An Electron Beam-Based Micro-LED Inspection Method

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The inspection of Micro-LED wafer is a critical step for defect interception, yield improvement, and manufacturing cost reduction. To address the limitations of conventional contact probe measurement methods， such as low testing speed, short probe lifespan, and susceptibility to chip damage[1]， we propose an inspection method based on electron beam excitation. This presentation introduces the working principle, experimental design, and test results obtained to date for the proposed method.

When a target is bombarded by an electron beam, localized charge accumulation occurs due to an imbalance between incident and emitted electrons[2]. Based on this principle, an electron beam can be directed to irradiate one terminal of the Micro-LED chip. By adjusting the incident energy of the electron beam, the potential difference across the chip can be modulated, eventually leading to its activation. This report proposes an equivalent circuit model to provide a simplified description of the charging process induced by electron beam irradiation of the Micro-LED. This model effectively explains the observed phenomena and fits well with the experimental data.

We experimentally validated the proposed inspection method by modifying an electron beam probe system. First, a Micro-LED wafer was fabricated, and the P-terminal of the chips was connected to electrical measurement pins via bonding wires. As shown in Figure 1, the electron beam was directed to irradiate the N-terminal of the chip, while the accelerating voltage and beam current of the incident electron beam were adjusted. The experimental results demonstrate that the proposed method can successfully drive the Micro-LED chip, as illustrated in Figure 2. The chip's current–voltage (I–V) characteristic curve is shown in Figure 3.

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[1] Hao Su, Jiawen Qiu, Junlong Li, Rong Chen, Jianbi Le, Xiaoyang Lei, Yongai Zhang, Xiongtu Zhou, Tailiang Guo, and Chaoxing Wu, "Non-destructive electroluminescence inspection for LED epitaxial wafers based on soft single-contact operation," Photon. Res. 12, 1776-1784 (2024)

[2] Xu, T., Zheng, H., Wang, J., Banhart, F., Sun, L. (2023). Electron Beam Irradiation Effects and In-Situ Irradiation of Nanomaterials. In: Sun, L., Xu, T., Zhang, Z. (eds) In-Situ Transmission Electron Microscopy. Springer, Singapore. https://doi.org/10.1007/978-981-19-6845-7_2

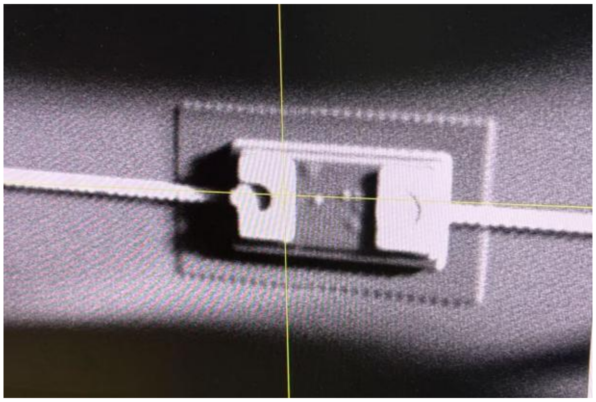

Figure 1:.The image is a secondary electron micrograph of a chip. The center of the yellow cross indicates the position of the electron beam incidence, which corresponds to the N-electrode pad of the chip.

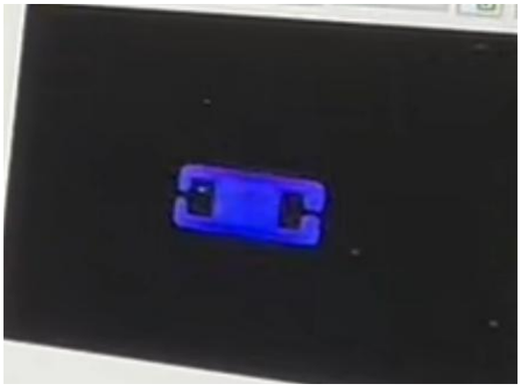

Figure 2: The continuous illumination of an LED driven by an electron beam was captured using a CCD camera through a coaxial optical system.

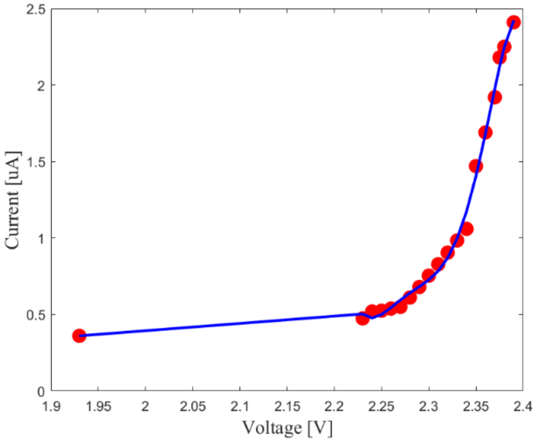

Figure 3: The graph presents the current-voltage (I-V) curve of a Micro-LED using electron beam. The red points represent the actual measured data, while the blue line indicates the fitted curve.