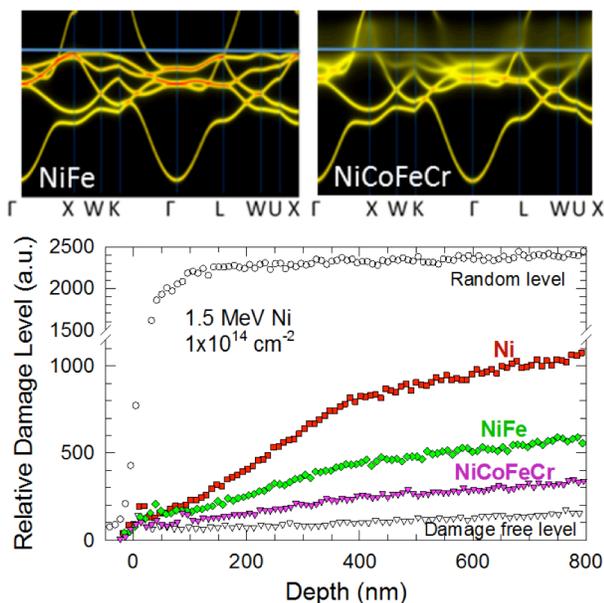


Chemical Complexity Controls Energy Dissipation and Defect Evolution

Increasing chemical complexity achieved orders-of-magnitude reductions in electron mean free paths and electron and thermal conductivities of alloys of NiCo, NiFe and NiCoFeCr, compared to Ni, and suppressed damage accumulation under ion irradiation.¹ This discovery provides insights to address the grand challenge of understanding complex electronic correlations and non-equilibrium atomic interactions, and the effect of these intrinsic properties and dynamic processes on energy transfer and defect evolution in irradiated materials.

In single-phase concentrated solid solution alloys (with no dominant element, unlike traditional alloys), transport measurements show that increasing the number of elements creates chemical disorder that substantially reduces electrical and thermal conductivity. Calculations demonstrate that electrical conductivity is modified due to the broadening of the electronic band structure by the disorder, and that this “smearing” depends both on the number of elements and on the particular elements in the complex alloys. Ion irradiation and ion beam analysis, molecular dynamics modeling of defect production and microstructural characterization of irradiated alloys support the finding that slow energy dissipation reduces defect production and suppresses damage accumulation at early stages. Understanding and controlling energy dissipation and defect dynamics by altering alloy complexity may pave the way for new design principles of radiation-tolerant structural alloys for energy applications.



(Top) Increased majority spin electronic structure broadening of NiCoFeCr relative to NiFe in equiatomic solid-solution alloys with increasing complexity. Note the lack of disorder broadening in NiFe. (Bottom) Reduced defect production as alloy disorder increases.

¹Yanwen Zhang, G. Malcolm Stocks, Ke Jin, Chenyang Lu, Hongbin Bei, Brian C. Sales, Lumin Wang, Laurent K. Béland, Roger E. Stoller, German D. Samolyuk, Magdalena Caro, Alfredo Caro, and William J. Weber, “Influence of chemical disorder on energy dissipation and defect evolution in nickel and Ni-based concentrated solid-solution alloys,” *Nature Commun.* **6**, 8736 (2015). DOI: 10.1038/ncomms9736.