HIGH-TEMPERATURE OXIDATION CHARACTERIZATION OF A REFRACTORY HIGH-ENTROPY ALLOY FOR STRUCTURAL APPLICATIONS

INTRODUCTION

Efficient structural materials for next-generation power generation and propulsion systems must combine high-temperature mechanical strength with sufficient oxidation resistance. Refractory high-entropy alloys (RHEAs) are attracting significant interest due to their excellent strength retention at elevated temperatures.

However, their oxidation behavior remains a critical factor limiting industrial deployment.
Thermogravimetric analysis (TGA) is a powerful technique for investigating oxidation kinetics, scale stability, and degradation mechanisms under service-relevant conditions.

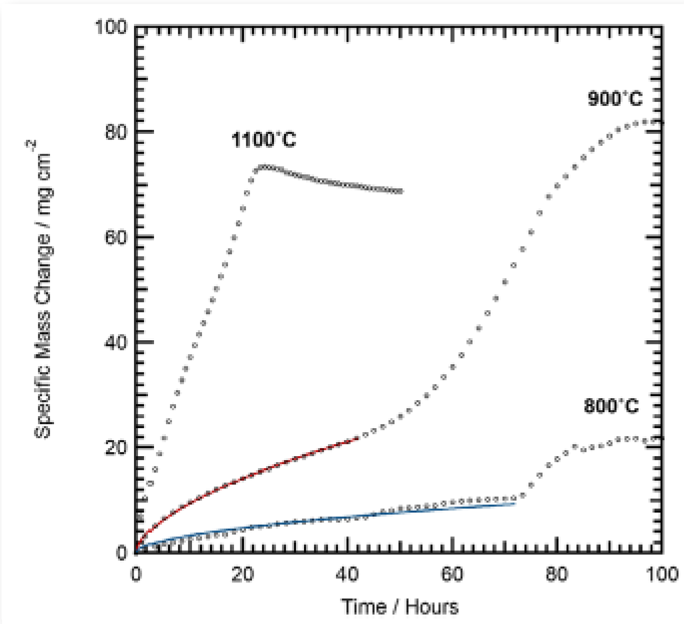
In this study, TGA was used to characterize the oxidation behavior of a refractory high-entropy alloy.

EXPERIMENT

Instrument: THEMYS TGA (formerly SETSYS Evolution TGA)

Sample: Rectangular specimens of homogenized $AlMo_{0.5}NbTa_{0.5}TiZr$ alloy, measuring approximately 5 × 6 × 0.5 mm.

Atmosphere: air flow at 30 mL/min.Temperature profile:
1. Heating from room temperature to the test temperature at 100 K/min.
2. Isothermal oxidation at 800°C, 900°C and 1100°C.



Specific mass uptakes vs. time for samples tested at 800, 900 and 1100 °C

RESULTS AND CONCLUSION

The high sensitivity of the THEMYS TGA enabled continuous monitoring of mass gain associated with oxide formation.

For $AlMo_{0.5}NbTa_{0.5}TiZr$, TGA measurements revealed substantial oxidation at all investigated temperatures. At 900°C and above, the alloy exhibited initially near-parabolic oxidation kinetics followed by accelerated degradation.

At 800°C, the THEMYS TGA detected repeated abrupt mass-loss events related to scale spallation after long-duration exposures, followed by a sharp increase in oxidation rate evidencing catastrophic oxidation behavior. The experiment at 900°C identified a marked increase in oxidation kinetics indicating the presence of a low-temperature accelerated oxidation regime.

The TGA results demonstrated oxidation rates several orders of magnitude higher than those typically reported for commercial high-temperature superalloys and revealed a severe "pesting" phenomenon leading to sample disintegration into powder.
These measurements provided critical insight into the degradation mechanisms of this specific RHEA and showed that, despite its attractive mechanical properties, its oxidation resistance remains insufficient for practical use in oxidative high-temperature environments.

Reference: G.J. Wise, N.L. Church, H.T. Pang et al., The Viability of the Refractory High-Entropy Alloy $AlMo_{0.5}NbTa_{0.5}TiZr$ for High-Temperature Structural Applications, Advanced Engineering Materials, 2025.

INSTRUMENT

THEMYS TGA

HIGH ACCURACY & VERSATILITY
Hang-down symmetrical beam balance, specifically designed for TGA applications

ULTRA-HIGH TEMPERATURE CAPABILITY
To 2400°C with a single furnace

MODULAR ADAPTIONS ALLOWING
TGA only, DTA only, TG-DTA, and TMA UP TO 2400°C, DSC only and TG-DSC up to 1600°C all in one instrument.

EXTERNAL COUPLING CAPABILITY
Designed for evolved gas analyzers (FTIR, MS, GCMS, MSFTIR or FTIR-GCMS).