INVESTIGATION OF COPPER MICRO-PATH ELECTRODE DESIGN AND LINE SPACING ON ELECTROCHROMIC DEVICE FUNCTIONALITY

Dainius Balkauskas[1], Titas Tamošauskas[1], Modestas Sadauskas[1], Edita Voitechovič[1], Romualdas Trusovas[1], Karolis Ratautas[1], Alexandr Belosludtsev[1]

[1]Lithuania, Center for Physical Sciences and Technology, Department of Laser Technologies, Savanorių ave. 231, Vilnius 02300

dainius.balkauskas@ftmc.lt

Electrochromic devices (ECDs) are increasingly important for applications such as smart windows and adaptive optical systems, yet their performance and cost remain strongly dependent on the choice of transparent electrodes. This study addresses the challenge of replacing conventional indium-based conductors with low-cost copper while maintaining optical transparency, electrochemical stability, and device durability. The objective was to evaluate how copper line-pattern electrodes of varying geometries perform in ECDs employing PEDOT:PSS or WO_3 electrochromic layers and $LiClO_4$ or H_2SO_4 electrolytes. Transparent microscale copper electrodes were fabricated using the SSAIL technique, and devices were assembled and characterized through optical transmittance measurements, switching-speed analysis, and cycling stability tests. The results show that electrode geometry strongly influences optical modulation and switching kinetics, with narrower line spacing yielding higher transmittance but increased resistance. Electrolyte choice proved critical: PEDOT:PSS devices with $LiClO_4$ demonstrated stable operation with copper electrodes, while H_2SO_4 caused rapid copper degradation and loss of electrochromic functionality. These findings highlight the importance of electrode–electrolyte compatibility and provide practical guidelines for designing durable, cost-effective ECDs using copper-based transparent electrodes.

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