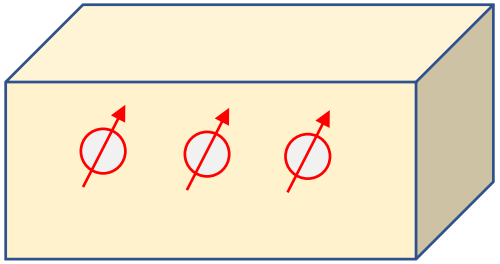
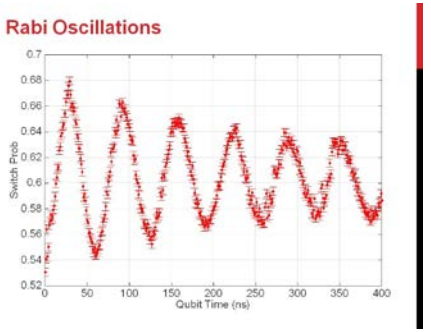
What makes an “Advanced Material” advanced?

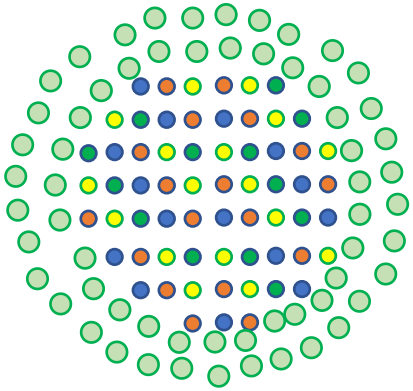
Is it *time ? (new = advanced?)*

Is it the resulting properties ?





Is it the chemical and physical microstructure ?



What makes an "Advanced Material" advanced?

ADVANCED MATERIALS: INFORMATION AND ANALYSIS NEEDS

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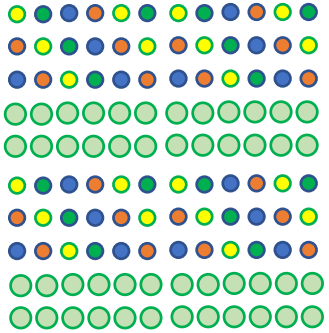
Advanced materials are those developed over the past 30 years or so, and being developed at present, that exhibit greater strength, higher strength density ratios, greater hardness, and/or one or more superior thermal, electrical, optical, or chemical properties when compared with traditional materials. Advanced ceramics, metals, and polymers, including composites of these, offer the promise of decreased energy consumption, better performance at lower cost, and less dependence on imports of strategic and critical materials. (page 5).

What makes an “advanced material” unique?

Internal structures (composition, structure) that might be “nano” even if the end product does not fit the official “nano” designation

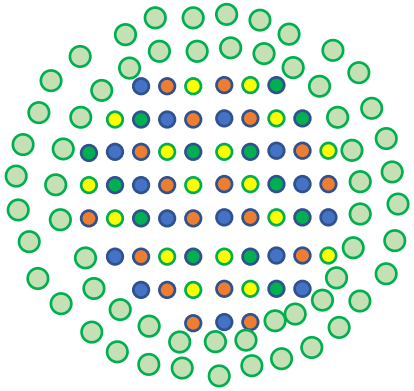
Examples:

- Core-shell materials
- Compositionally graded structures
- Heterostructures



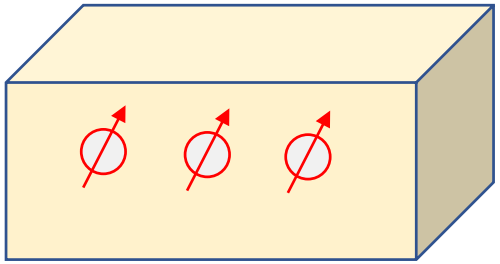
Superlattices

Micro/Nanoelectronics
Optics/photonics



Core-shell >nano?

Energy Storage
(LIBs, supercaps, solar)



Quantum defects
(Nv, SiV, etc. centers)

Quantum technologies

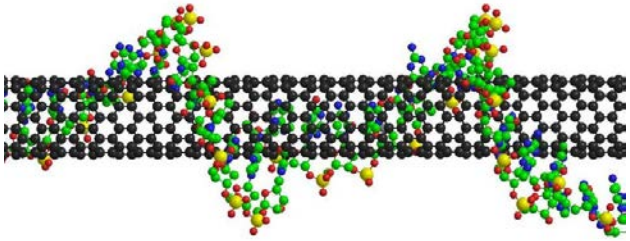
My own perspective…

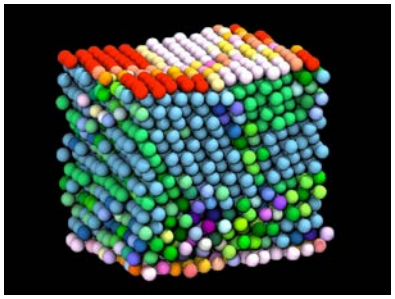
"Nano" was based almost entirely on *size* as the dominant/unique factor controlling materials properties at small length scales, and it was implict that small length scales brought unique unique chemical, physical, environmental helath and safety aspects.

Emerging industrial materials are more frequently using complex chemical compositions /chemical structuring along with physical nanostructuring.

There is a gap in understanding materials in which the chemical and physical structures together lead to emergent new properties.

- Amorphous materials
- Compositionally disordered materials (e.g., $LiNi_xMn_yCo_{1-x-y}O_2$) LIB cathodes
- Emergent compositions (silicenes, phosphores, 2-D materials/alloys
- Computational prediction of properties of non-crystalline / complex materials





https://cbe.princeton.edu/research/theory-and-simulation