The Exploration of Scandium in Nanostructured Ferritic Alloys
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Introduction
Nanostructured ferritic alloys (NFAs) are a promising class of material able to meet structural challenges for nuclear fusion reactors as NFAs can endure high heat fluxes and intensive irradiation damage. NFAs may serve as the first wall and blanket structural components in a fusion reactor with operating temperature up to 800°C. NFAs are dispersion strengthened by a high number density of Y-Ti-O precipitates. These precipitates, known as nanofeatures (NFs), are the key to NFAs’ promising characteristics by healing radiation damage, managing high concentrations of helium, and providing thermal stability for high creep strength. Unfortunately, alloying Y with iron requires mechanical alloying, which is costly for large-scale production. In order to economically produce NFAs in large-scale, it may be possible to replace the Y by another group III element, Sc. This approach is believed to enable less costly, conventional melt processing techniques. The Sc-NFA is investigated and is shown to have similar strength to Y based NFAs, and nanometer scale Sc based NFs are present.

Motivation
• Reduce cost of NFA production
• Improve mechanical properties of NFAs

Methods
Sc and Fe-Cr alloy powder were mechanically alloyed to produce nanocrystalline powder.

Nanocrystalline powder was heat treated at 850°C or 1000°C to induce precipitates.

Micro-hardness testing was done on alloy surface in order to measure yield strength.

Results
Alloy (20mm diameter) was created using SPS.

Hardness results show yield strength reduction with increasing temperature.

Mass-to-charge spectrum shows peaks corresponding to field evaporated atom species.

• Sc-NFAs in 850°C or 1000°C or SPS consolidation show comparable hardness to traditional Y-NFAs.
• Nanoscale Sc-rich precipitates were observed in 850°C annealed powder.
• The possibility of replacing Y with Sc has been demonstrated.
• Various melt processing techniques will be tested to process Sc-NFAs.
• Sc-NFAs will be thermally aged to verify thermal stability.
• Using TEM and EBSD, grain sizes of Sc-NFAs will be examined while employing the Hall-Petch relation to recommend mechanical properties.

Discussion

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