Scanning of quench cracks utilizing dichroism sensitivity photoacoustic microscopy

Hongsung An[1], Yong-Jae Lee[2], Eunwoo Park[3], Chulhong Kim[3], Tae Joong Eom[4]

[1]Conno-Mechatronics Engineering, Pusan National University, Republic of Korea, [1]Engineering Research Center for Color-Modulated Extra-Sensory Perception Technology, Pusan National University, Republic of Korea, [1]Department of Convergence IT Engineering, Pohang University of Science and Technology, Republic of Korea, [1]Department of Congo-Mechatronics Engineering, Pusan National University, Republic of Korea

Heat treatment processes are widely employed across various industries to enhance the mechanical strength of metal structures. However, it is imperative to acknowledge that these processes can unintentionally give rise to the formation of quench cracks. Such cracks can exert a substantial impact on the functionality and structural integrity of critical components, such as electric vehicle axles. The precise measurement and analysis of quench cracks in metals play a pivotal role in material development and safety evaluations. To address this, PAM(photoacoustic microscopy) has emerged as a dependable method for detecting microcracks. PAM utilizes laser-induced acoustic signals to image these cracks while minimizing the influence of optical noise. This study places emphasis on DS-PAM(dichroism-sensitive photoacoustic microscopy), which represents an extension of PAM, incorporating the observation of dichroism. DS-PAM enables the observation of variations in optical absorption rates associated with dichroism at surface defects in metals. This is achieved by adjusting the polarization state of the incident light. To attain precise measurements, linearly polarized laser light was generated employing a polarizing beam splitter and a half-wave plate. The angle of polarization was fine-tuned using a rotary stage. The acquired PAM image of a microcracked metal sample furnished invaluable insights into the crack's dimensions. In our evaluation, we examined a quench crack sample with dimensions measuring 300 μm in width and 150 μm in depth. Subsequent dichroism results underscored the presence of dichroism at the crack edges, which exhibited more pronounced characteristics in contrast to the surrounding normal regions. This DS-PAM analytical approach demonstrates promise in accurately quantifying and analyzing quench cracks in metals. It offers valuable contributions to material development and safety assessments, all while circumventing the need for complex three-dimensional image analysis.