Abnormal temperature dependence of strength in Fe-2.4wt.%Si by microscale cryogenic testing

Chunhua Tian*[1], Pei-Ling Sun[1], Marcus Hans[2], Jakob Schwiedrzik[3], and Sandra Korte-Kerzel[1]

[1]Institute of Physical Metallurgy and Metal Physics [RWTH Aachen University] – Germany
[2]Materials Chemistry, RWTH Aachen – Germany
[3]EMPA Mechanics of Materials and Nanostructures – Switzerland

Abstract

Well-known is that the strength of body-centered-cubic (bcc) metals exhibits a strong temperature dependence, namely, increasing with decreasing temperature, which is correlated with the thermal assistance of kink pair nucleation. However, by microscale cryogenic testing (-80 ∘C to 25 ∘C) on Fe-2.4 wt.% Si, we have observed a strength anomaly with temperature. The anomaly is most significant for 1 μm (diameter) small pillar size and gradually weakened by increasing pillar size (Fig.1c). Besides the strength anomaly, the compressed morphology of slip patterns differs noticeably. Particularly at -30 ∘C where the lowest strength occurs, the slip traces are so diffusive which are instead localized at 25 ∘C. The diffusive complex patterns might originate from the intensive cross slips, as we see wavy dislocation lines in TEM images implying changing slip planes. Molecular dynamics simulation is performed to further understand the strength anomaly.

*Speaker