Boosted IGZO Optoelectronic Synaptic Performance by Mitigating Photolithography-Induced Surface Effects

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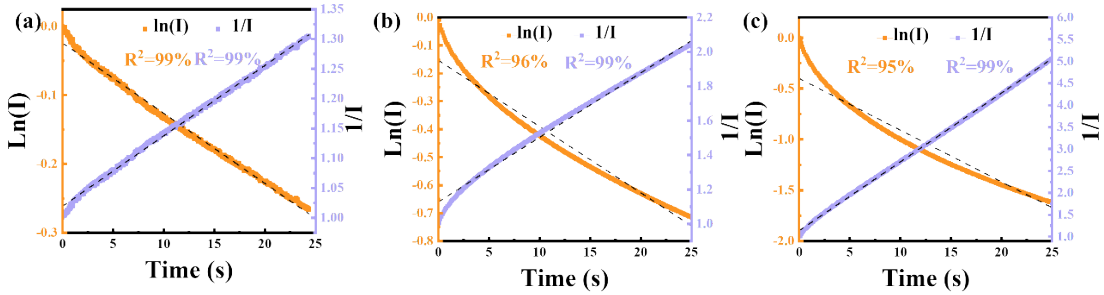

Figure. S1 Relaxation dynamics fitting curves for (a) A-TFT, (b) B-TFT, (c) C-TFT

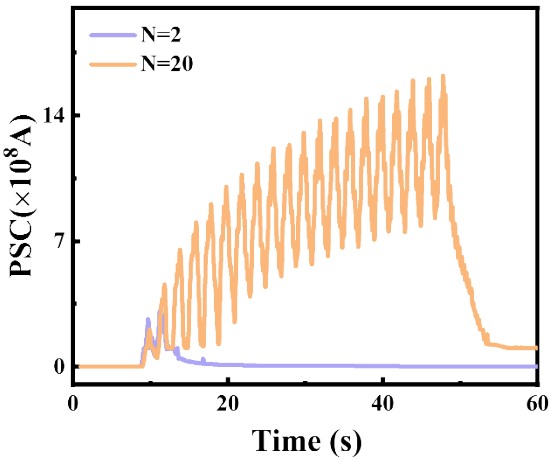

Figure.S2 The transition of STP to LTP by increasing the optical pulse number (λ= 300 nm, P=130 μW/cm^2)

Calculation of photoresponsivity:

The photoresponsivity of a device indicates the magnitude of photocurrent or photovoltage generated per unit optical power incident on the device. The calculation formula is as follows:

$$R = (I_{ph} - I_{dark})/P \times S \qquad \text{(S1-1)}$$

Where *P* is the power density of the incident light, and *S* is the irradiated area of the device. Photoresponsivity is influenced by various factors, primarily including the light absorption characteristics of the material, carrier mobility, device structure, incident light wavelength, and bias voltage.

Calculation of Activation Energy E_a:

The relaxation process of photogenerated carriers reflects the persistent photoconductivity phenomenon in the device. The activation energy (Ea) determines the difficulty for charged oxygen vacancies to revert to their ground state in AOS TFTs. We employed a small-signal injection model and numerical analysis methods to study the photocurrent, with the specific process as follows:

The trend of photoconductivity changing with time is as follows:

$$\sigma_{ph}(t) = e\mu n_{ph}(t) \qquad \text{(S2-1)}$$

The photogenerated carriers can be calculated using the following formula:

$$n_{ph}(t) = \int g(E)e^{-t/\tau(E)}dE \qquad \text{(S2-2)}$$

Where *e* is the charge constant, μ is the carrier mobility, and $\tau(E)$ is the escape time, which

is related to the activation energy of photogenerated carriers and can be described as:

$$\tau(E) = \frac{1}{\nu} exp(E/_k T) \quad \text{（S2-3）}$$

where v is the escape frequency (~10^{13} s^{-1}), k is the Boltzmann constant, and T is the test environment temperature. The photogenerated carriers $n_{ph}(t)$ are expanded using the exponential term:

$$n_{ph} = \sum N_i exp(-t/\tau_i) \quad \text{（S3-4）}$$

The photoexcited defect states (density of effective states) *g(E)* are derived using Laplace transform, where the energy E corresponding to the peak of *g(E)* is the activation energy E_a:

$$g(E) = \sum_i \frac{N_i \quad \nu e^{-E/k_B T}/\tau_i}{k_B T(\nu e^{-E/k_B T} + 1/\tau_i)^2} \quad \text{（S4-5）}$$