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Zinc oxide thin films for radiation hardened devices by materials engineering

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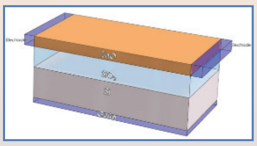
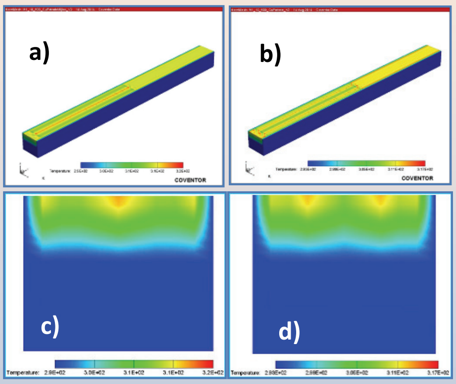
► Application of zinc oxide thin films in advanced opto-electronic devices designed to operate in space environment raises issues on material properties and device function modification under radiation exposure.

► Colliding heavy charged particles can affect the structure as well as the optical and electrical properties of ZnO, by the accumulation of radiation induced defects.

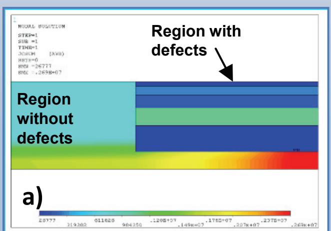
► In this work we report results of an experiment performed with alpha particles at 3 MeV, 5.3 kGy/h, and various exposure periods between 100s and 8 h, aiming to understand the atomic-level mechanisms of defects build-up in irradiated ZnO thin films.

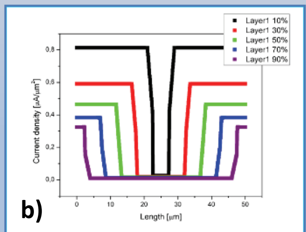
3. Electro-thermal and electrical simulation





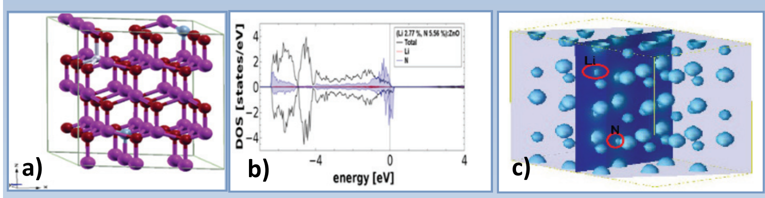
Test structure: ZnO channel of a FET with embedded vertical columns of defects situated in a row (a) or in two rows (b). Temperature distribution in the channel cross section (c,d).





Test structure: ZnO channel of a FET containing layers with variable concentration of defects (a) and current density distribution as function of defected area 10-90% (b).

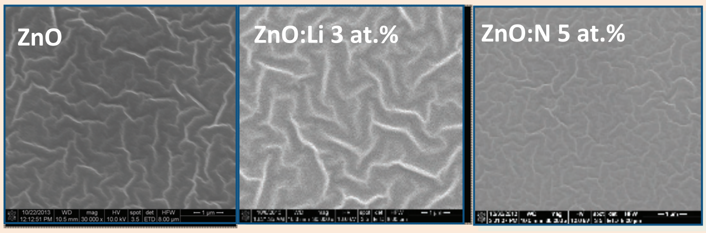
4. Electronic properties of ZnO : Li, N and (Li, N) systems



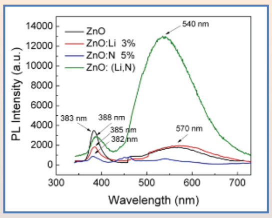
(2.78% Li, 5.56% N): ZnO System. Supercell structure (a), Density of states (DOS), (b) Isosurfaces of total charge density (c).

Results

1. Thin films properties

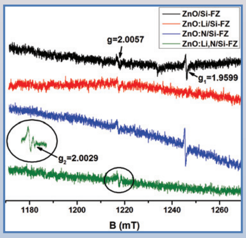


Surface morphology of thin films deposited on Si/SiO_2 substrates by sol-gel spin coating.



Thin films	PL emission peaks energy (eV)	
ZnO	3.24 383 nm	2.17 571 nm
ZnO:Li 3%	3.22 385 nm	2.16 574 nm
ZnO:N 5%	3.25 382 nm	-
ZnO:Li 3% N 5%	3.21 386 nm	2.29 541 nm

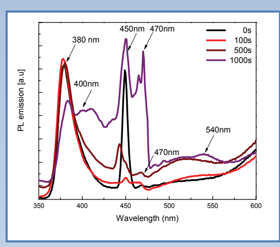
Photoluminescence emission: 3.24 eV emission peak related to donor-to-acceptor pairs and 2.4 eV emission peak related to deep-level emissions involving defects in thin films.



Electron Paramagnetic Resonance spectra of ZnO, ZnO:Li, ZnO:N and ZnO:Li,N films deposited on floating zone silicon, measured at 90 K (Q-band).

2. ZnO thin films exposed to alpha particles

Surface morphology of thin films exposed to 3 MeV alpha radion.



Photoluminescence emission of irradiated ZnO thin films: 100 s, 500 s and 1000 s .

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