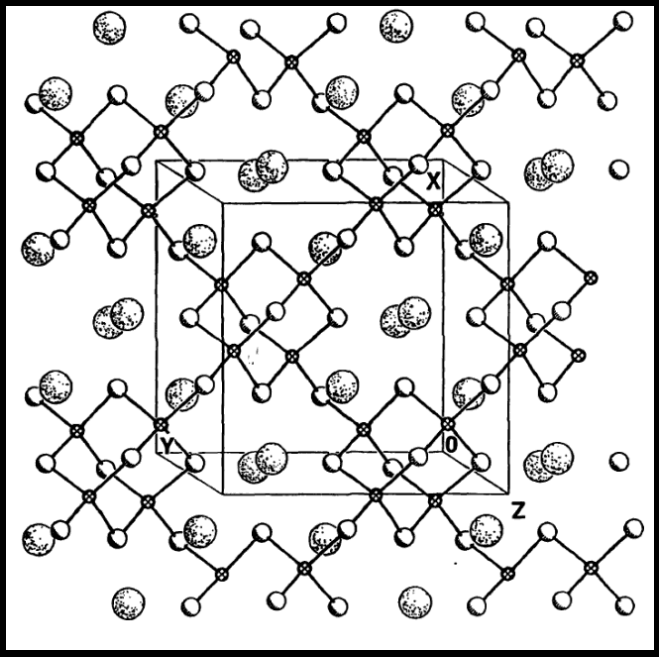
PtSeTe can be interesting for band enginnering, sensors, optoelectronics, valleytronics, memory devices, transistors, topological transition, Rasha effect.
Ref.: J. Phys.: Condens. Matter 30, 245502 (2018); Nanoscale Adv. 3, 6608 (2021)

https://crystmat.com

$KInS_2$



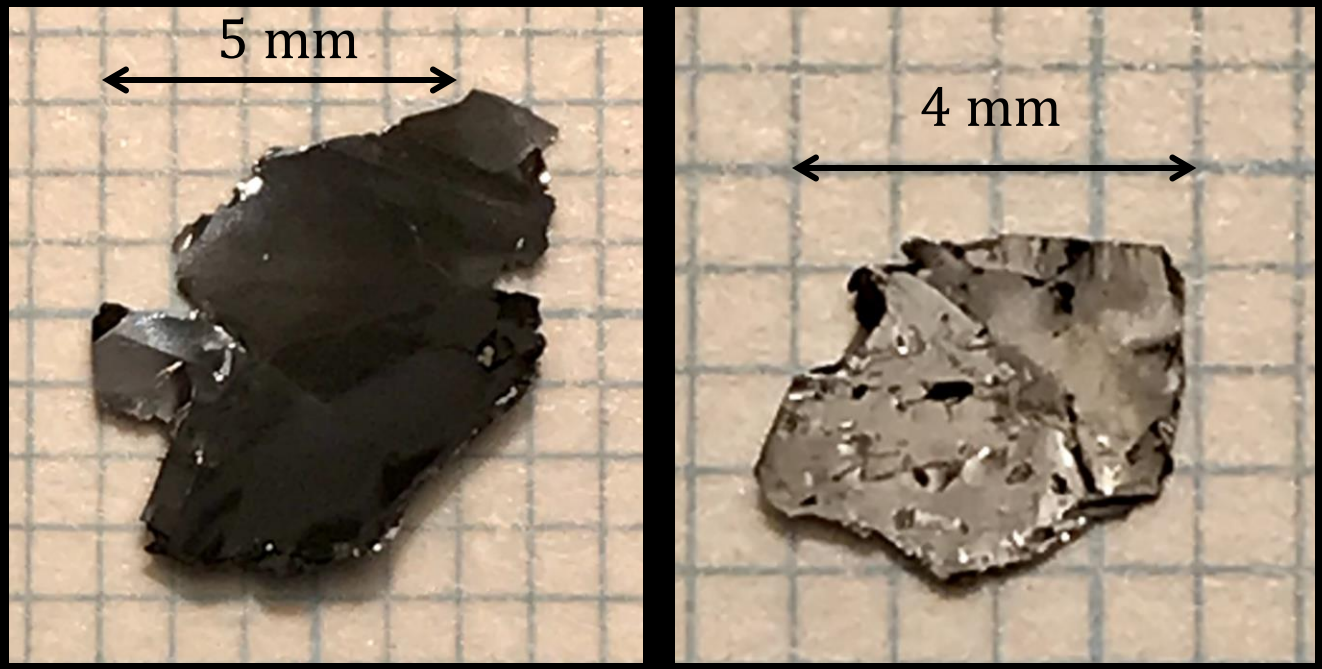
Optical image of $KInS_2$ samples



$KInS_2$ crystallizes in the monoclinic space group C2/c. The bonding is highly covalent and exhibits both 2D and 3D features.

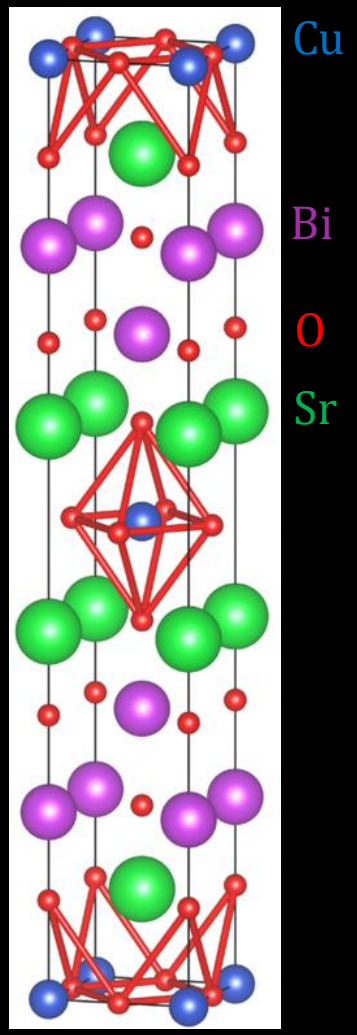
Limited information on the physical properties of $KInS_2$ is available. It has a band-gap of 3.0 eV. Ref.: J. Solid State Chem. 92, 2, 520-530 (1991)

2D Cuprate $Bi_2Sr_2CuO_{6+x}$



Optical images of $Bi_2Sr_2CuO_{6+x}$ crystals

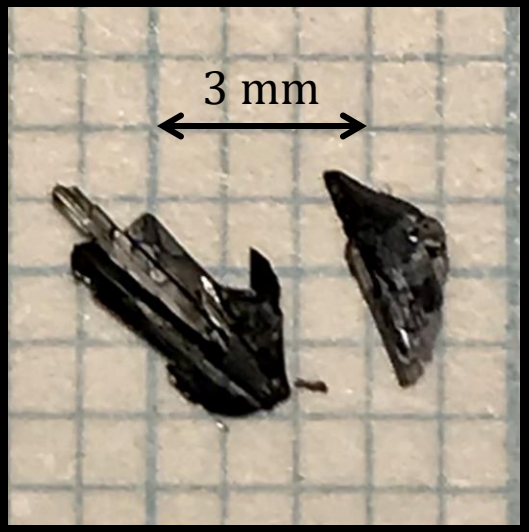
Bi2201 is simpler than its relatives like Bi2212 and Bi2223 because it only contains a single CuO_2 layer between Bi-based layers, making it a model system for studying the role of these planes in the superconducting mechanism.



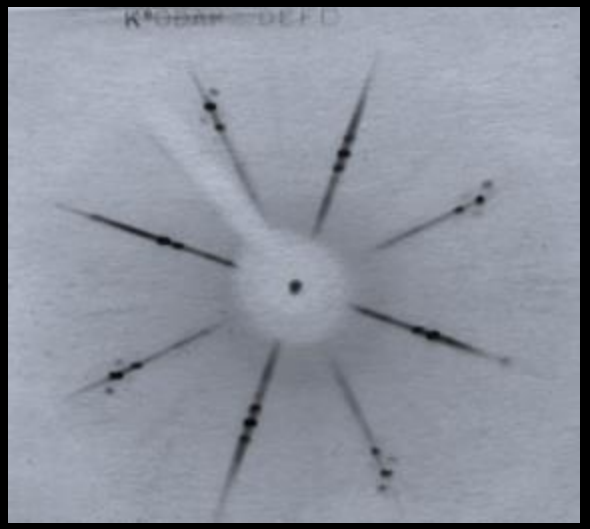
$Bi_2Sr_2CuO_{6+x}$

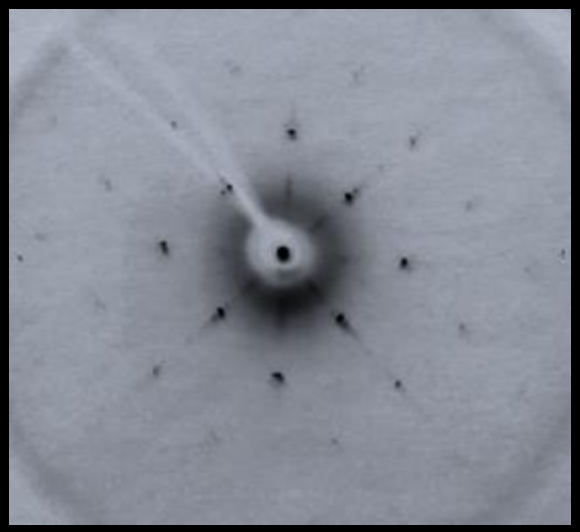
https://crystmat.com

2D Superconductor $Bi_2Sr_2CaCu_2O_{8+x}$

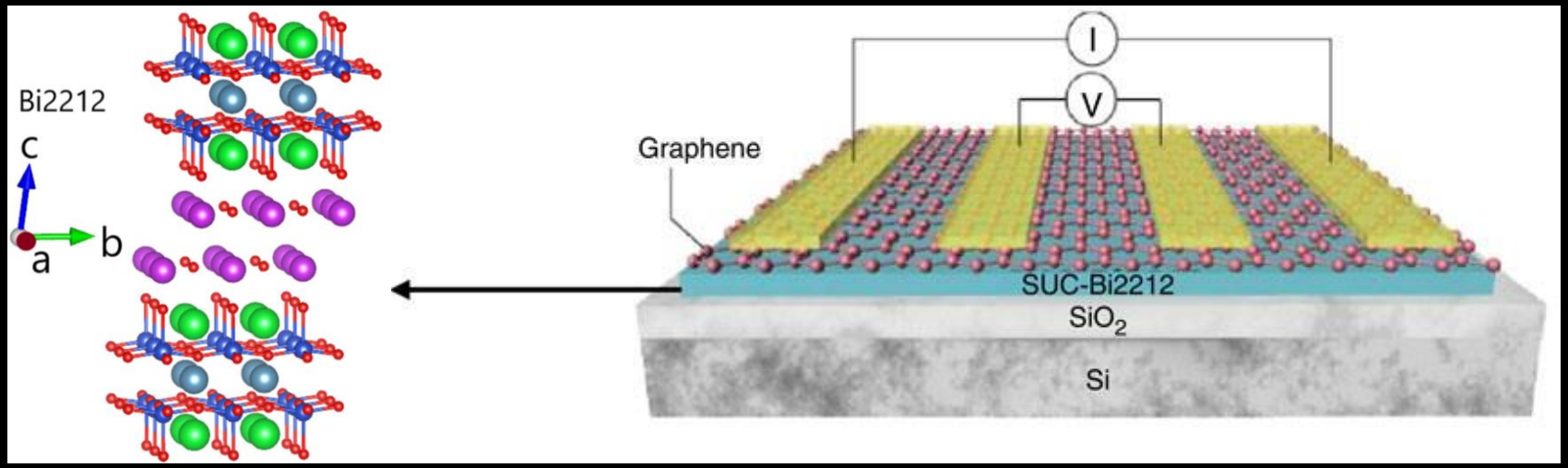


Optical image of Bi2212





Laue diffraction patterns of $Bi_2Sr_2CaCu_2O_{8+x}$ crystals

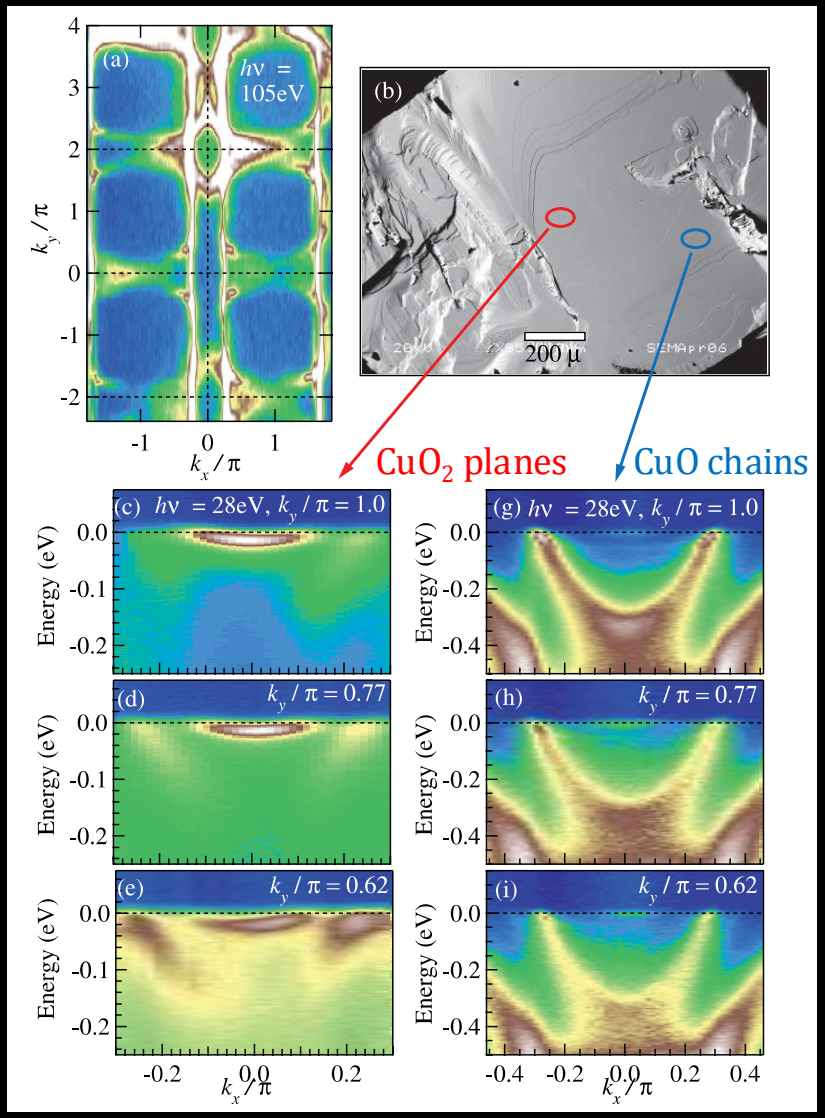


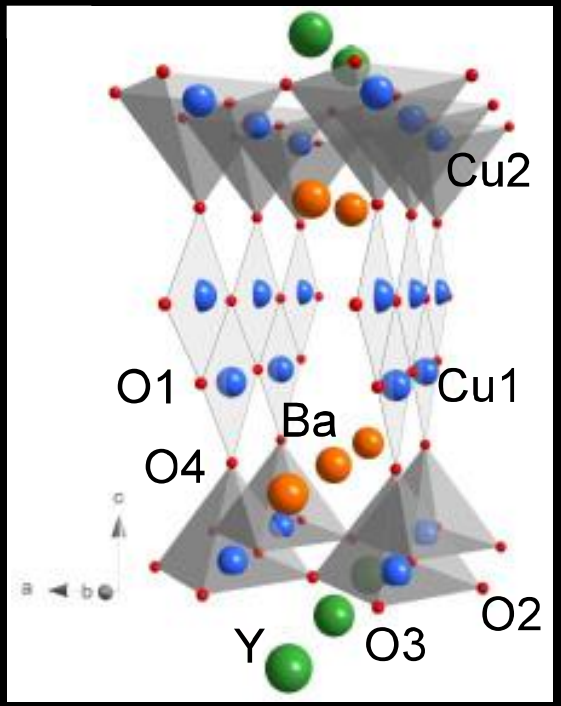
Quasi 2D cuprate Bi2212 provide insights into mechanisms of superconductivity

Ref.: Nat. Commun. 5, 5708 (2014); J. Phys.: Condens. Matter 6, 8969 (1994)

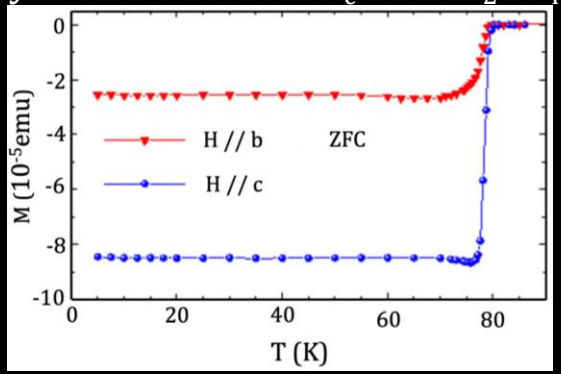
https://crystmat.com

$YBa_2Cu_4O_8$





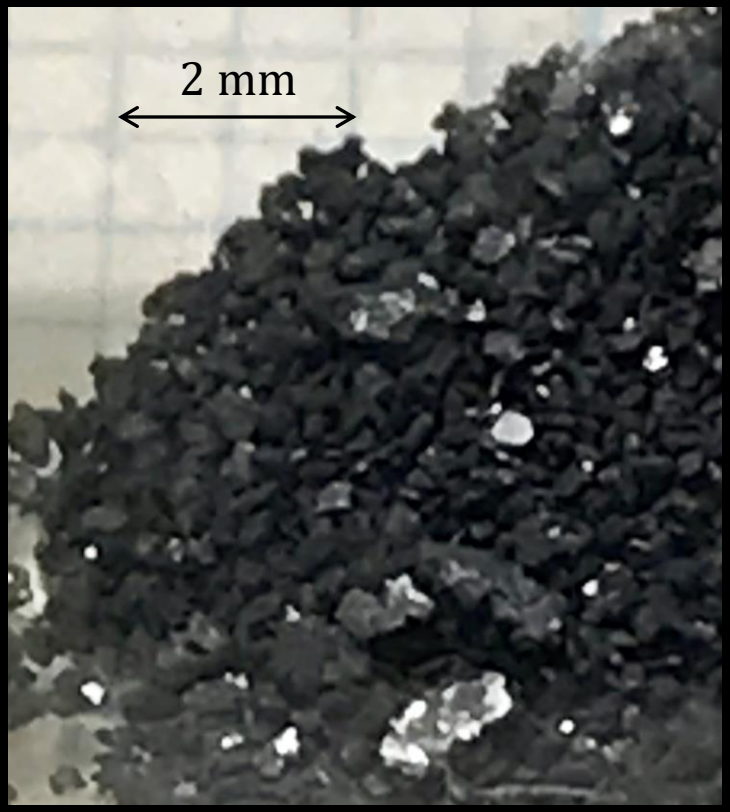
Crystal structure & T_c of $YBa_2Cu_4O_8$



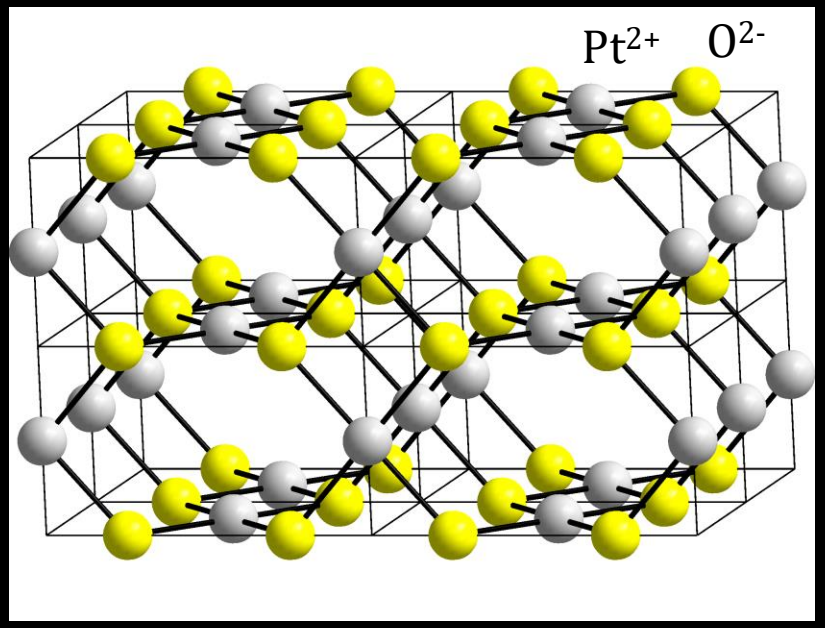
Superconductor without oxygen ordering in chains & with fixed oxygen stoichiometry. ARPES allows separately investigate electronic properties of CuO_2 planes and CuO chains. Ref.: Phys. Rev. Lett. 98, 157002 (2007) ; Phys. Rev. B 90, 140501 (2014)

https://crystmat.com

PtO



Optical image of PtO sample



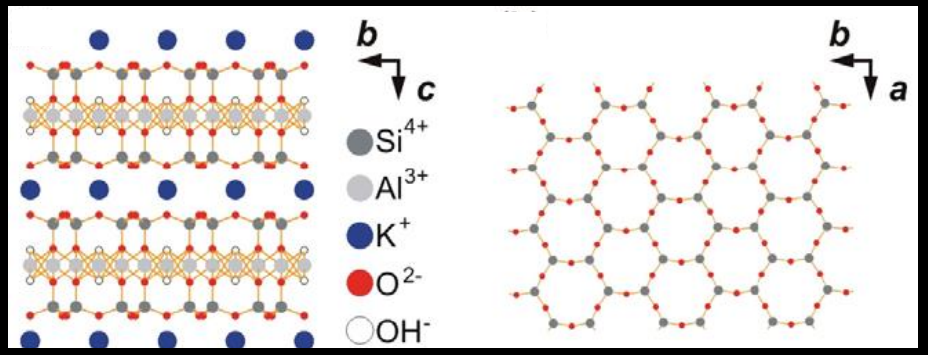
PtO crystallizes in tetragonal symmetry with P4/mmc space group

PtO key points: catalysis, hydrogenation reactions, hydrogen storage, fuel cells, precursor for Pt nanoparticles, thermal stability, photocatalysis, electronic devices.

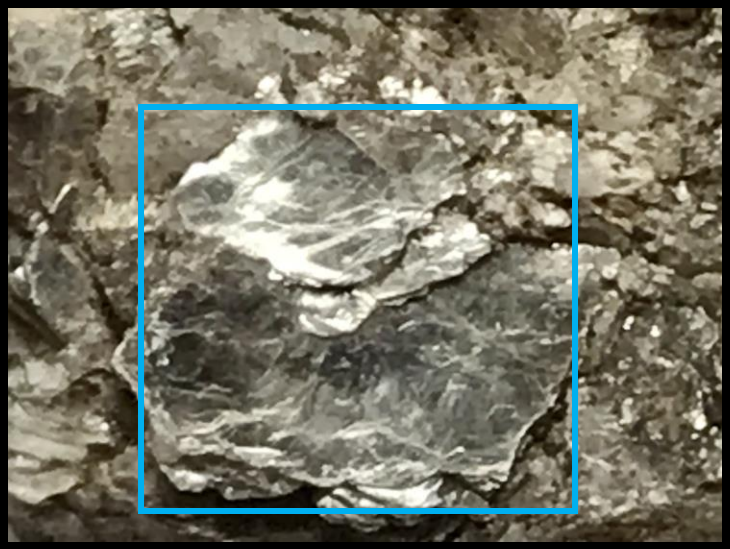
Experimental data for PtO is very limited and contradicted. Doubts remain even for bulk PtO structures. Ref.: Phys. Rev. B 84, 100101(R) (2011)

https://crystmat.com

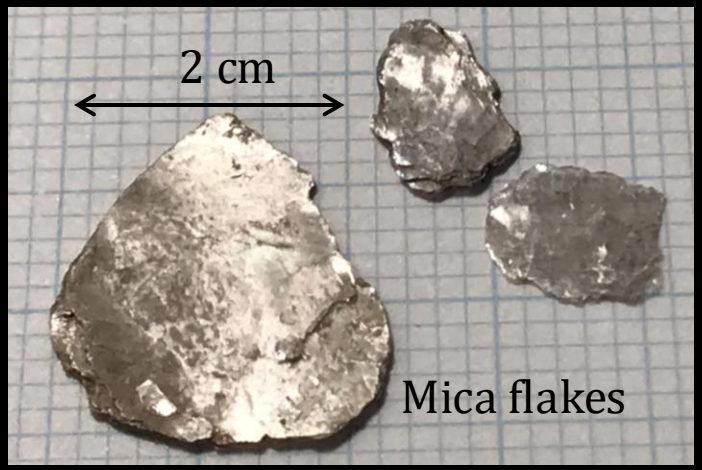
2D Mica Mineral



Schematic view of mica crystal structure



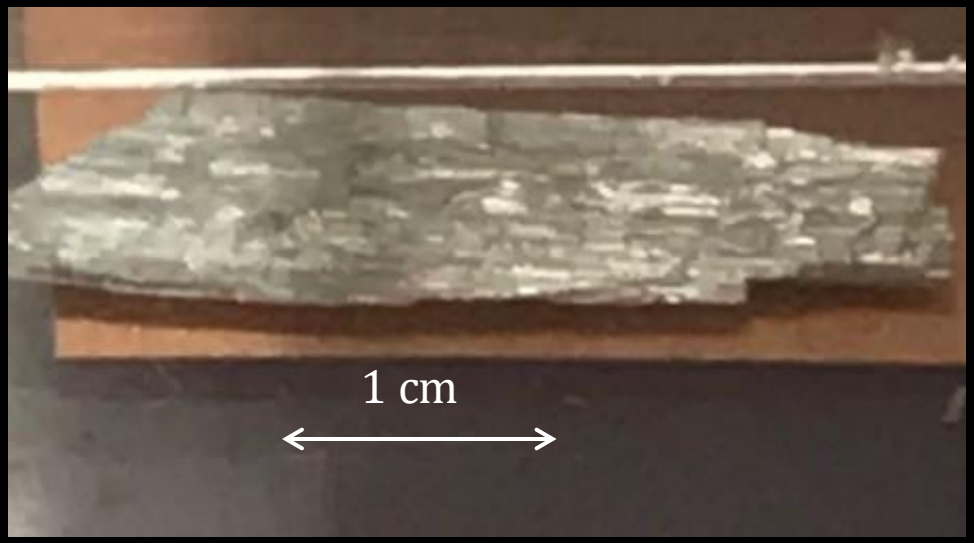
A rock with mica from
Canton of Ticino, Switzerland



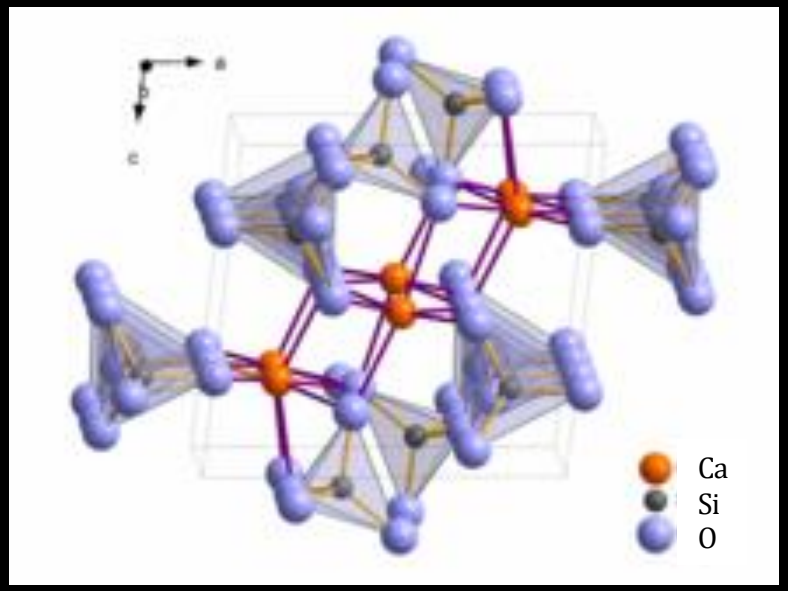
Mica has a wide band gap of 5 eV, great thermal and chemical resistance, making it an excellent insulating substrate for heterogeneous 2D material structures.

Ref.: Nanotechnology 19, 305705 (2008)
Sci. Reports 12, 14076 (2022)

$CaSiO_3$



Optical image of Wollastonite – calcium silicate mineral $CaSiO_3$



The unit cell of triclinic $CaSiO_3$. This formula may also be written as $Ca(Si_3O_9)_{0.33}$ or as $Ca_3(Si_3O_9)$.

Canadian Wollastonite is a little-known a relatively rarely-occuring mineral with a pearly luster on cleavage surfaces and a granular texture. Ref.: Wikipedia.org

https://crystmat.com