Materials Characterization
Volume 69, July 2012, Pages 9-15

Atomic force microscopy applied to the quantification of nano-precipitates in thermo-mechanically treated microalloyed steels

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https://doi.org/10.1016/j.matchar.2012.04.006

Abstract

Quantification of nanometer-size precipitates in microalloyed steels has been traditionally performed using transmission electron microscopy (TEM), in spite of its complicated sample preparation procedures, prone to preparation errors and sample perturbation. In contrast to TEM procedures, atomic force microscopy (AFM) is performed on the as-prepared specimen, with sample preparation requirements similar to those for optical microscopy (OM), rendering three-dimensional representations of the sample surface with vertical resolution of a fraction of a nanometer. In AFM, contrast mechanisms are directly related to surface properties such as topography, adhesion, and stiffness, among others. Chemical etching was performed using 0.5% nital, at time intervals between 4 and 20 s, in 4 s steps, until reaching the desired surface finish. For the present application, an average surface-roughness peak-height below 200 nm was sought. Quantification results of nanometric precipitates were obtained from the statistical analysis of

AFM images of the microstructure developed by microalloyed Nb and V–Mo steels. Topography and phase contrast AFM images were used for quantification. The results obtained using AFM are consistent with similar TEM reports.

Highlights

▶ We quantified nanometric precipitates in Nb and V–Mo microalloyed steels using AFM. ▶ Microstructures of the thermo-mechanically treated microalloyed steels were used. ▶ Topography and phase contrast AFM images were used for quantification. ▶ AFM results are comparable with traditionally obtained TEM measurements.

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Keywords

Atomic force microscopy; Microalloyed steel; Nanometric precipitates; Chemical etching

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