Nano-micro Characterization and Electron-irradiation Properties in Mechanical-
alloyed Austenitic Stainless Steel including Y$_2$O$_3$

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The oxide dispersion strengthened (ODS) ferritic steels, which are candidate structure materials for the fast reactor and fusion reactor, show excellent properties in high-temperature strength, creep rupture resistance and irradiation resistance due to the existence of stable and nano-sized oxide particles (Y$_2$O$_3$) produced by mechanical alloying (MA) and hot consolidation. Ferritic steels were targeted in conventional ODS steel studies because of their higher void swelling resistance. However, ferritic steels have poor corrosion resistance compared to austenitic steels, that has also been an object in the development of ODS ferrite steels. In this research, oxide particles were first distributed in an austenitic steel (PNC316) by means of MA, as a fundamental research of ODS austenitic steels. Nano-micro Characterization and Electron-irradiation were carried out for surveying ODS particle distribution and irradiation properties.

For the first step we tried to find the optimum condition of MA and heat-treatment. The base material used in this study was Fe-16Cr-18Ni-3Mo-Ti, Y, O (PNC316), and the powders were ball-milled with Y$_2$O$_3$. The samples were annealed at 800 - 1200 °C for 2 hrs without hot-extrusion. Nano-micro characterization and hardness measurement were carried out for these samples as the function of annealing temperature and MA condition. The non-equilibrium dissolution during MA and the nano-sized precipitation of Y$_2$O$_3$ in the subsequent annealing could be confirmed. Vickers hardness of annealed MA powder showed the maximum value at 600 °C which greatly decreased at 1100 °C. This is probably due to a synergy effect of a decrease in the dislocation density and grain growth by heat-treatment.

For the second step, electron irradiation was carried out to the same samples for the nano-characterization by means of a high-voltage electron microscope of 1250 kV, where the dose and temperature were 15 dpa and 300 - 600 °C. We confirmed the optimum condition for suppressing dislocation loops and voids as a function of ODS distribution.