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# *In-situ* TEM investigation of void swelling in nickel under irradiation with analysis aided by computer vision

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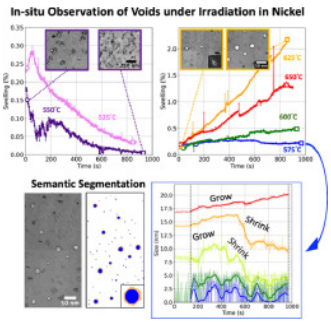
## Abstract

Understanding the stability of irradiation-induced voids in materials is important for engineering material's swelling behavior under irradiation. *In-situ* TEM offers a spatial and temporal resolution that is suitable for investigating the evolution of voids under irradiation. However, the *in-situ* videos have often been too large to be analyzed manually, leaving the valuable data underutilized. We developed a deep learning-based semantic segmentation model to consistently study the growth and shrinkage of voids in nickel under 1 MeV krypton ion irradiation at various temperatures from 525 °C to 650 °C. With a foil thickness near 100 nm and ion flux of $6.3 \times 10^{11}$ ions· $cm^{-2} \cdot s^{-1}$, the pre-existing voids, which were created beforehand by irradiation at 600 °C to 0.5 dpa, shrank at low temperatures and grew at high temperatures under irradiation, where the transition occurred at 575 °C (~0.5 $T_M$). The observed stability transition provided new insight for the shrinkage mechanism of voids under irradiation. In addition, an annealing experiment on nickel, previously irradiated at 600 °C to 3 dpa, was performed sequentially at 650 °C to 720 °C to reveal the shrinkage rate of void as a function of temperature and void size. The advantage of combining computer vision and *in-situ* TEM to obtain comprehensive void evolution was demonstrated.

## Graphical abstract

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