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Phase Transformation Analysis in Titanium at Nanosecond Time-Resolution

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There is current interest in characterizing the sequence and the dynamics of the rapid martensitic phase transformations that occur in Ti and its commonly used alloys during rapid heating and cooling [1-6]. In the present investigation, thin polycrystalline titanium films were subjected to steep heating/cooling rates of $10^{11}/10^{8}$ Ks^{-1} via pulsed laser irradiation. The induced martensitic phase transformations were followed by imaging and diffraction with a high-speed transmission electron microscope on the time scale of nanoseconds [7,8]. The fast processes were observed by recording bright-field electron images and selected-area diffraction patterns with an exposure time of 7 ns at different times after the treating laser pulse, ranging from 0 ns to 100 μs.

The usually rapid martensitic phase transformation in titanium occurs during quenching or rapid heating, and changes the crystal structure from hcp to bcc and back to hcp; hcp being the low-temperature and bcc the high temperature phase respectively. The phase transformation occurs at about 1155 K, being generally increased by impurities and alloying elements. The mechanism of the diffusionless phase transformation is commonly visualized by shearing plus contracting/expanding the crystal structure, resulting in small correlated displacements of the atoms, that can usually be accommodated because of similarities in lattice parameters and the specific orientation relations between the two crystal structures [9]. While the mechanism is known, little is known about the time frame during which such fast structural transformation occurs.

The present investigation examines the temporal evolution of the martensitic phase transformation in Ti films subjected to very much higher heating/cooling rates associated with extreme super-heating/cooling. We are able to determine that the martensitic phase transformation in locally and *in-situ* heat-treated thin titanium films is completed within a few microseconds. Moreover, we are able to obtain diffraction patterns of the high-temperature bcc phase *in-situ* and analyze potential texture patterns and orientation relations that are transferred from the low-temperature hcp into the bcc phase and back into the hcp phase during the transformation.

References
[1] W. Zhang et al., Appl. Phys. Lett. 84, 4872 (2004).

[2] J. W. Elmer, J. Wong, and T. Ressler, Met. Mat. Trans. 29A, 2761 (1998).
[3] J. W. Elmer, T. A. Palmer, and J. Wong, J. Appl. Phys. 93, 1941 (2003).
[4] J. W. Elmer et al., J. Appl. Phys. 95, 8327 (2004).
[5] C. J. Butler and D. G. McCartney, Acta Mat. 46, 1875 (1998).
[6] G. G. E. Seward et al., Acta Mat. 52, 821 (2004).
[7] O. Bostanjoglo, in Advanced Imaging and Electron Physics, edited by. P. W. Hawkes, Academic Press, New York, 2002, Vol. 121, p.1.
[8] H. Dömer and O. Bostanjoglo, Rev. Sci. Instrum. 74, 4369 (2003).
[9] W. G. Burgers, Physica 1, 561 (1934).
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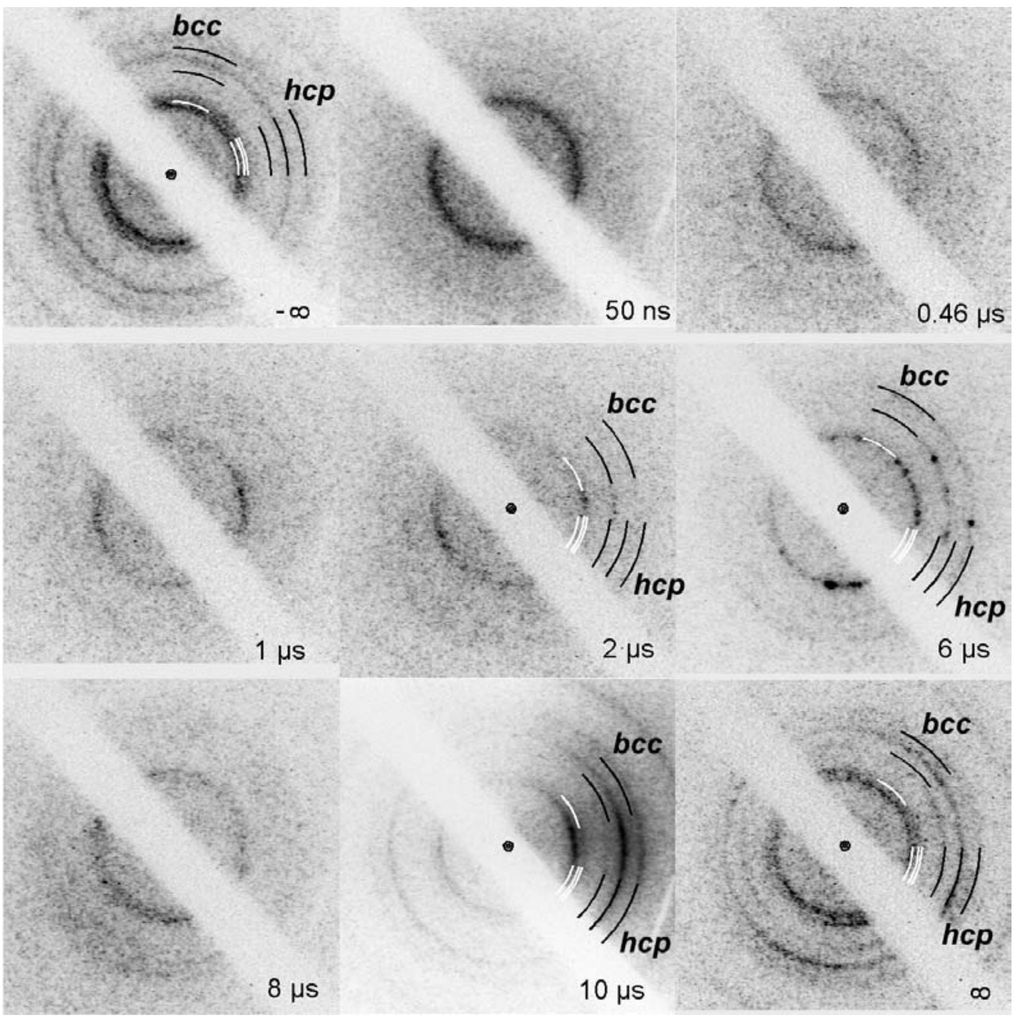

Fig. 1
A series of short-exposure time diffraction patterns, showing the bcc-hcp phase transformations during cool-down of molten Ti. Calculated diffraction ring positions for hcp and bcc phases are marked by segments of circle (hcp: $\{10\bar{1}0\}$, $\{0002\}$, $\{10\bar{1}1\}$, $\{10\bar{1}2\}$, $\{\bar{1}2\bar{1}0\}$, and $\{20\bar{2}0\}$; bcc: {110}, {200}, and {211}).

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