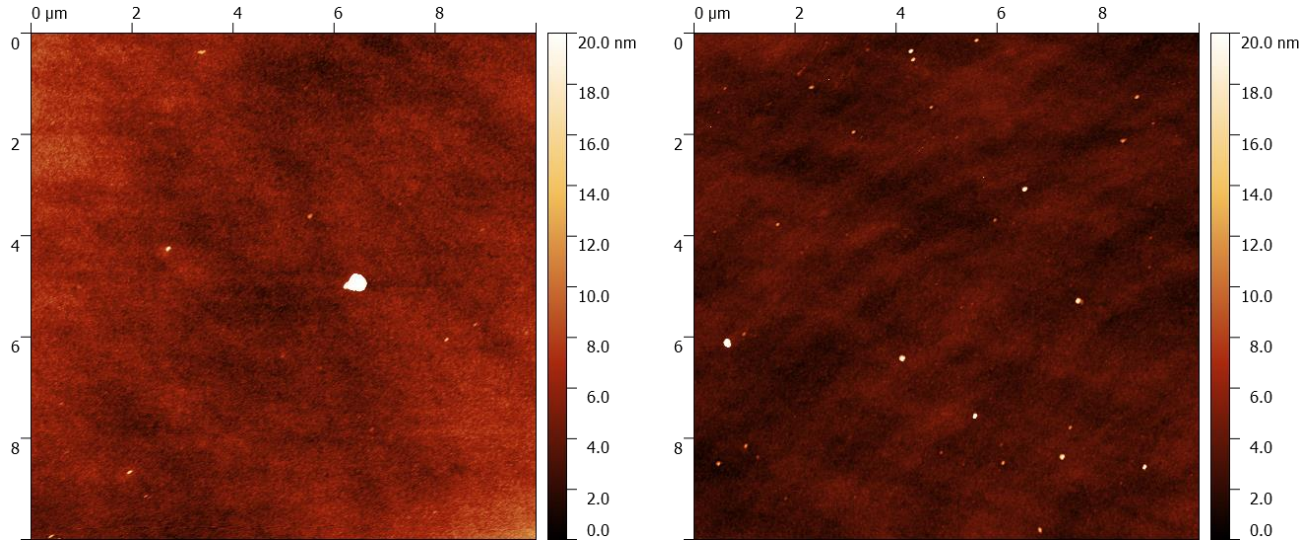
Supplementary material for the article

Resistive switching in non-stoichiometric germanosilicate glass films containing Ge nanoclusters

1. Surface morphology of Si substrates

The surfaces of silicon substrates were studied to verify their low roughness, since roughness could affect the electrical characteristics and influence the quality of the studies structures. Scans were made once to evaluate the topography. The "Solver Next I" scanning probe station manufactured by NT-MDT (Zelenograd, Russia) was used to carry out the surface topography measurements in semicontact tapping regime with the ScanAsyst-Air probes (Bruker, USA). The scanning parameters were: scan area 10 × 10 μm, scan rate 0.5 Hz, resolution 512 × 512 pixels. The nominal tip radius of the probes was 2 nm, spring constant ~0.4 N/m.



(**a**) (**b**)

Figure 1. The 2D AFM topography images of the GeO[SiO_2] samples: (**a**) as-deposited; (**b**) annealed.

The surfaces of both samples had a very low value of surface roughness in the scale of 1 nm. A higher value of roughness for the as-deposited sample is related to an object in the center of the scanned image. The annealed sample was slightly smoother than as-deposited. The major parameters of 3D surface roughness for the scanned areas are given in Table 1.

Table 1. Roughness parameters of Si surfaces.

	As-deposited	**Annealed**
Sq, nm (Root mean square height of the surface)	2.72	0.91
Sa, nm (Arithmetical mean height of the surface)	0.75	0.58
Sdr, % (Surface area ratio)	0.19	0.07

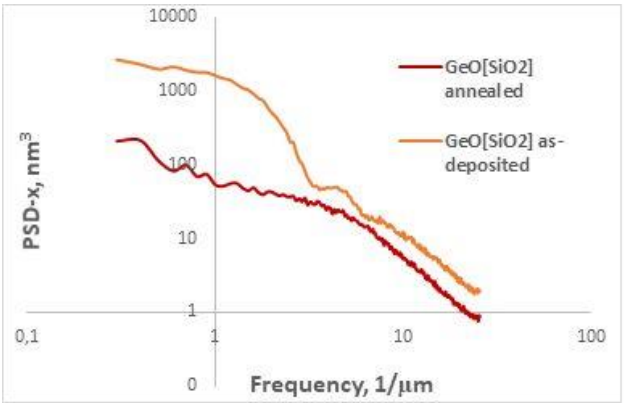


Figure 2. Power spectral density (PSD) of roughness measured for fast scan axis direction X shows small values of object sizes (X-axis, nm^3) and amount of objects (Y-axis, μm^{-1}) for the entire spectral range.

2. Transmittance and reflectance data

Separate values of transmittance and reflectance for annealed thick GeO[SiO_2] and GeO[SiO] films on quartz substrate are demonstrated in Figure 3. These data were used to build up the graphs of the sum of transmittance + reflectance for Figure 4c,d in the body of the manuscript.

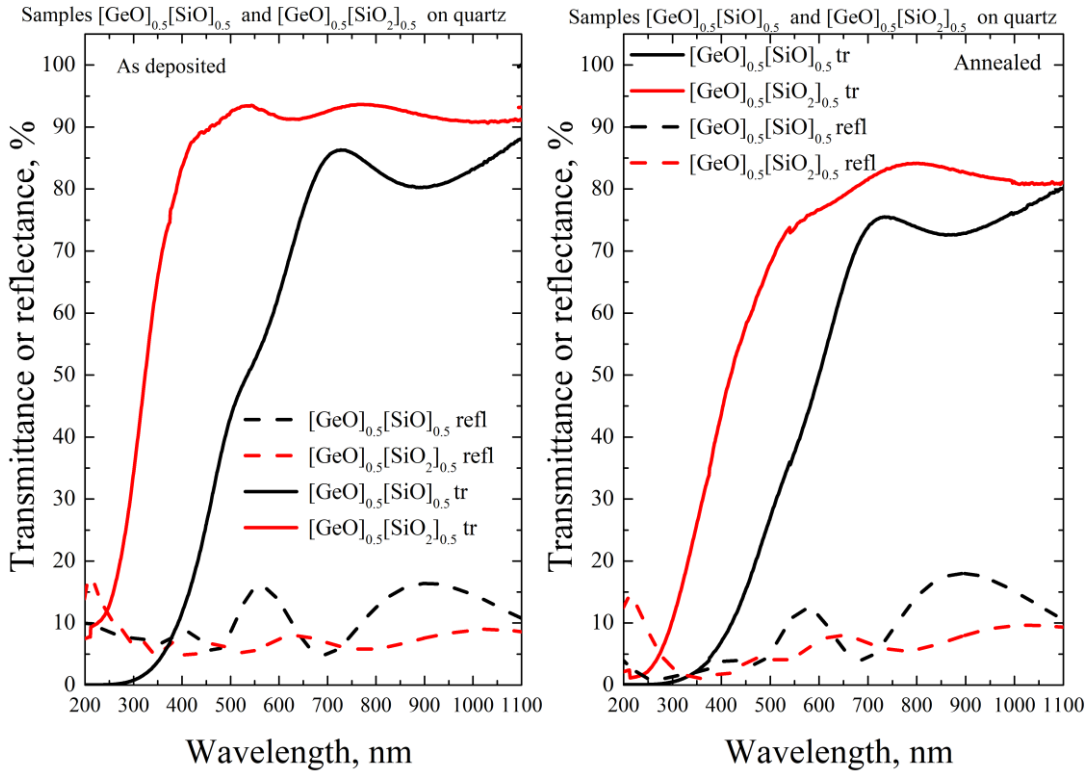


Figure 3. Transmittance and reflectance curves for GeO[SiO_2] and GeO[SiO] films on quartz substrates: (left) image–as-deposited films; (right) image–annealed films.

3. Current-voltage characteristics

Experimental I–V characteristics of the as-deposited GeO[SiO] film on n^+-Si substrate are shown below. These data were used for comparison with the modeling of j-F characteristics of corresponding structures in Figure 8a of the manuscript.

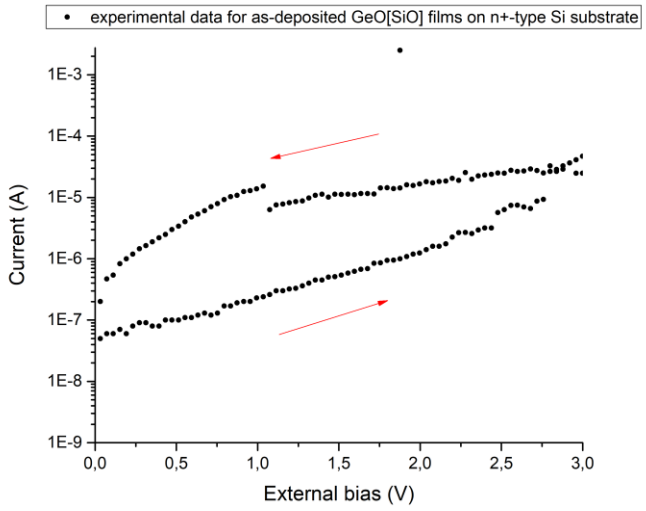


Figure 4. Exemplary experimental I-V characteristics of the as-deposited GeO[SiO_2].