**Beyond the pixel: oxide TFTs shaping smart, sustainable systems**

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Thin-film transistors (TFTs) have been essential to the display industry, enabling active-matrix backplanes for individual pixel addressing. However, their unique advantages—such as ultra-low cost, mechanical flexibility, and compatibility with large-area fabrication—have also driven major advancements in flexible system-on-chip (SoC) integration over the past decade.

Building on our group's extensive experience at CENIMAT|i3N in low-temperature oxide TFTs, this presentation explores three distinct application domains where low-voltage operation and/or low power consumption were primary design constraints:

* Pixel circuits for electroluminescent displays, targeting µLEDs and spin-coated quantum-dot (ELQD) technologies. These circuits were optimized for a 35 µm pixel pitch in high-resolution displays, with sub-3 V data voltages enabling microampere-range currents and fine gray level control in miniaturized light-emitting elements.
* Ionizing radiation detectors, with fast response and high sensitivity to x-rays. Since the initial demonstrations of oxide TFTs as dosimeters by University of Bologna and NOVA FCT [1], more recently we optimized a bi-layer gate dielectric structure by atomic layer deposition enabling unprecedented sensitivity of (63±2) V/Gy, an order of magnitude larger than previously reported values [2].
* Energy management circuits for autonomous sensing platforms. These include an ultra-low-power wake-up timer (27 nW) [3] and voltage regulation blocks capable of supplying three independent power rails from solar energy sources. Key strategies included the use of low-dropout regulators and circuit topologies that exploit transistor leakage currents to generate ultra-low-frequency timing signals.

In addition, an innovative and universal approach for integrating these flexible circuits with other components—whether on rigid or flexible substrates—will be presented. This method uses conductive adhesives with printed interconnects to link flexible circuit pads to external components, overcoming the limitations of wire bonding and direct printing techniques.

[1] T. Cramer, *et al.*, Passive radiofrequency x-ray dosimeter tag based on flexible radiation-sensitive oxide field-effect transistor, *Sci. Adv.* 4, eaat1825 (2018). <https://doi.org/10.1126/sciadv.aat1825>

[2] C. Bordoni, *et al.*, Dielectric multilayers impact on radiation-induced charge accumulation in highly sensitive oxide field effect transistors, *APL Mater.* 12, 031106 (2024). <https://doi.org/10.1063/5.0189167>

[3] D. Narbón, *et al.*, An ultra-low power wake-Up timer compatible with n-FET based flexible technologies, *npj Flex Electron* 9, 3 (2025). <https://doi.org/10.1038/s41528-024-00374-4>