Image: Design-Relevant Level Definitions for Structured Materials

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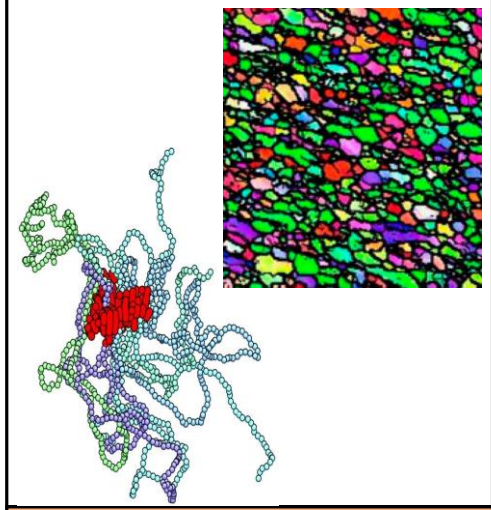
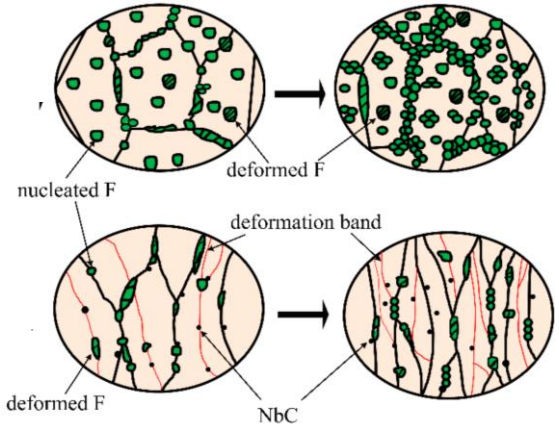
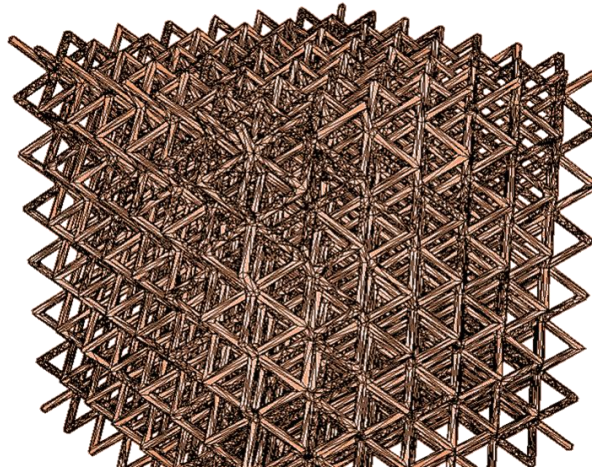
Design perspective on structured material (SM) levels

Natural material ← ***Source of Dominant Properties*** → **Structure and processing**







Sub-microstructure	Microstructure	Mesostructure	Macrostructure
❑ Natural material structure on atomic, crystal, or molecular level ❑ May be influenced by processing conditions ❑ **Examples**: Polymer chains, grain structure details in metals	❑ Structure observable using an optical microscope, heavily influential on macro-scale properties ❑ Strongly influenced by processing conditions ❑ **Examples**: Porosity, metal grain layout, scan structure in 3-D printed materials	❑ Designed or patterned structure, may be generated by element layout or designed inclusions/defects/voids ❑ Solid, homogeneous materials do not have a mesostructure ❑ **Examples**: Honeycomb structure, metamaterial, unit cell-based lattice	❑ In design, typically the “useful level” ❑ Generally the final component or product that is to be made from the designed material ❑ For homogeneous solid materials, microstructure drives macrostructure properties (no mesostructure)

References

Barrios-Muriel, J., Romero-Sanchez, F., Alonso-Sanchez, F.J., et al. (2020). Advances in orthotic and prosthetic manufacturing: A technology review. *Materials, 13*(2): 295.

Borgue, O., Muller, J., Leicht, A., et al. (2019). Constraint replacement-based design for additive manufacturing of satellite components: Ensuring design manufacturability through tailored test artefacts. *Aerospace, 6*(11): 124.

Hall, K.W., Sirk, T.W., Percec, S., et al. (2020). Monodisperse polymer melts crystallize via structurally polydisperse nanoscale clusters: Insights from polyethylene. *Polymers, 12*(2): 447.

Liu, C., Peng, Q., Xue, Z., et al. (2018). Microstructure-tensile properties relationship and austenite stability of a Nb-Mo micro-alloyed medium-Mn TRIP steel. *Metals, 8*(8): 615.

Thingiverse: https://www.thingiverse.com/thing:2788117

Yeh, Y-E. (2020). Prediction of optimized color designs for sports shoes using an artificial neural network and genetic algorithm. *Applied Sciences, 10*(5): 1560.

Zhao, J., Deng, Y., Xu, F., et al. (2019). Effect of initial grain size of Al-Zn-Cu alloy on the recrystallization behavior and recrystallization mechanism in isothermal compression. *Metals, 9*(2): 110.

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