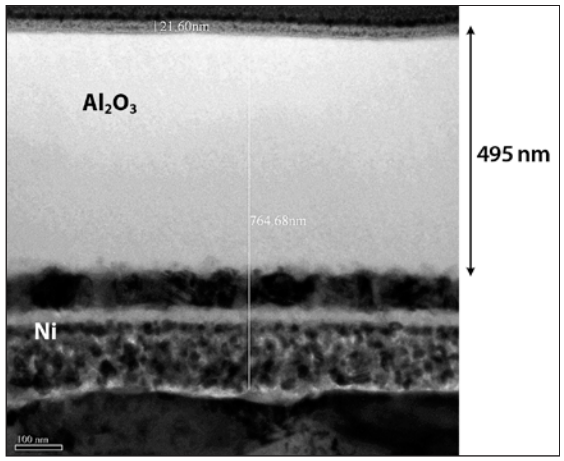
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Fights Corrosion to Cut Costs in CSP Plants

Highlights in Research & Development

NREL investigates how best to protect tanks and piping used for thermal energy storage and heat transfer fluids.

Molten salts and supercritical carbon dioxide (s-CO_2) are thermal energy storage (TES) and heat transfer fluids (HTFs) that are good candidates for next-generation concentrating solar power (CSP) plants. However, these fluids are corrosive, and combined with extreme operating temperatures, can damage tanks and piping. To increase the lifetime of such vessels, they must be composed of exceptionally durable materials.



Cross-section of a nickel bond coat and aluminum oxide top coat after annealing. Nanocrystals of alumina and stratification of the bond coat were resolved. Calculations will reveal which types of defects are most detrimental, and which will inform experimental optimization of coatings. Transmission electron microscope image by NREL

The National Renewable Energy Laboratory (NREL), the University of Wisconsin, and Sandia National Laboratories are working to understand the fundamental mechanisms of how these materials degrade when exposed to TES and HTF liquids.

Studying the corrosion characteristics of different TES and HTF fluids requires different approaches. For molten salt corrosion, the researchers use thermodynamic and molecular dynamic models along with electrochemical and thermogravimetric techniques to understand and control the hot corrosion mechanisms. For s-CO_2 corrosion, autoclave and flow corrosion tests are used.

Coatings must be able to withstand long-term exposure to these corrosive fluids at temperatures greater than 600°C to meet the aggressive cost and performance targets of the U.S. Department of Energy's SunShot Initiative. Another necessary characteristic is low wettability when in contact with the working fluids. To identify the most detrimental crystalline defects in candidate coatings, the team is using first-principles molecular dynamics modeling, in which diffusion of reactive species through the structure can occur. This modeling will be used to understand and control the possible degradation reactions. Coating materials are prepared and characterized for adhesion, wettability, and chemical qualitative analyses before degradation tests. Contact angles between the fluids and the evaluated materials are measured at high temperatures under controlled atmospheres.

The researchers will develop and evaluate advanced protective coatings and surface modification techniques to achieve degradation rates lower than 100 micrometers per year, which is expected to yield materials with a 30-year lifetime. NREL also intends to investigate how this modeling and experimental capability can be applied to other materials experiencing temperatures lower than those seen in CSP plants.

Technical Contact: Judith Gomez, *judith.gomez@nrel.gov*

Reference: Gomez, J.; Anderson, M.; Kruizenga, A. (2013). "Degradation Mechanisms and Development of Protective Coatings for TES and HTF Containment Materials." U.S. Department of Energy SunShot Initiative CSP Program Review, April 23–25, 2013.

Key Research Results

Achievement

The research yielded fundamental knowledge of degradation mechanisms in aggressive fluids at high temperature.

Key Result

The team was able to identify and down-select coating candidate systems that could protect metals from chloride and carbonate molten salts.

Potential Impact

The knowledge gained from this effort will enable the design and evaluation of potential coatings and protective conditions to extend the lifetime of containment materials. Such extended lifetimes will reduce capital and maintenance costs.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 | www.nrel.gov

NREL/FS-5500-61772 | April 2014

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.