**Beyond the Average Structure:**

**Misfit and Superstructure of Chalcogenide Nanotubes**

Download the paper titled:

*Asymmetric misfit nanotubes: Chemical affinity outwits the entropy at high-temperature solid-state reactions*

The full paper and associated files can be found at <https://doi.org/10.1073/pnas.2109945118>.

**Learning Objectives:**

Define the terms “misfit” and “superstructure”.

Identify key experimental evidence of nanotubes with a misfit layered superstructure.

Interpret diffraction and microscopy data to characterize misfit layers compounds

Discuss the importance of misfit superstructures in technological applications.

**Pre-Discussion Questions**

1. Who are the authors of this paper? What are their affiliations?
2. Explain why inversion symmetry is important to technological applications.
3. What is meant by the term “Janus nanotube” or “Janus nanoparticle”?
4. The following acronyms are found in the paper. What do they represent?

XRD; TEM; STEM, HRSTEM; EDS; MLC; DFT

**Discussion Questions**

1. Figure 1A shows the LaS-TaS2 MLC lattice. What sublattices are depicted here? How do the authors refer to each sublattice? In which direction(s) are the sublattices misfit? Figure 1B may also be helpful.
2. In Figure 1B, what do the black, pink and green lines represent? How is the incommensurate nature of the *a*-axis different than the commensurate nature of the *b*-axis?
3. At what critical concentrations of Se does the nature of the sublattices change? What are the sublattices for each critical concentration of Se? What change is observed in the XRD pattern at each critical concentration?
4. Calculate the *d*-spacing and *c*-axis length for the x = 0.2 and x = 0.8 concentrations.
5. What is the structure of Se concentration at x = 1.0?
6. What do the HRSTEM images indicate about the structure of x = 0.2 versus x = 0.8?
7. Why do the authors project that the x = 2.0 structure does not exist?