Seminar

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Institute for Plasma Research

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Title: Materials in Extreme Conditions: High Temperature and Radiation Environment

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Abstract

The demand for the materials capable of withstanding extreme conditions, such as high temperatures and radiation environments, has significantly increased in recent years.

The study of materials in extreme conditions such as high temperatures, pressures, or aggressive environments and radiation environment involves the understanding how these materials behave under challenging circumstances for critical applications like aerospace, nuclear industries, or oil and gas industries.

Present work is about the materials application and their behavior in the conditions such as chemical or corrosion attack at high temperature or pressure and high temperature concurrent environment in chemical, oil-gas industries and gas turbine engine respectively. This abstract is based on the studies of different types materials behavior in hot corrosion in molten salt, high temperature environment and radiation environment. The effects of related extreme environments like hot corrosion in molten salt Na_2SO_4+NaCl medium, high temperature and radiation environment on the behavior of metallic alloy (AISI 304 stainless steel, modified Ni based alloy), ceramics (yttria stabilized zirconia and La-YSZ) and polycrystalline tungsten, respectively were studied. The modified Ni alloy developed in the form of layer by high velocity oxy-fuel (HVOF) spray process was shown performance superior to AISI 304 stainless steel in hot corrosion in molten salt medium.

Nickel enhanced basic fluxing (NiO^{2-}) in salt medium causes formation of their protective spinel oxides. Formation of stable SiO^2 around grain boundary which does not involve any ionic solute formation hence it does not show the basic/acidic dissolution anymore.

In another attempt the behaviour of ceramics modified with addition of La_2O_3 in 8YSZ developed by plasma spray process causes the formation of presence of pyrochlore $La_2Zr_2O_7$ phase formation in the inter splats boundary along with $LaYO_3$ phase. This modification in YSZ ceramic enhances the oxidation resistance and failure life by reducing growth kinetics of TGO between intermediate layer (CoNiCrAlY) and top layer (La_2O_3-YSZ) material of the material in thermal barrier application at high temperature.

The experimental and simulation studies of tungsten in radiation environment had been carried out. The characterization of lattice defects created by irradiation of heavy and light mass ions (Au and B ions respectively) with the fluence of 1.3×10^{14} at.cm^{-2} in tungsten was performed in terms of identification of defects types and their quantification. The vacancy type defects were analyzed by slow positron annihilation spectroscopy and defects characteristics and quantification were determined by transmission electron microscopy. Eventually the

distribution of deuterium and helium profile trapped into the defects were also studied by Elastic recoil detection analysis (ERDA) and Secondary ion mass spectroscopy (SIMS) successfully.

A recent study concerns He plasma with the fluence of 2×10^{15} at.cm^{-2} exposure of undamaged and pre-damaged tungsten, where the behavior of He in defects produced in tungsten by proton irradiation (for fluence 5×10^{15} and 4.6×10^{16} at.cm^{-2}) was studied. The major task was to develop/modify the plasma irradiation facility and He/D plasma irradiation parameters optimization for materials exposure. The E-H mode inductive and capacitive coupling plasma were stabilized for low pressure. The α and γ regimes of plasma obtained at optimized pressure. The annealed polycrystalline tungsten samples were analyzed by positron anhelation spectroscopy, NRA for retained He amount in pre-damaged tungsten. The results show the trapping of helium in mainly mono vacancy type defects.