Alloying Elements and Properties of Steel

Here is a comprehensive list of are a few major alloying elements for steel, what they do, and what they are used for.

For clarity, there are no links. Look up these modules for explanations:

- Science of Alloying
- Alloying Elements in Detail
- Properties of Steel

Illustration

Element	Stabilizes....	Hardness Increase Mechanism	Tendency to form hard Carbides	Major / Minor Functions
Manganese **Mn**	Austenite Open γ-field	Moderate increase Powerful solution strengthener	Middle	**1.** Takes care of *Sulphur* (**S**). **2.** Makes special steels in high concentrations **3.** *Cheap* increase of hardenability.
Silicon **Si**	Ferrite Closed γ-field	Hardens, but *reduces ductility*Moderate increase	None	**1.** Deoxidation ("killing") of *liquid steel*. . **2.** Increases *electrical resistivity* (important for transformer cores). **3.** Improves oxidation resistance.
Aluminum **Al**	Ferrite Closed γ-field	Small Grain size hardening	No carbides but nitride.	**1.** Deoxidation ("killing") of *liquid steel*. **2.** Improves oxidation resistance.
Chromium **Cr**	Ferrite Closed γ-field	Moderate increase (Secondary) prec. hardening	Strong	**1.** Corrosion resistance. **2.** Strength + oxidation resistance at *high **T***. **3.** *Abrasion resistance* (needs high **C**, too).
Titanium **Ti**	Ferrite Closed γ-field	Strong increase; Prec. hardening Grain size hardening	Extremely strong	**1.** Oxygen, nitrogen and sulphur scavenger. Forms hard carbides. prevents grain growth. **2.**Prevents *local depletion* of carbon in stainless steels due to **Cr**-carbide formation
Vanadium **V**	Ferrite Closed γ-field	Very strong increase Prec. hardening Grain size hardening Moderate solid solution hardening	Very strong	**1.** *Restricts grain coarsening* of austenite. **2.** Increases hardenability. **3.** Delays softening during tempering.
Nickel **Ni**	Austenite Open γ-field	Mild increase	None	**1.** Enables austenitic steels. **2.** Enables Invar steel

Molybdenum **Mo**	Austenite Open ɣ-field	Strong increase Prec. hardening Grain size hardening	Very strong	**1.** Improves *corrosion resistance of stainless steels*. **2.** Prevents embrittlement of certain **Ni/Cr** steels. **3.** Keeps strength at higher **T**. **4.** Provides high *abrasion resistance*.
Boron **B**	? Major changes i at very small concentrations	Strong increase Prec. hardening Grain size hardening	Very strong	**1.** High strength steel **2.** Nitrogen scavenger **3.** Replacement for expensive elements without compromising properties