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Technology Offer

Precise Contactless Temperature Measurement for Micro-Samples

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Abstract

Reliable determination of surface temperatures at the microscale is crucial for the study of material behavior under extreme thermal conditions. Conventional measurement setups often rely on sensors placed near heating sources rather than directly at the sample's surface, resulting in significant inaccuracies caused by thermal gradients. The presented invention introduces a novel hot stage system capable of accurate, contactless temperature measurement of micro-samples and indenter tips at temperatures above 800 °C. By implementing dual independent hot stages and an intelligent thermocouple arrangement, the system enables precise monitoring of thermal fields without physically touching the specimen. This eliminates the risk of damaging sensitive microstructures while achieving stabilization times significantly faster than existing solutions. The technology ensures reproducibility and reliability in high-temperature micromechanical experiments, paving the way for advanced material testing in demanding research and industrial environments.

Background

High-temperature micromechanical testing has become a key approach to understanding the performance of modern materials, such as alloys, ceramics, and composites, under realistic conditions. The ability to probe small-scale mechanical properties is essential for developing materials used in turbines, aerospace, and microelectronics. However, current experimental setups suffer from limited accuracy in temperature determination. Most systems monitor temperatures close to the heating source, rather than directly at the sample surface. This leads to systematic errors due to spatial and temporal thermal gradients. Moreover, achieving thermal equilibrium in traditional setups is a slow and inefficient process, often resulting in long waiting times and thermal damage to both micro-samples and test tips. A more efficient and precise method to determine the true surface temperature of microstructures is therefore urgently needed.

Technology

The invention introduces a new hot stage design that enables accurate and contactless measurement of sample surface temperatures in micromechanical experiments at high temperatures. The setup consists of two independent heating stages, one for the micro-sample and one for the indenter tip. Each stage can be controlled individually, allowing both surfaces to be heated to more than 800 °C without mutual thermal interference.

A key innovation lies in the intelligent placement of thermocouples within the stage assembly. Instead of direct contact with the sample, the thermal field is monitored at multiple positions. From these data, the system accurately estimates the absolute surface temperature with a precision better than ±2.5 °C at 600 °C. This unique approach eliminates the need to attach fragile thermocouples directly to the sample, thereby preventing structural damage to micron-sized test specimens.

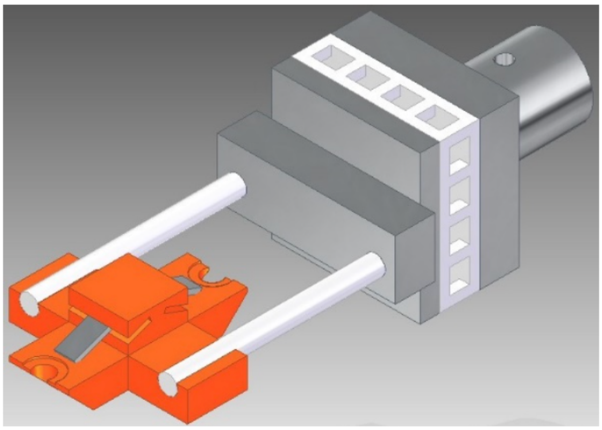

Figure 1: Schematic illustration of the dual hot stage system with independent heating elements for sample (orange) and indenter tip (grey), enabling precise and contactless temperature measurement in micromechanical testing.

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Additionally, the design significantly accelerates thermal stabilization, enabling researchers to conduct experiments more efficiently. The combination of independent heating, non-invasive measurement, and precise monitoring ensures reliable and repeatable results in high-temperature micromechanical characterization, making it a breakthrough in experimental material science.

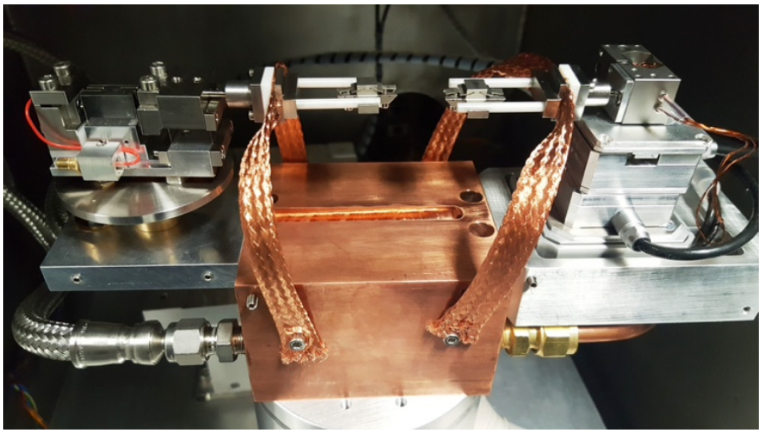

Figure 2: Experimental setup with dual hot stage assembly, showing independent heating units, cooling elements, and copper shielding for stable high-temperature micromechanical testing.

Advantages

- Accurate prediction of surface temperature without direct contact, preserving delicate micro-samples during testing.
- High precision measurement with an error margin of less than ±2.5 °C at 600 °C.
- Independent dual heating stages allow simultaneous and controlled heating of both sample and indenter tip.
- Extremely fast and stable temperature equilibration, reducing downtime between experiments.
- Avoids thermal damage and tip degradation, ensuring reproducible results in demanding test environments.

Potential applications

- High-temperature micromechanical testing of alloys, ceramics, and composite materials.
- Characterization of turbine blade and aerospace materials under realistic operating conditions.
- Testing of electronic micro-components exposed to thermal stress.
- Research on novel high-performance materials for energy conversion and storage.
- Development of advanced coatings and protective layers requiring elevated thermal stability.

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