Novel MEMS-Based Heating Stage for In-Situ, High Resolution Electron Microscopy

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Introduction

With the advent of aberration-corrected electron microscopes that provide sub-Ångström image resolution, it is of great interest to study the behavior of materials at elevated temperatures while maintaining the resolution capabilities of the microscope. However, conventional heating stages for electron microscopy use relatively large furnaces as a heat source and their slow response times and substantial drift often limits their use for high resolution, in situ heating studies. In collaboration with ORNL, a new paradigm for high resolution in-situ heating experiments that overcomes a number of performance problems with standard heating stage technologies is being developed. This new heating system replaces standard furnaces with microfabricated, semiconductor-based heating devices as specimen supports. These devices use an ultra-thin, conductive ceramic membrane to simultaneously support and heat the sample. This approach provides extremely accurate and well-controlled sample heating with virtually no drift. The low thermal mass of the ceramic membrane also allows for extremely fast response times, up to 1,000,000°C per second to temperatures up to 1200°C. With excellent stability and true reaction- rate heating, the software controlled heating system enables novel, in situ experiments on any electron microscope - including sintering, rapid thermal cycling and lifetime testing, grain growth, phase changes, surface reactions and quenching - all at the highest resolution possible.