Radiation-Induced Microstructural Changes under Neutron and Ion Irradiations

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This presentation will discuss the microscopic aspects in simulating neutron damage by ion irradiation. Ion irradiation as a simulation tool to study neutron damage has made significant contributions to our understanding of radiation effects in nuclear reactor materials. With rapid advance of computational tools and *in situ* experimental techniques, the full realization of the role of ion irradiation in simulating neutron damage has become increasingly promising. Damage correlation between neutron and ion irradiations involves a number of variables, e.g. irradiation parameters including the type and energy of irradiating particles, temperature, flux and fluence, metallurgical parameters including material chemistry and pre-irradiation microstructure, and geometrical parameters such as sample geometry (bulk vs thin foil), and damage profiles (uniform vs inhomogeneous). A comparison of irradiation-induced microstructural changes produced by neutrons and ions must consider both defect production and defect migration. Defect production is dictated by the primary recoil spectrum, and ion irradiation has a unique advantage of altering the recoil spectrum by using different types and energies of ions. Defect migration leads to defect cluster nucleation, defect growth or shrinkage, or defect loss at sinks such as various boundaries (surfaces, interfaces, grain boundaries). Further microscopic effects to be considered for damage correlation include the transient or steady state behavior such as in void swelling, the influence of injected interstitials under ion irradiation, and the transmutation effect. To simulate the effects of transmutation products such as He, pre-implantation of He or simultaneous He implantation and cascade damage enabled by the dual-ion beam facility are common simulation techniques and the He/dpa ratio is an important correlation parameter. Recent effort has demonstrated a promising direction in predicting neutron damage of pure metal in the low-dose, low-temperature regime using a closely coordinated approach of *in situ* ion irradiation experiment and computer simulation. A framework towards predicting neutron damage in complex materials by ion irradiation is suggested.