Possibilities for Radiation Damage Resistance: Perspectives from Atomistic Modeling

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For many years, the goal of alloy development programs for nuclear materials has been to identify alloy compositions that minimize the response of materials to irradiation. In some cases, promising improvements in alloy response have been achieved. For example, work in the 1970s and 1980s dramatically improved the swelling resistance of austenitic stainless steels as evidenced by increases in the low-swelling transient or swelling incubation time shown in Figure 1[1,2]. However, truly radiation-resistant materials have become an elusive holy grail of alloy development. Most recent work has focused on developing microstructures that remain stable under extended irradiation by promoting recombination of radiation-produced vacancies and interstitials. A significant potential limitation to this approach is the impact of transmutation products, both solid and gaseous (He, H) that can not be recombined. Such chemical species can drive microstructural evolution in spite of high levels of point defect recombination. The prospects for long-term success of in the pursuit of radiation damage resistance will be discussed from the point of view of the information provided by atomistic simulations and kinetic models.

[1] R.J. Puigh and F.A. Garner, Radiation-Induced Changes in Microstructure, ASTM-STP 955, ASTM International (1987) p. 154.
[2] I. Shibahara, N. Akasaka, S. Onose, H. Okada, and S. Ukai, J. Nucl. Mater. 212-215 (1994) 487-491.

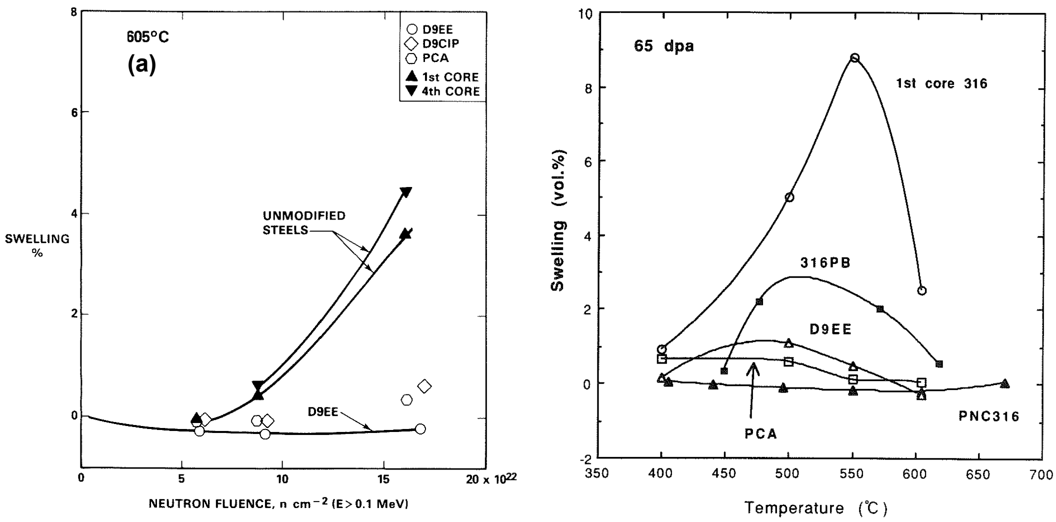

Figure 1. Improved void swelling resistance for modified austenitic stainless steels: (a) fluence dependence at 550°C and (b) temperature dependence at 65 dpa [1,2].