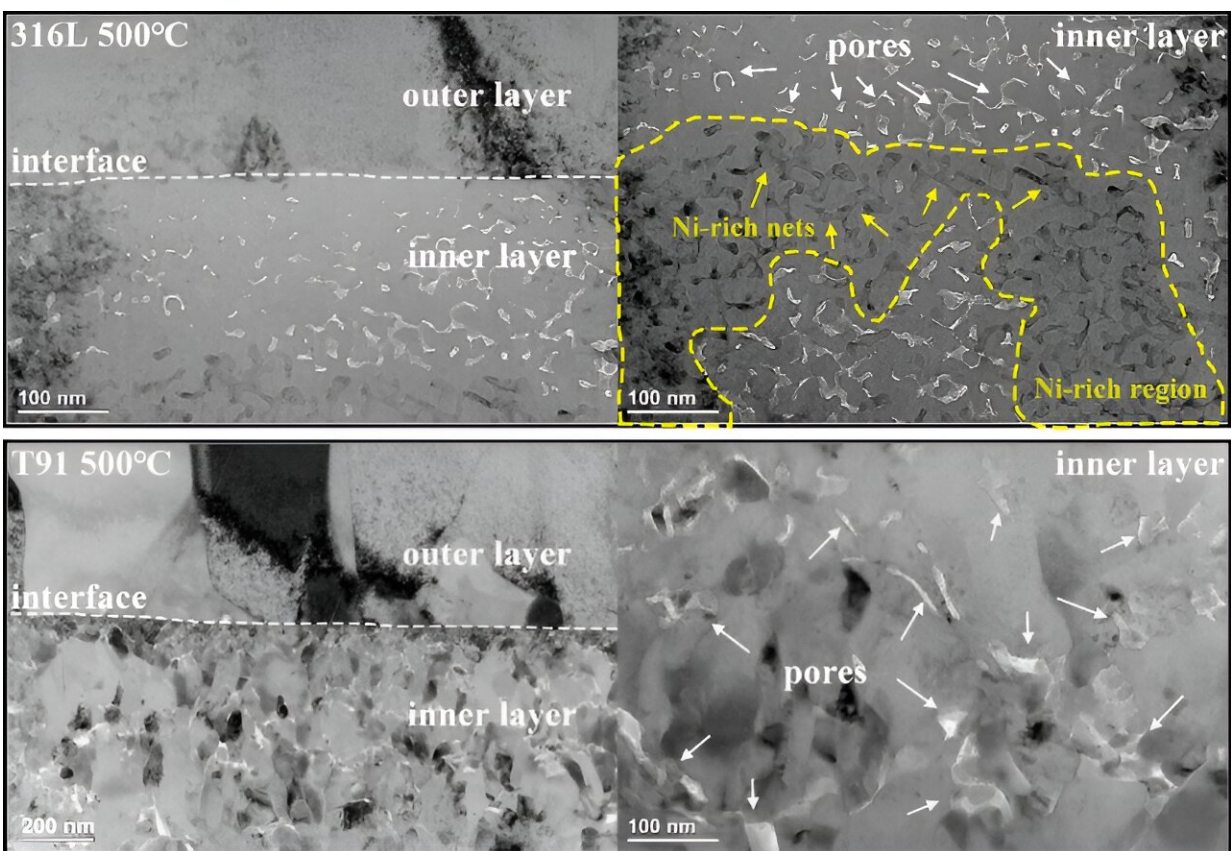


Researchers investigate microstructure evolution of oxide films of Fe-Cr-based alloys

October 24 2023, by Liu Jia



TEM images of nanopores in 316L and T91 oxide films. Credit: Liu Chao

Ferritic/martensitic steels and austenitic steels are the primary candidate

materials for advanced nuclear energy systems. The corrosion resistance of the materials is one of the factors that ensures the safe service of key components. Since the corrosion resistance of materials is highly related to the characteristics of the formed oxide films, it is crucial to investigate the oxide films of candidate materials in high-temperature water.

Researchers at the Institute of Modern Physics (IMP) of the Chinese Academy of Sciences (CAS) selected candidate materials (15-15Ti, 316L and T91) to study their early oxidation behavior in high-temperature steam and the evolution process of the oxide microstructure. The results were [published](#) in *Journal of Materials Science & Technology*.

The Ni-rich layer in the oxide film of austenitic steels (15-15Ti, 316L) is composed of Fe-Cr spinel oxide and Ni-rich phase. Researchers at IMP found a large number of nanopores in the inner oxide layer that could serve as a rapid gas transport channel for oxidant. They revealed the evolution process of Ni-rich layer and the formation mechanism of nanopores in the inner oxide layer.

As a product of elements migration and vacancies aggregation during the corrosion process, the pores also have an important influence on the diffusion-dominated oxidation behavior. The researchers used [transmission electron microscopy](#) (TEM) to further study the microstructure of the 316L and T91 oxide films, focusing on the microscopic characteristics such as the morphology, distribution, and size of the pores within the film.

High-resolution observations using TEM showed that the inner layer of 316L and T91 oxide films is more porous than the outer layer at the nanoscale, which is different from most previous observations using optical microscopes and scanning electron microscopes. By analyzing the phase, structure and composition of the oxide film, it was clear that the

oxidation resistance of 316L is better than T91 in high-temperature steam due to its porous Cr-rich inner oxide layer.

The researchers then revealed the influence mechanism of nanopores on the oxidative corrosion performance of materials. With the model calculation, they suggested that the migration and diffusion of Ni element was the dominant factor in the formation of nanopores in the inner [oxide](#) layer of austenitic steel 316L exposed to 350°C–500°C steam.

This study provides a scientific basis and technical support for the research and development of new anti-corrosion materials.

More information: Chao Liu et al, TEM comparative study on oxide films of 316L and T91 steel exposed to 350–500 °C steam, *Journal of Materials Science & Technology* (2023). [DOI: 10.1016/j.jmst.2023.07.046](#)

Provided by Chinese Academy of Sciences

Citation: Researchers investigate microstructure evolution of oxide films of Fe-Cr-based alloys (2023, October 24) retrieved 27 April 2024 from <https://phys.org/news/2023-10-microstructure-evolution-oxide-fe-crbased-alloys.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.