

The Development of *In Situ* High Temperature Transmission Electron Microscopy for Heat-Resistant Ceramics

Shogo Kikuchi¹⁾, Manabu Tezura¹⁾, Masao Kimura²⁾, and Tokushi Kizuka¹⁾ †

¹⁾ Division of Materials Science, Faculty of Pure and Applied Sciences,
University of Tsukuba

(1-1-1, Tennoudai, Tsukuba, Ibaraki 305-8573, Japan)

²⁾ Institute of Materials Structure Science, the High Energy Accelerator
Research Organization (KEK)

(1-1, Obo, Tsukuba, Ibaraki 305-0801, Japan)

†E-mail: kizuka@ims.tsukuba.ac.jp

One of essential processes of the development in advanced materials is to analyse dynamics of microstructure at actual environment of usage. We have developed *in situ* high temperature transmission electron microscopy (TEM) because the method can provides all the kinds of the information of high temperature dynamics of microstructures of various heat-resistant materials. We have already developed a new type of a 2000 K class high temperature stage for TEM of various shaped materials, as reported in the 2nd Symposium on SIP-IMASM 2016 [1, 2]. In this study, we report one of the applications of the *in situ* high temperature TEM to thermal barrier ceramics coating used in advanced jet engines.

[1] Tokushi Kizuka, Shogo Kikuchi, Manabu Tezura, and Tomo-o Terasawa, the 2nd Symposium on SIP-IMASM 2016.

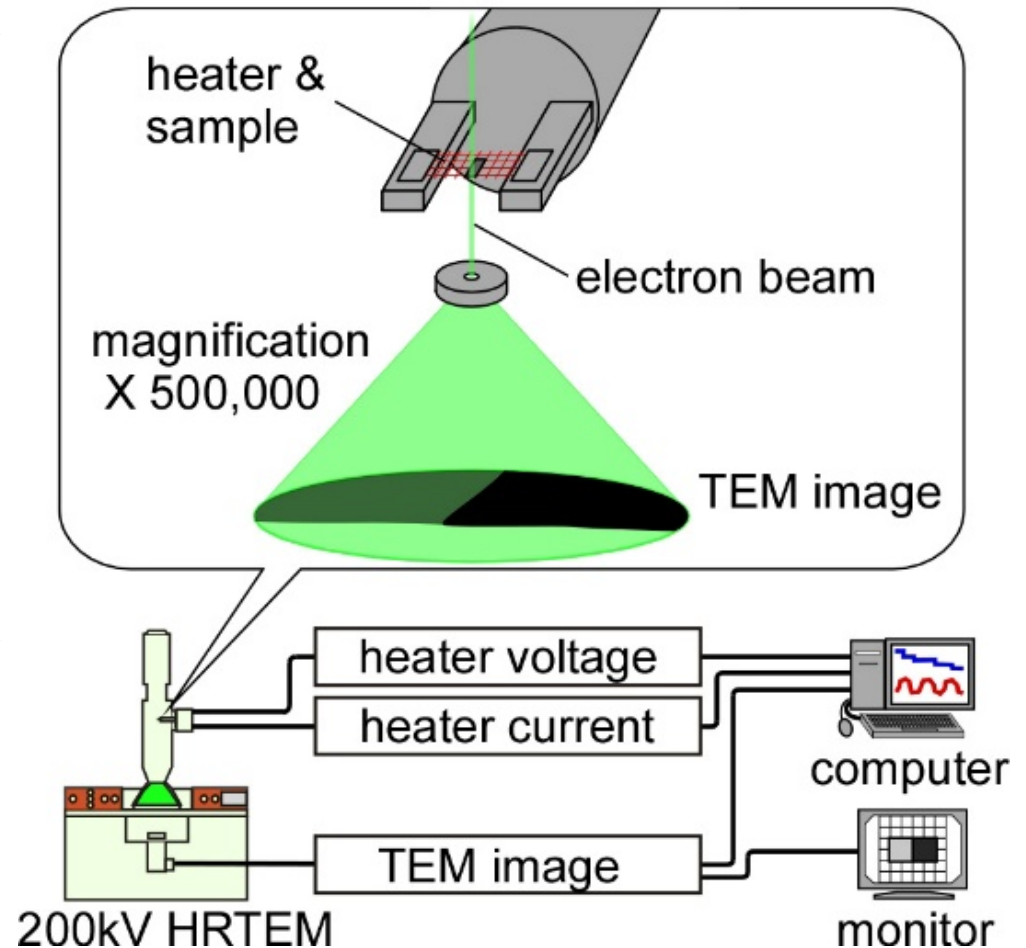
[2] Tomo-o Terasawa, Shogo Kikuchi, Manabu Tezura, and Tokushi Kizuka, J. Nanosci. Nanotechnol. **17**, 2848 (2017).

Master samples of thermal barrier ceramics coating were cut and milled mechanically to observe the interface cross section of the coating and were thinned using an ion beam focused method. The sample was sandwiched by an originally designed mesh heater. The heater containing the sample was mounted on the sample holder for the *in situ* high temperature TEM (JEOL JEM-2011KZ-Custom) [3–5].

[3] Tokushi Kizuka and Shin Ashida, Sci. Rep. **5**, 13529 (2015).

[4] Manabu Tezura and Tokushi Kizuka, Sci. Rep. **6**, 29708 (2016).

[5] Kohei Yamada and Tokushi Kizuka, Sci. Rep. **7**, 42901 (2017).



Schematic of the *in situ* high-temperature TEM of thermal barrier ceramics coating.

During the heating process, the structural dynamics of the variation of the texture was observed *in situ* by lattice imaging of high-resolution TEM using a video capture system.

We could successfully observe the fracture process of the thermal barrier ceramics coating and confirm that the method enables the investigation of high temperature dynamics of the coating texture of heat-resistant ceramics at the atomic scale.

The authors thank Drs. T. Yamaguchi and S. Kitaoka of Japan Fine Ceramics Center for providing master samples of thermal barrier ceramics. This study was supported by Cross-Ministerial Strategic Innovation Promotion Program – Unit D66 – Innovative measurement and analysis for structural materials.