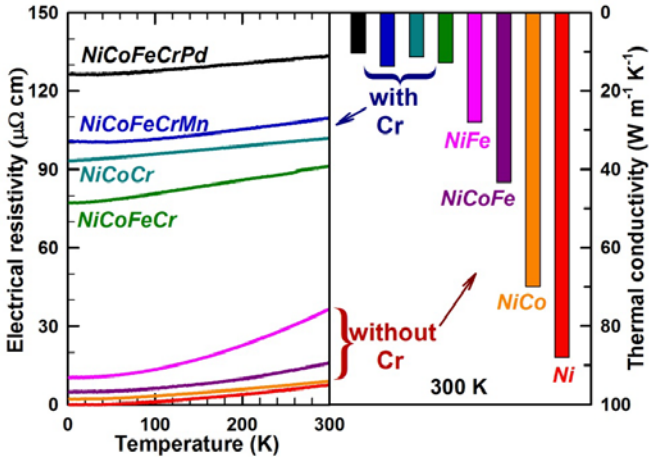
Dramatic Compositional Effects on Transport in Concentrated Solid Solution Alloys

Compositional complexity is found to strongly affect electrical, thermal, and magnetic properties of nickel-containing face-centered cubic concentrated alloys.[1] Tuning the physical properties to fulfill certain application demands can thus be achieved by modifying the number and species of alloying elements.



(Left) Increasing compositional complexity (especially when alloying with Cr) enhances the electrical resistivity. (Right) The thermal conductivity of the complex alloys is reduced due to the reduction of electronic thermal conductivity.

Nickel and a family of seven structurally simple (face-centered cubic) but compositionally complex alloys, from binary to quinary, have been systematically studied over a temperature range of 4-300 K. The electrical resistivity exhibits a weak correlation with the number of alloying elements but a strong dependence on the type of elements; the alloys containing Cr have an order of magnitude larger resistivity than those alloys without Cr. Korring-Kohn-Rostoker coherent-potential-approximation calculations have revealed that such strong scattering of electrons is primarily due to the magnetic disorder induced from the anti-parallel alignment between the magnetic moment of Cr and the other alloying elements. Furthermore, high electrical resistivity suppresses the electronic thermal conductivity, largely reducing their total thermal conductivity. This observation enables a systematic control of the heat transport, or the energy dissipation, in this newly developed alloy system.

[1] K. Jin, B. C. Sales, G. M. Stocks, G. D. Samolyuk, M. Daene, W. J. Weber, Y. Zhang, and H. Bei, "Tailoring the physical properties of Ni-based single-phase equiatomic alloys by modifying the chemical complexity," *Sci. Rep*. **6**, 20159 (2016). DOI: 10.1038/srep20159.