OXIDE THIN FILMS FOR SUSTAINABLE, MULTIFUNCTIONAL AND FLEXIBLE ELECTRONICS

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The growing range of applications of large-area electronics (LAE) in the last years is starting to require levels of performance, functionality and cost not compatible with the current thin-film technologies, such as a-Si or low-temperature polysilicon (LTPS) thin-film transistors (TFTs). This starts to be even more relevant when low-cost flexible substrates and processing technologies are considered. In this context, amorphous oxide semiconductors (AOS) are becoming essential materials in this field. AOS are recognized for their remarkable features such as good uniformity even when produced at room temperature, enabling applications in large area and flexible electronics; wide band gap (thus high transparency), making them suitable for transparent electronics; and good electrical performance despite their amorphous structure, enabling flexible circuitry operating at high-kHz to MHz range. Since the initial publication by Nomura et al. on indium-gallium-zinc oxide (IGZO) TFTs in 2004, these devices had a tremendous development and are now implemented in Gen10 display fabs for the production of low power consumption, high refresh rate and high resolution displays.
But oxide electronics has a great potential for going well beyond display backplane applications: in fact, by combining new materials/structures, processing techniques and circuit design architectures having in mind conventional CMOS concepts adapted to the speed and (typically) unipolar limitations of oxide TFTs, these devices can be seen as a powerful platform for sustainable, multifunctional and flexible electronics.

This presentation will precisely address these topics, which are currently being studied at CENIMAT:

- Turning oxides into an even more sustainable approach for electronics, by replacing IGZO by indium- and gallium-free semiconductors, such as zinc-tin oxide (ZTO). Even if the initial reports on this material have shown largely inferior TFT performance and superior processing temperature when compared to IGZO TFTs, it will be shown that sputtered ZTO TFTs with On/Off ratio above 106, field effect mobility close to 10 cm2/Vs, subthreshold slope of 0.3 V/dec and non-significant performance variation under bending can now be obtained on PEN foil with only 150 C processing temperature.
- Taking oxide TFTs towards the limits of microscale patterning, investigating the peculiarities found for oxide TFTs with channel lengths as low as 1 micron. While short channel effects as channel length modulation or drain induced barrier lowering start to be relevant, cut-off frequencies of oxide TFTs can exceed 100 MHz at this scale. The electrical characterization is being supported by TCAD simulations. [1, 2]
- Integrating oxide TFTs in digital, analog and mixed-signal circuits with a significant level of complexity (100s of TFTs). To compensate for the intrinsic performance limitations compared to Si-based CMOS, high-gain topologies are being used to create logic gates, amplifiers, multipliers, phase-generators, among many other blocks. As examples, four-quadrant analog multipliers with a gain improvement of 7.2 dB over the Gilbert cell with the diode-connected load or amplifiers with a gain of 34 dB and a power consumption of 0.576 mW (load of 10 MOhm//16 pF) will be presented [3, 4]. These blocks are being used for different fields of applications, such as smart-bottles or flexible x-ray sensors. For this last application we recently found our oxide TFTs to have excellent ionizing-radiation hardness, showing to be insensitive even to exposure doses of 410 krad(SiO2) [5].

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