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Numerical Assessment of Laser Annealing Effects on Optoelectronic Performance of Sputter-Prepared ITO/Ag/ITO Electrodes

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Abstract: (Times new roman, font size 12) (Max. 500 words)

In this study, we performed laser annealing (LA) experiments on ITO/Ag/ITO transparent electrodes to assess changes in their optoelectronic properties. We utilized finite element simulations and machine learning techniques to estimate the maximum temperature of the silver layers under varying heating conditions. Analysis of numerical and experimental data revealed a reduction in the defect density of the silver layers after the LA process, significantly enhancing the conductivity of the multilayer electrodes. This enhancement depends on maintaining the LA temperature of the silver layers within their recovery temperature range. However, if the LA temperature promotes recrystallization of the silver layers, nanostructures formed during this process induce surface plasmon resonance, absorbing yellow-red light and imparting a blue-green color to the sample. This transformation results in a notable decrease in the optical transmittance of the electrodes. In our experiments, the Haacke index of the verification sample increased from $\phi_{vis} = 18.7 \times 10^{-3}\ \Omega^{-1}$ to $24.5 \times 10^{-3}\ \Omega^{-1}$, primarily due to a significant reduction in sheet resistance from 7.86 Ω/sq to 6.14 Ω/sq. Future work aims to refine the finite element model to better estimate temperature distributions during LA processes, facilitating optimization of LA parameters to further enhance the optoelectronic properties of these multilayer electrodes.

Keywords: Laser annealing; Transparent conductive electrode; Haacke index; Finite element simulation; Gaussian process; Machine learning.