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Supplementary Materials for

Passive radiofrequency x-ray dosimeter tag based on flexible radiation-sensitive oxide field-effect transistor

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Supplementary Information

Model to describe the dependence of sensitivity on dielectric thickness: We assume that the ionization charge density σ is distributed equally in the dielectric. The ionization charge is counterbalanced on one site of the dielectric by mobile hole carriers causing a shift in the transistor threshold

$$\Delta V_t = \frac{\sigma(d)}{2c(d)} \tag{1}$$

Both, σ as well as the specific capacitance of the dielectric *c* depend on dielectric layer thickness d.

The amount of ionization charge that is produced in the dielectric depends on the exposed energy dose *ΔD* (expressed in air kerma). Knowing the X-ray photon absorption length λ one can estimate the amount of absorbed energy DE

$$\Delta E(d) = \frac{\Delta D\ d}{c_{m,air}\,\lambda} \tag{2}$$

for the low absorption limit (d << λ).

The amount of charge produced depends then on the electron-hole-pair formation energy $W_{e\text{-}h}$ and the internal efficiency of the process Q_I that is limited due to recombination processes and thermal dissipation

$$\sigma(d) = \frac{Q_I\, e\, E(d)}{W_{e-h}} \tag{3}$$

with *e* being the unit charge.

The capacitance of the multilayer is described as

$$\frac{1}{c} = \frac{d}{\varepsilon_M \varepsilon_0} \tag{4}$$

With c_i being the interfacial capacitance of the SiO_2 capping layer and ε_M the permittivity of the multilayer.

Combining equations1-4 we obtain

$$\frac{\Delta V_t}{\Delta D} = \frac{Q_I e}{2c_{m,air}\,\lambda\,\varepsilon_M \varepsilon_0\, W_{e-h}} d^2$$

which is used in the main text.

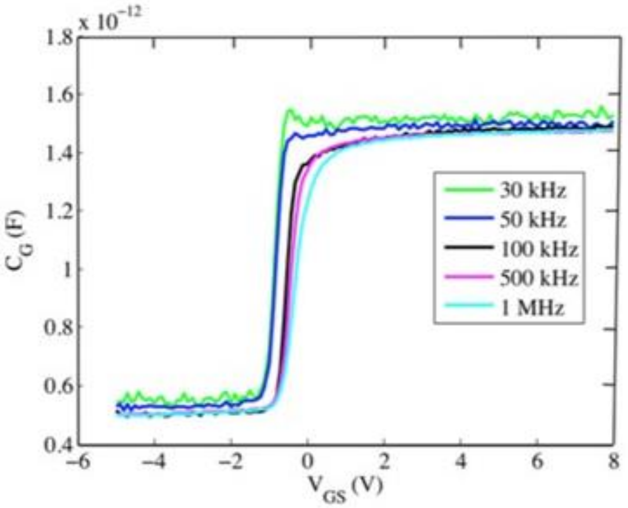

fig. S1. Fast transistor operation and switching: Gate capacitance C_G as a function of gate voltage V_{GS} for different frequencies.

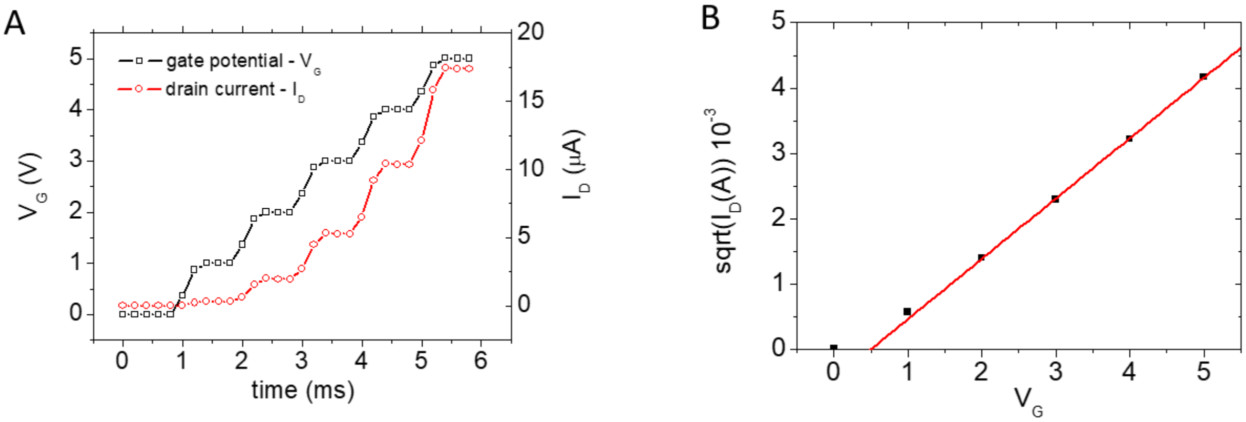

fig. S2. Fast transfer characteristic acquisition. Fast transfer acquisition: (A) Gate voltage and drain current as a function of time. (B) Transfer characteristics obtained from the fast transfer in saturation and line fit to obtain Vt.

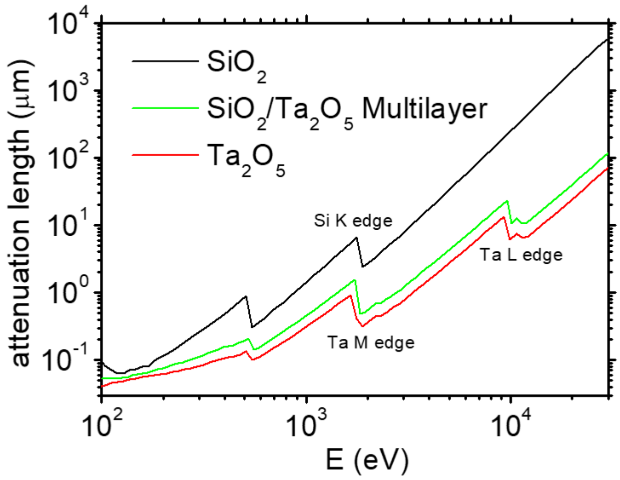

fig. S3. Calculated attenuation length spectra for silicon oxide, tantalum oxide, and the multilayer dielectric based on National Institute of Standards and Technology database.

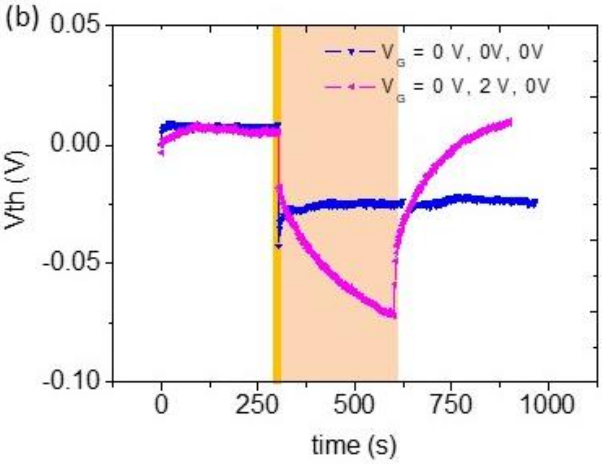

fig. S4. Accelerated recovery of ROXFET due to application of positive gate voltage. Accelerated recovery of ROXFET due to application of positive gate voltage: the blue data points represent the transistor whose terminals were connected to ground. Violet instead shows data from a transistor that was biased at 2 V on the gate after exposure during the indicated period. During bias, stress effects shift the V_t to more negative values. Once the gate is again grounded, it returns to the initial V_t value. In contrast, the ROXFET that was always kept at ground maintains its V_t value.

table S1. Properties of a set of IGZO transistors with *W* = 320 µm and *L* = 20 µm and varying multilayer dielectric thickness. Trap state density was calculated from the subthreshold slope and the capacitance using

$$S = \frac{kT \ln 10}{e}\left(1 + \frac{e^2}{C_i} N_t\right)$$

d (nm)	µ (cm^2/Vs)	S (V/dec)	Leakage at 5 V (pA)	C (nF/cm2)	N_t (10^{11}/cm2eV)
114	29.4 ± 1.7	0.16 ± 0.01	0.250 ± 0.005	54 ± 1	5.9 ± 0.9
205	22.5 ± 1.8	0.27 ± 0.04	0.150 ± 0.005	38 ± 1	8.7 ± 1.0
293	17.3 ± 1.8	0.30 ± 0.10	0.10 ± 0.01	28 ± 1	7.3 ± 1.0
352	12.0 ± 0.4	0.35 ± 0.13	0.05 ± 0.01	27 ± 1	8.5 ± 1.1