Nanotube/nanowire as effective defect sinks in metals: atomistic simulations and *in situ* ion radiation transmission electron microscopy

Kang Pyo So[1┼], Penghui Cao[1┼], Yang Yang[1], Jong Gil Park[2], Mingda Li[1], Yan Long[1], Jing Hu[3], Mark Kirk[3], Meimei Li[3], Young Hee Lee[2], Michael P. Short[1]*, Ju Li[1]*

[1]Department of Nuclear Science and Engineering and Department of Materials Science and Engineering, Massachusetts Institute of Technology Cambridge, Massachusetts, 02139, USA
[2]IBS Center for Integrated Nanostructure Physics, Institute for Basic Science (IBS), Sungkyunkwan University 440-746, Republic of Korea

3 Argonne National Laboratory

┼Authors contributed equally to this manuscript

*Corresponding authors: liju@mit.edu and hereiam@mit.edu

Abstract

The accumulation of defects during irradiation leads to material property degradation modes such as embrittlement and swelling, eventually causing material failure. Effective and efficient removal of defects is of crucial importance to design radiation damage-tolerant materials. Here, by biasing defect migration pathways via carbon nanotube (CNT) infiltration, we present a greatly enhanced damage-tolerant Al-CNT composite with defect storage measured to be one order of magnitude lower than that in pure, irradiated Al. Furthermore, extreme-value statistics of defect clusters are significantly changed in the presence of CNT. *In situ* ion irradiation transmission electron microscopy (TEM) experiments and atomistic simulations together reveal the dynamic evolution and convergent diffusion of radiation-induced defects to CNTs, facilitating defect recombination and enhancing radiation tolerance. The occurrence of CNT-biased defect convergent migration is tuned by the thermodynamic driving force of stress gradient in Al matrix due to the CNT phase transformation.