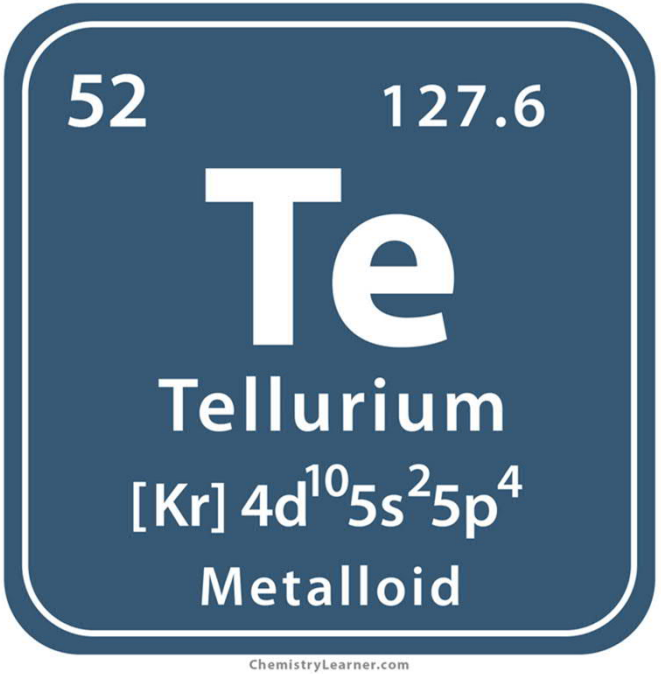
Tellurium



Images: https://images-of-elements.com/tellurium.php, https://www.chemistrylearner.com/tellurium.html

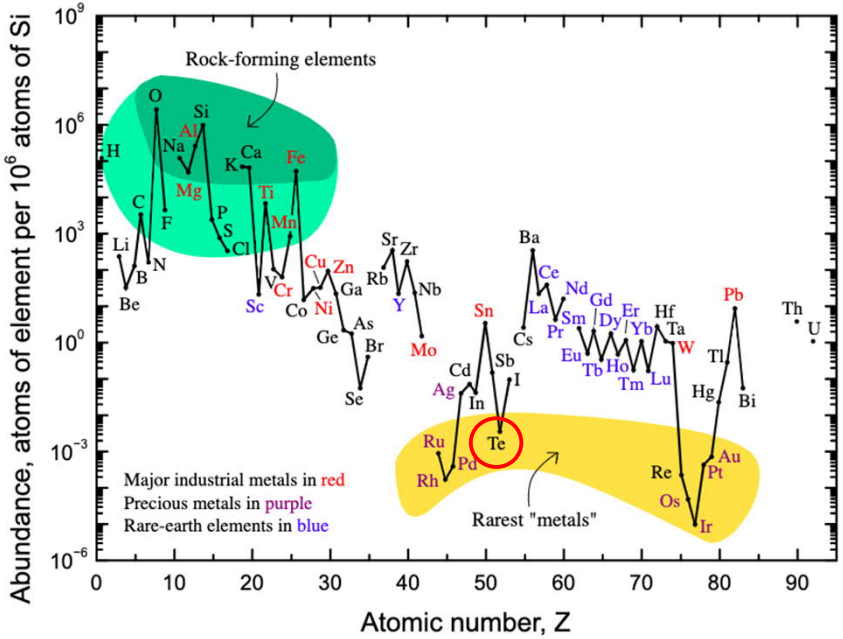
Tellurium

- Discovered in 17th century in Romania
- Name refers to earth (latin “tellus”)
- Silvery-white appearance
- Brittle & easily pulverised
- Indicates varying conductivity with crystal alignment and increases with light exposure
- Can be doped with silver, copper, gold, tin, or other elements.
- Tellurium has no biological role.
- All tellurium compounds are highly toxic

Reference: WebElements https://www.webelements.com/tellurium/
Image: Winter, M. (2020) 20180515lnp3-tellurium.jpg

Abundance and production

- One of the rarest elements on earth, but not as rare in the universe
- Crustal abundance 1 ppb
- Eight stable isotopes, most common Te-128, Te-130
- Mainly produced in China, Japan, Russia, Sweden (2019)
- Largest sources of tellurium is as a by-product of copper and lead production.
- Main applications: metallurgy, and semiconductor and electronics industry



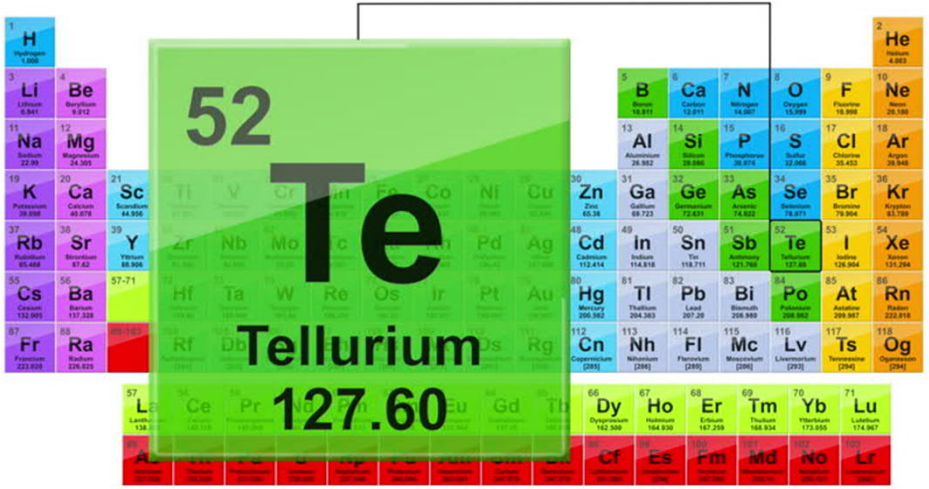
References: Royal Society of Chemistry, website, https://www.rsc.org/periodic-table/element/52/tellurium,
U.S. Geological Survey, Mineral Commodity Summaries, January 2020 https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-tellurium.pdf
Image: Gordon B. Haxel, Sara Boore, and Susan Mayfield from USGS

Chemistry

- Metalloid
- Electron configuration:

  [Kr] $4d^{10}\ 5s^2\ 5p^4$
- Oxidation states -2, +2, +4 and +6
- Atomic radius 137 pm

  Ionic radius 221 pm (Te^{2-})



Reference: Royal Society of Chemistry, website, https://www.rsc.org/periodic-table/element/52/tellurium
Image: https://www.shutterstock.com/video/clip-1016995108-periodic-table-52-tellurium-element-sign-position

COMPOUNDS

- Tellurium burns in oxygen and forms the dioxide (TeO_2)
- TeO_2 is unaffected by hydrochloric acid, but nitric acid oxidizes it to tellurous acid (H_2TeO_3).
- H_2TeO_3 reacts with the halogens to form halides.
- It also combines with most metals at high temperatures to form tellurides.
- No single use has been developed that creates a large demand.

Reference: Encyclopedia Britannica. (2020) https://www.britannica.com/science/tellurium.
Image: https://en.wikipedia-on-ipfs.org/wiki/Pyrotechnic_colorant.html

Compounds	Chemical formula	Color	Special properties	Chemical Applications
Tellurium dioxide	TeO_2	white & pale yellow powder	amphoteric	reluctant glass former
Hydrogen telluride	H_2Te	Colourless gas	garlic odour, degrade at RT	not many uses, highly toxic
Sodium telluride	Na_2Te	white powder	sensitive to air	Reagents, organic synthesis

Reference: Tellurium dioxide, 2020
https://www.guidechem.com/encyclopedia/tellurium-dioxide-dic409921.html
Encyclopedia Britannica. (2020) https://www.britannica.com/science/tellurium.
Image: https://en.wikipedia.org/wiki/

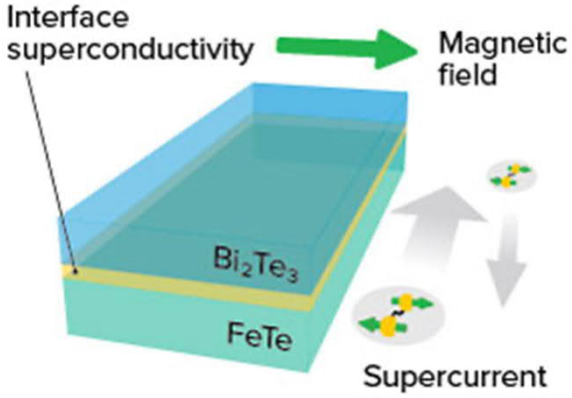
Gold and Silver tellurium

- Found in nature from various gold ores
- both gold and silver in its structure
- The most common : Sylvanite $AuTe_2$
- Known as non-stoichiometric compound.
- It shows metallic conductivity
- Gold telluride Au_3Te_5 :
  - Superconductor at 1.62 K

Reference: https://www.miningmetalnews.com/20190802/1111/demands-tellurium-rare-element-are-rise
Image: https://en.wikipedia.org/wiki/Gold_chalcogenides

Tellurium thin films

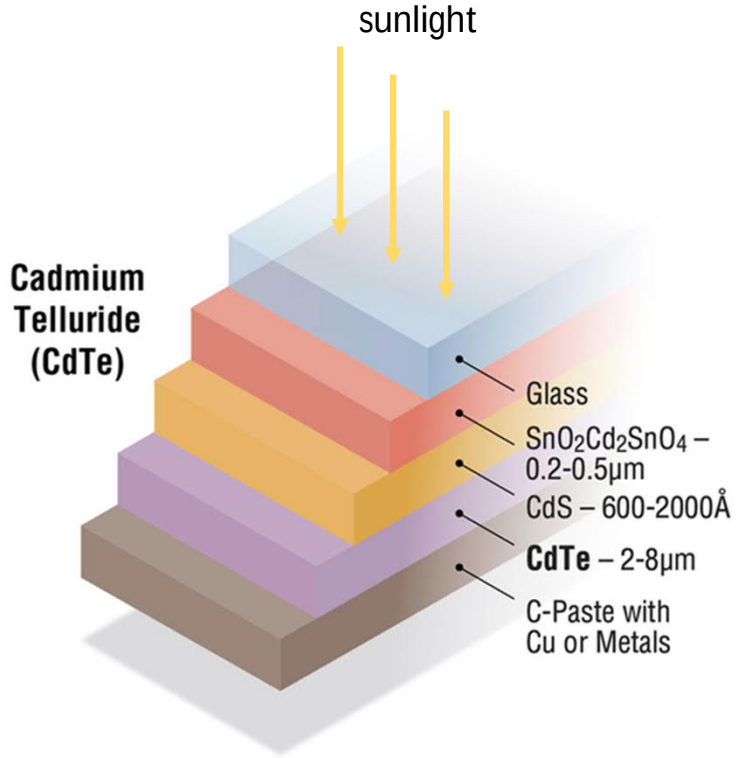
- Thin film grown by thermal vacuum evaporation.
- Sensor technology & photosensitive devices
- Excellent electrical and low thermal conductivity.
- Used in thermoelectric devices either as sources of electricity or for cooling purposes.
- Superconductivity



Reference: T siulyanu, Dumitru. (2011). Tellurium Thin Films in Sensor Technology. 363-. 10.1007/978-94-007-0903-4_38.
Janan H., S., & Abdulkhadhim A. H. (2014). Citeseerx.ist.psu.edu.
Zhao, C., Tan, C., Lien, DH. *et al.* Evaporated tellurium thin films for p-type field-effect transistors and circuits. https://doi.org/10.1038/s41565-019-0585-9
Image: https://www.riken.jp/en/news_pubs/research_news/rr/20190830_FY20190024/

Cadmium telluride photovoltaics (PV)

- Thin film solar panel technology
- Can commercially compete with Si-based solar cells
  - Good efficiency (Up to 22 %)
  - Low cost
  - High optical absorption coefficient
  - Close to optimal direct band-gap (1.45 eV)
- Thin film techniques: close-spaced vapor transport (CSVT) and close-spaced sublimation (CSS)
- P-type CdTe and n-type CdS form p-n junction
  - ➢ The energy of the light can be converted into electricity



References: Bosio, A., Pasini, S., & Romeo, N. (2020). The History of Photovoltaics with Emphasis on CdTe Solar Cells and Modules. Coatings, 10(4), 344.
Image: Alfred Hicks/NREL.gov https://understandsolar.com/thin-film-solar-panels
Fthenakis, V., Athias, C., Blumenthal, A., Kulur, A., Magliozzo, J., & Ng, D. (2020). Sustainability evaluation of CdTe PV: An update. Renewable and Sustainable Energy Reviews, 123, 109776.

Tellurium as a rare element

- Considered as a technology-critical element
- Not used in many different applications (solar 40 %, thermoelectric production 30 %, metallurgy 15 %)
- Tellurium demand will most likely increase as the demand for solar energy increases
- Efficient recycling is important (also mitigate concerns on toxicity)

References: ALS Europe. Website. https://www.alsglobal.se/en/environment/technology-critical-elements-analysis
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