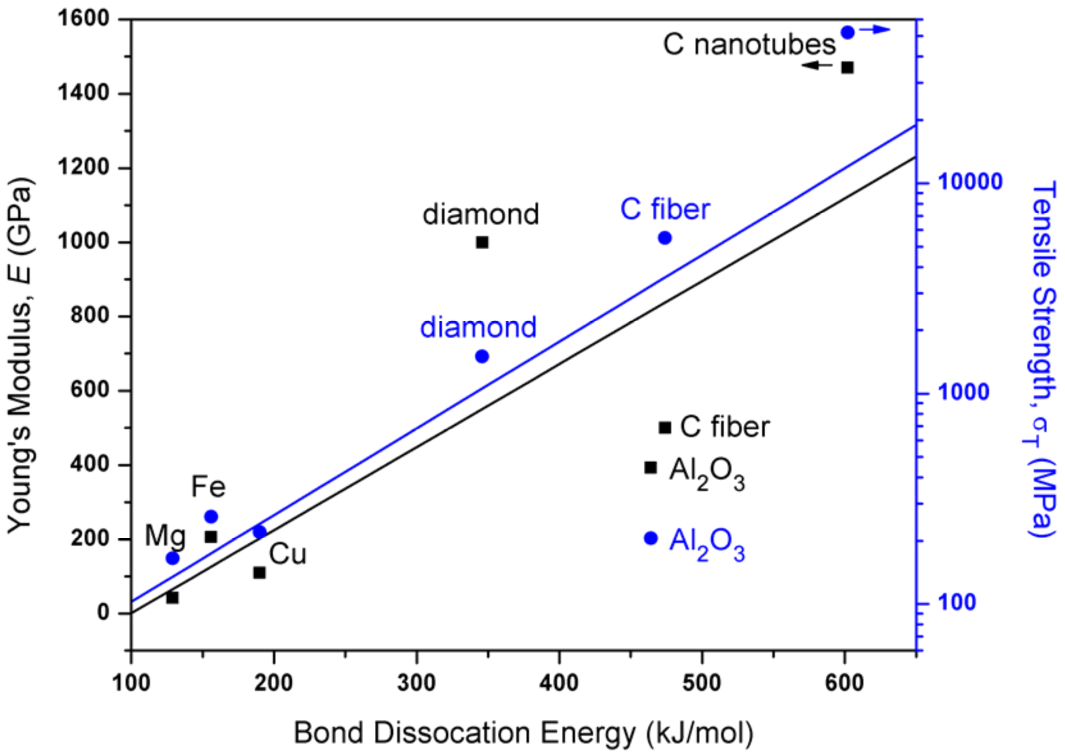
Correlation of Stiffness (E) and Tensile Strength (σ_T) with Bond Dissociation Energy

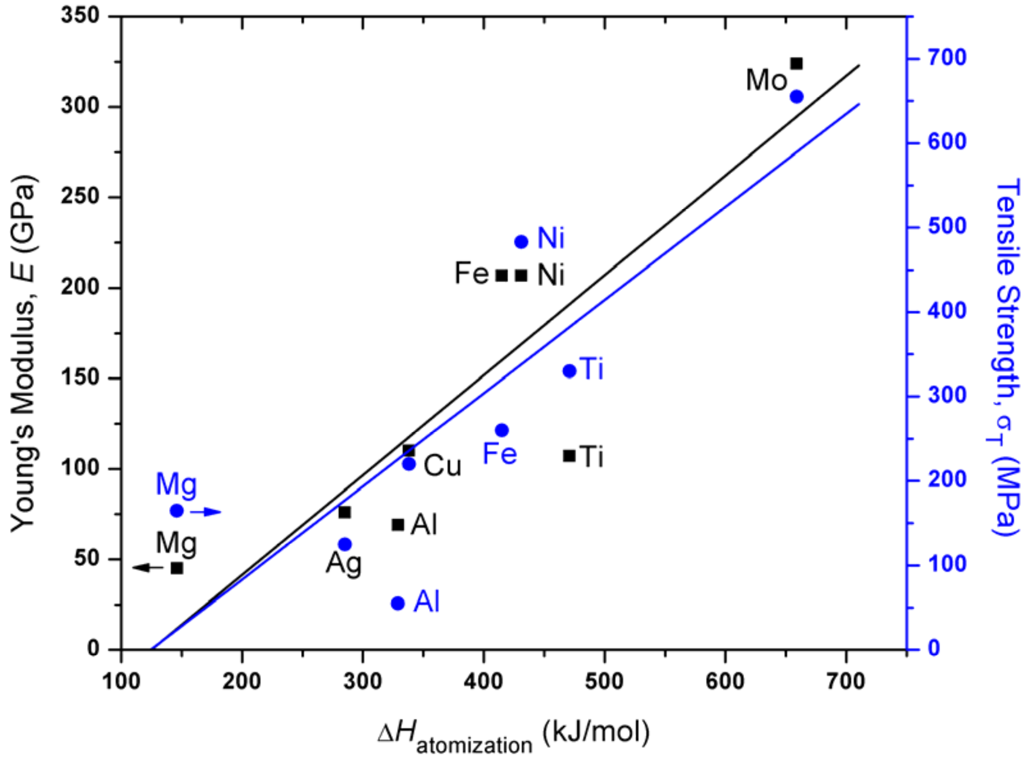
- **Neither stiffness (E) nor tensile strength (σ_T) correlate strongly with bond strength (BDE):**

Material	**BDE (kJ/mol)**	***E* (GPa)**	**σ_T (MPa)**
C nanotubes	602	1470	52,000
C fiber	602/346 = 474 (ave.)	500	5500
Al_2O_3	464	393	206
Diamond	346	1000	1500
Cu	190	110	220
Fe	156	207	260
Mg	129	42	165



- Note that the Tensile-Strength axis is a logarithmic scale.
- The lines are linear fits meant only to guide the eye.
- Although E and σ_T generally increase with BDE, there is considerable scatter in the data.
- Note that one of the weakest materials (in terms of σ_T), Al_2O_3, has one of the largest BDEs.
- Note also that one of the weakest (Al_2O_3) and one of the strongest (C fiber) materials have nearly the same BDE.
- Thus, strong correlations of E and σ_T with BDE do not exist.

Correlation of Stiffness (E) and Tensile Strength (σ_T) with the $\Delta H_{atomization}$ of Metals



- Bond dissociation energies are not well known for metals; the heat of atomization is used instead as a measure of cohesive energy or bonding energy of metal-metal bonds.
- The lines are linear fits meant only to guide the eye.
- Again, although E and σ_T generally increase with $\Delta H_{atomization}$, there is considerable scatter in the data.
- Thus, strong correlations of E and σ_T with $\Delta H_{atomization}$ do not exist.

Summary of this discussion:

- *E* actually correlates with bond stiffness not bond strength
- Only a poor correlation exists between BDE and tensile strength
- Materials with weak bonds *can't* be strong…
- Whereas materials with strong bonds aren't *necessarily* strong.
- **Thus strong bonding is a necessary but insufficient condition for a strong material.**