Investigations into the Negative Sensitivity Phenomenon in the Detection of Hidden Defects using Coplanar Capacitive Sensors

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Non-destructive Evaluation and Testing techniques play a crucial role in the inspection of materials and structures, and among them, the capacitive technique has emerged as a promising approach. Previous studies have highlighted the presence of a significant challenge known as the negative sensitivity phenomenon in coplanar capacitive sensors, which affects the interpretation of surface defect inspection results. In this study, investigations were conducted, combining simulations and experiments, to explore the existence and composition of the negative sensitivity phenomenon and its application in detecting hidden defects. The simulations and experimental findings unequivocally demonstrate that the negative sensitivity phenomenon is an inherent characteristic within the sensitivity distribution of a coplanar capacitive sensor. It was found out that the negative sensitivity phenomenon not only exists but also constitutes the largest portion of the sensitivity distribution, with two critical points influencing its behavior. Additionally, it was observed that the thickness of the material under test, along with its properties, significantly influences the sensitivity distribution. Furthermore, this study reveals that the pre-defect peak-trough effect observed is a result of the composition and perturbation of the sensitivity distribution caused by the defects themselves. Through experimental validation, the feasibility of utilizing the negative sensitivity phenomenon region for the detection of hidden defects is validated.