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Practical Nano-indentation Theory and Experiments of the Pyramidal Indenter (5th. Comparison between the calculated truncation length of the Berkovich indenter tip with the expanded nano-indentation theory and that with the AFM testing)

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＜選考経過報告＞

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＜受賞理由＞

本報告は，ナノインデンテーション試験法において最も重要な圧子先端の truncation を試験力／侵入深さ曲線から理論的に算出する方法を提案している。さらに，この方法により求めた値と実際に原子間力顕微鏡を用いて圧子を観察した結果を比較検討し，この方法の有効性を証明している。著者らの提案する方法は，ナノインデンテーション試験法において基本となる試験・評価技術として利用ができ，材料試験技術上で特に優秀な学術研究である。

＜論文概要＞

In this paper, the agreement between the truncation length T_{Tri} of the Berkovich indenter calculated from the loading and unloading experimental data with the expanded nano-indentation theory and the estimated truncation length with the AFM (atomic force microscope) is discussed.

First, the loading and unloading experiments are carried out for two specimens: the BK7 (glass) specimen and the HMV500 (carbon steel) specimen: using Shimadzu DUH-W201S dynamic nano-indentation hardness tester with the Berkovich indenter. The loading and unloading experimental curves are obtained and shown for three loads: 9.8, 49 and 98mN. The truncation $T_{Tri(1)}$ and machine calibration factor x are calculated from the measured values of the indentation depth δ_t and elastic recovery displacement δ_r for three loads: 9.8, 49 and 98mN.

Second, the AFM [Pacific Nanotechnology Nano-R] testing for this Berkovich indenter tip is carried out. The AFM images, contour plot and geometrical facts are obtained. From the corrected values of these, the truncation length $T_{Tri(2)}$ is estimated by the curve fitting method

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to the projected area function $A_P(hT_{Tri}) = C_{0(Ap)} \cdot (\delta + T_{Tri(2)})^2$. As a result, it is shown that two values $T_{Tri(1)}$ and $T_{Tri(2)}$ have the considerable agreement within a few nanometers. Furthermore, the truncation length $T_{Tri(3)}$ is calculated from the values of δ_t and δ_r obtained at the minimum test load in this experiments; 0.2mN neglecting the elastic deformation δ_E of the tester. The quantitative agreements between $T_{Tri(3)}$ and $T_{Tri(1)}$, $T_{Tri(2)}$ are obtained.

Finally, the validity of the measured values of T_{Tri} is verified by comparing between the Hertz's elastic contact curve and the loading curve. The reasonable correspondence between the calculated elastic contact curves and the beginning of the loading curves is obtained.