

[Supplementary Material]

**Europium induced point defects in SrSnO<sub>3</sub>-based  
perovskites employed as antibacterial agents**

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### **Characterization details – conditions of analysis**

Conventional X-ray powder diffraction (XRD) measurements were performed with a Shimadzu Lab X/XRD-6000 diffractometer, using Cu K $\alpha$  radiation. The scanned range was  $2\theta = 15$  to  $80^\circ$ , with a  $0.02^\circ$  step and a step time of 2.0 s.

Infrared (IR) analyses were carried out with a Shimadzu IRPrestige-21 spectrophotometer, using KBr pellets in the range of 4000-400  $\text{cm}^{-1}$ . UV-vis spectra were obtained using a Shimadzu UV-2550 spectrometer in total reflectance mode.

Photoluminescence (PL) measurements were performed using a Monospec 27 monochromator (Thermal Jarrel Ash, USA) coupled to an R446 photomultiplier (Hamamatsu, Japan) and the PL spectra were obtained at room temperature using a krypton ion laser with a 350.7 nm wavelength (Coherent Innova 90 K, USA) as an excitation source, with maximum output power at 250 mW.

Field emission scanning electron microscopy (FE-SEM) images were obtained using a JSM 7100-FSEM (JEOL Ltd, Japan), operated at low voltage, typically 10 kV, to limit charge effects. The morphological characterisation of the synthesised materials was performed using a High-Resolution Scanning-Transmission electron microscope S-TEM Hitachi HD2700 (Hitachi, Tokyo, Japan), cold field emission, operated at 200 kV, coupled with double EDX detector (Oxford Instruments, Oxford, UK, AZtec Software, version 3.3). The samples were dispersed in pure ethanol, sonicated, and placed on 200 mesh, 3 mm diameter copper grids.

The specific surface area was calculated from N<sub>2</sub> adsorption-desorption isotherms measured in an ASAP 2420 Multi-port surface area and porosimetry analyser (Micromeritics Instrument, USA) using the Brunauer-Emmett-Teller (BET) equation.

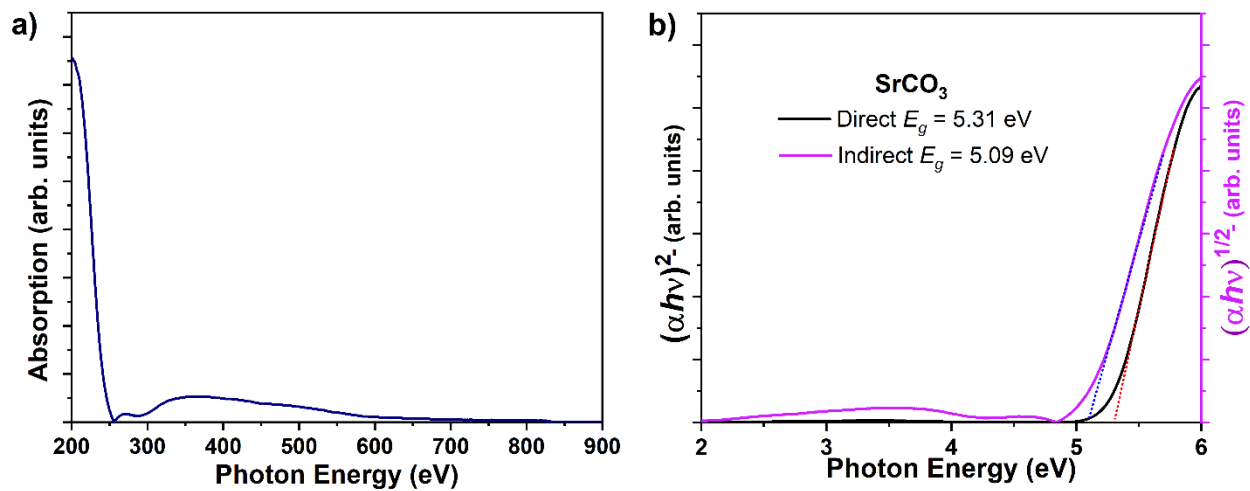
The paramagnetic centres in the powder samples were characterised by EPR spectroscopy

with an E-500 ELEXSYS (Bruker, Germany) Q-band spectrometer at 33.94 GHz. In addition, a Bruker X-SHQ 4119HS-W1 X-band resonator was used to study the SrCO<sub>3</sub> characteristics. All EPR measurements were carried out at room temperature.

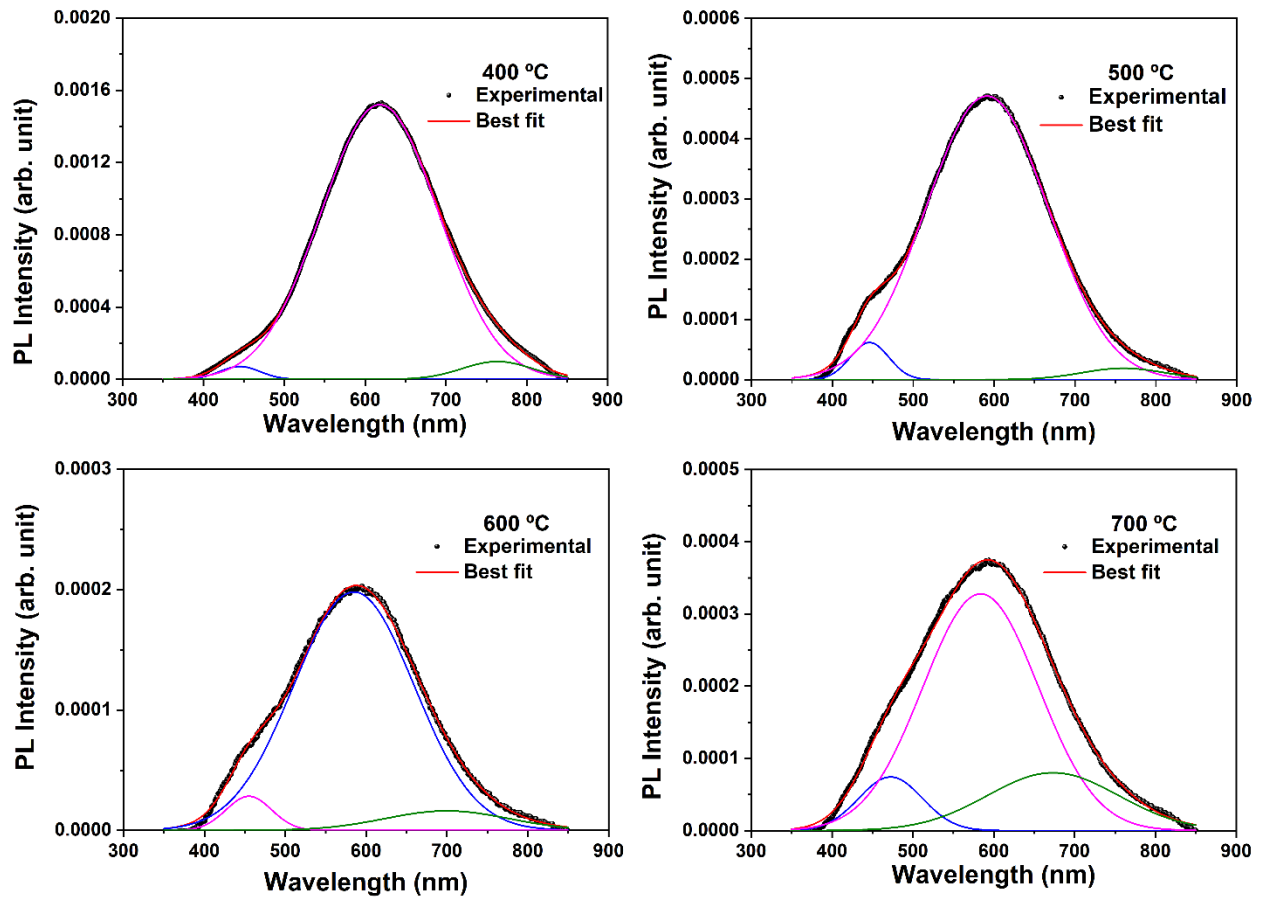
The XPS spectra were obtained with a VSW HA-100 spherical analyser using an Al K $\alpha$  radiation ( $h\nu = 1486.6$  eV). The high-resolution spectra were measured with constant analyser pass energies of 44 eV (which produces a full width at half-maximum (FWHM) line width of 1.6 eV for the Au(4f<sub>7/2</sub>) line). The pressure during the measurements was always lower than  $6 \times 10^{-8}$  mbar. The powdered samples were pressed onto double-faced carbon tape, fixed to a stainless-steel sample holder, and analysed without further preparation. Surface charging was corrected, shifting all spectra so that the C1s line due to adventitious carbon was at 284.6 eV. Curve fitting was performed using Gaussian line shapes, and a Shirley background was subtracted from the data. Where necessary, X-ray satellites were subtracted during the analysis.

The point of zero-charge (PCZ) of the materials was determined by potentiometric titration using a Zetasizer Nano Series with He-Ne laser of 633 nm equipped with an MPT-2 Autotitrator (Malvern Panalytical, U.K.). A 0.05 g/L suspension of the different perovskites were prepared using a 0.1 mmol/L NaNO<sub>3</sub> solution. Aliquots of 10 mL of the suspensions were sonicated at room temperature, and pH values were adjusted by adding 0.1 mol/L HNO<sub>3</sub> or 0.1 mol/L NaOH solutions.

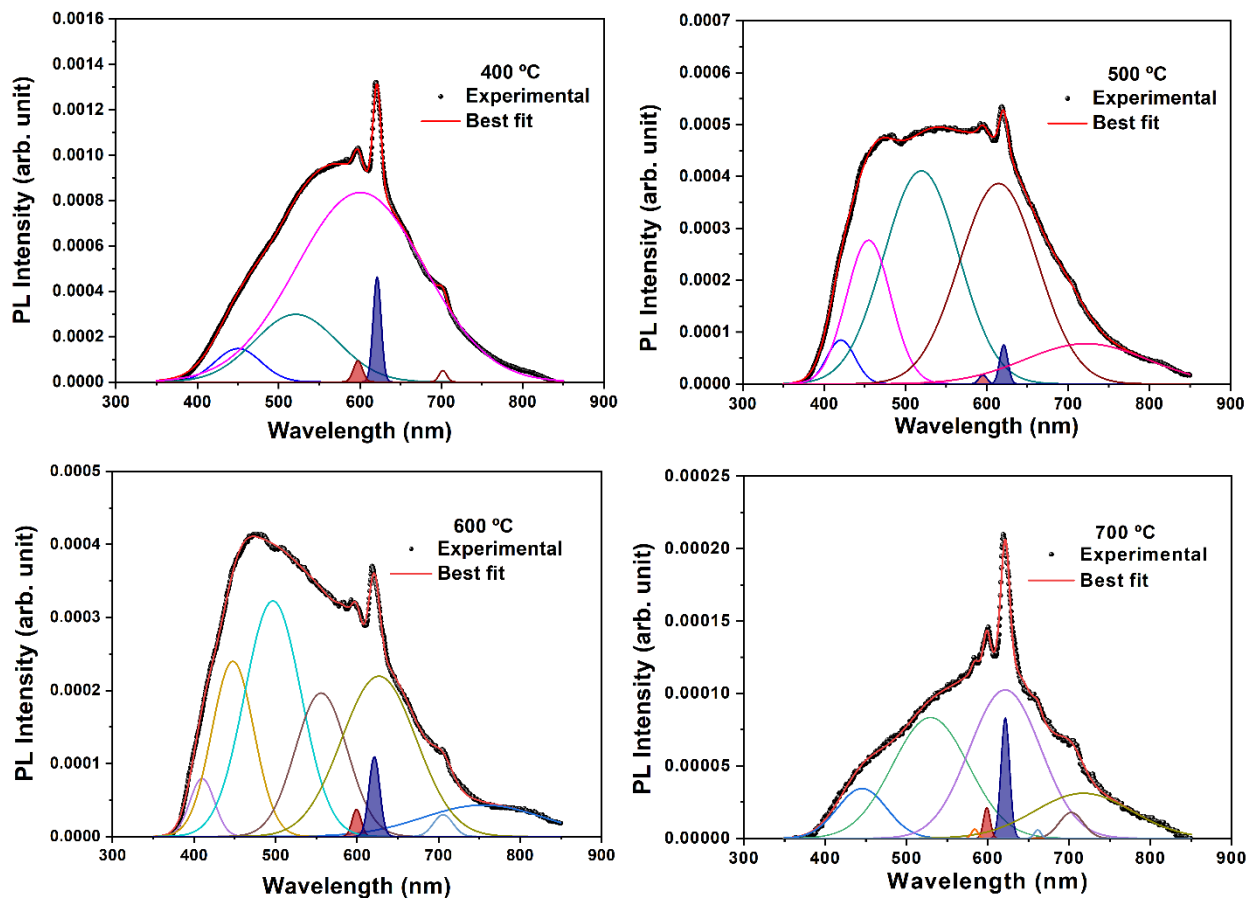
**Figure S1** – UV-Vis absorption spectrum (a) with the  $(\alpha h\nu)^2$  and  $(\alpha h\nu)^{1/2}$  vs. photon energy plots to derive direct (b) and indirect (c)  $E_g$  values, respectively.



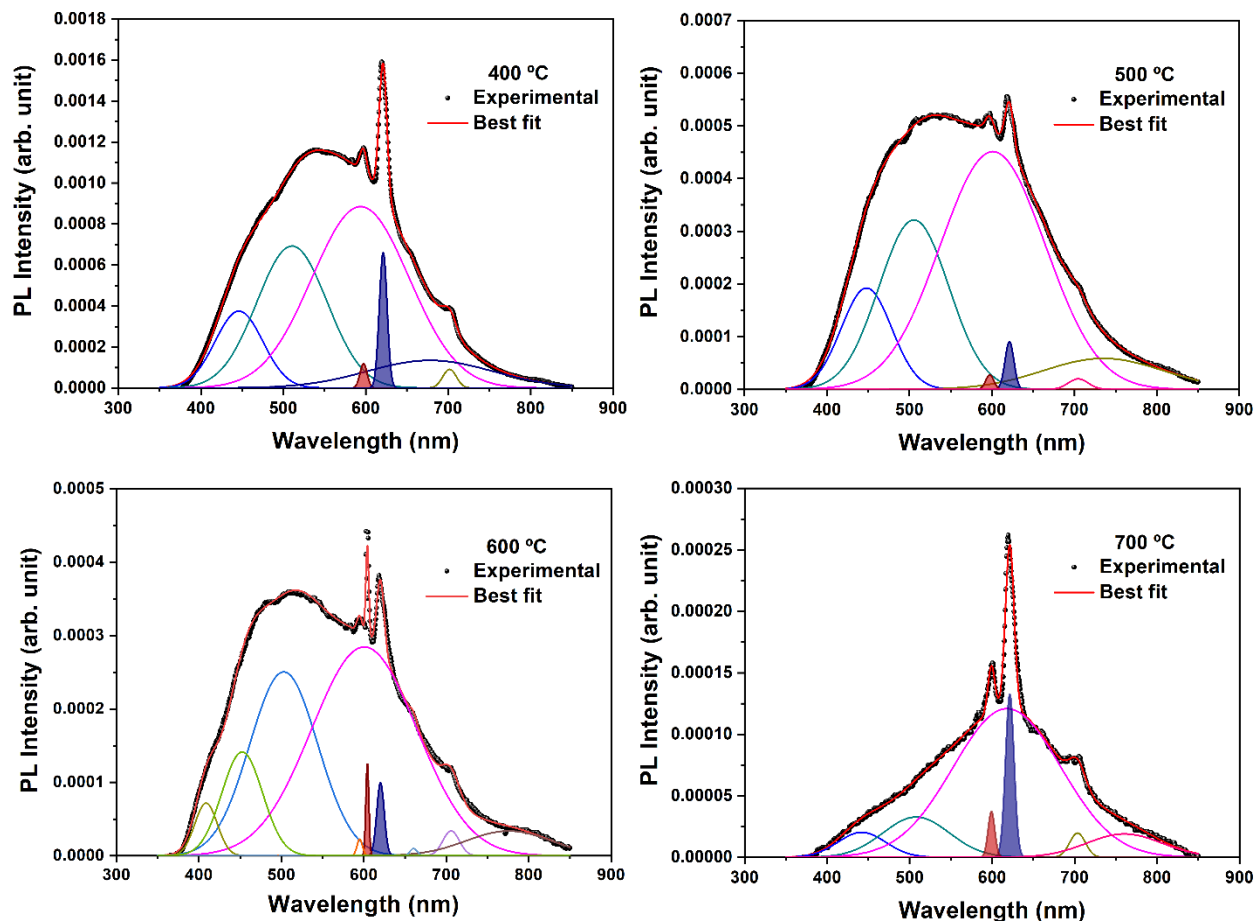
**Figure S2** – Deconvolution of the PL spectra of SrSnO<sub>3</sub> samples calcined at different temperatures.



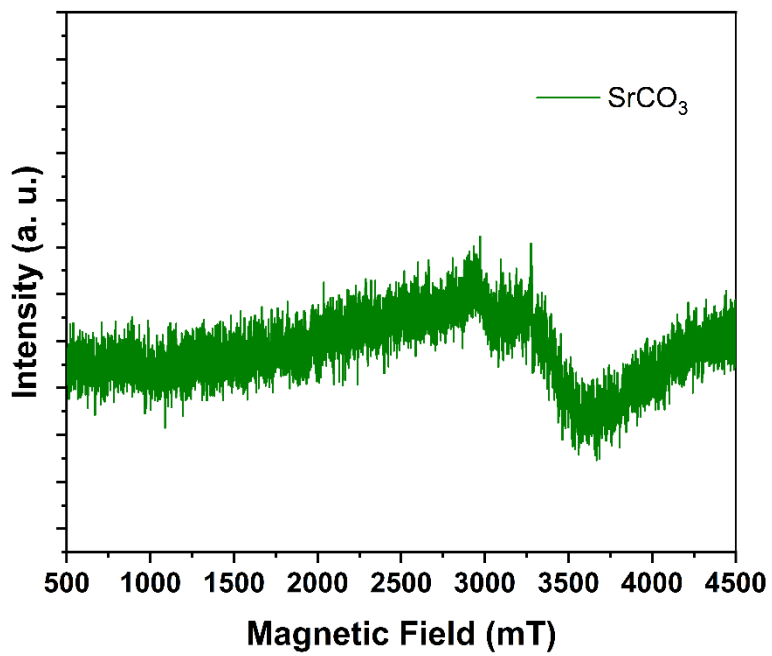
**Figure S3** – Deconvolution of the PL spectra of  $(\text{Sr}_{0.99}\text{Eu}_{0.01})\text{SnO}_3$  samples calcined at different temperatures.



**Figure S4** – Deconvolution of the PL spectra of  $\text{Sr}(\text{Sn}_{0.99}\text{Eu}_{0.01})\text{O}_3$  samples calcined at different temperatures.

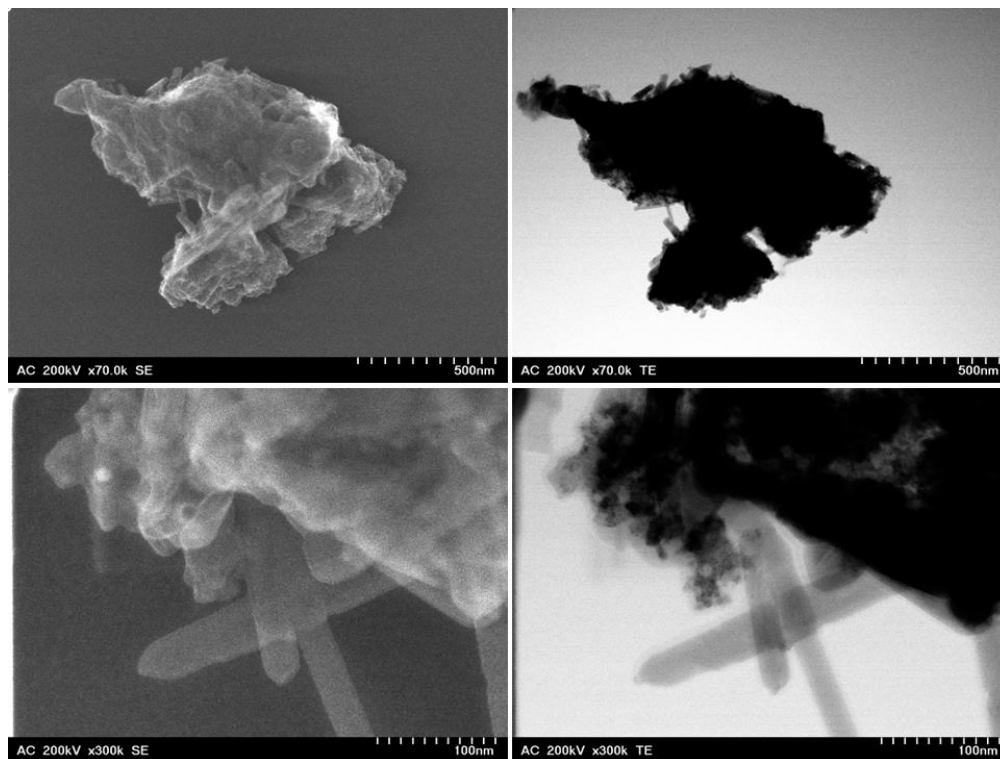


**Figure S5** – EPR spectra of the standard SrCO<sub>3</sub> sample.

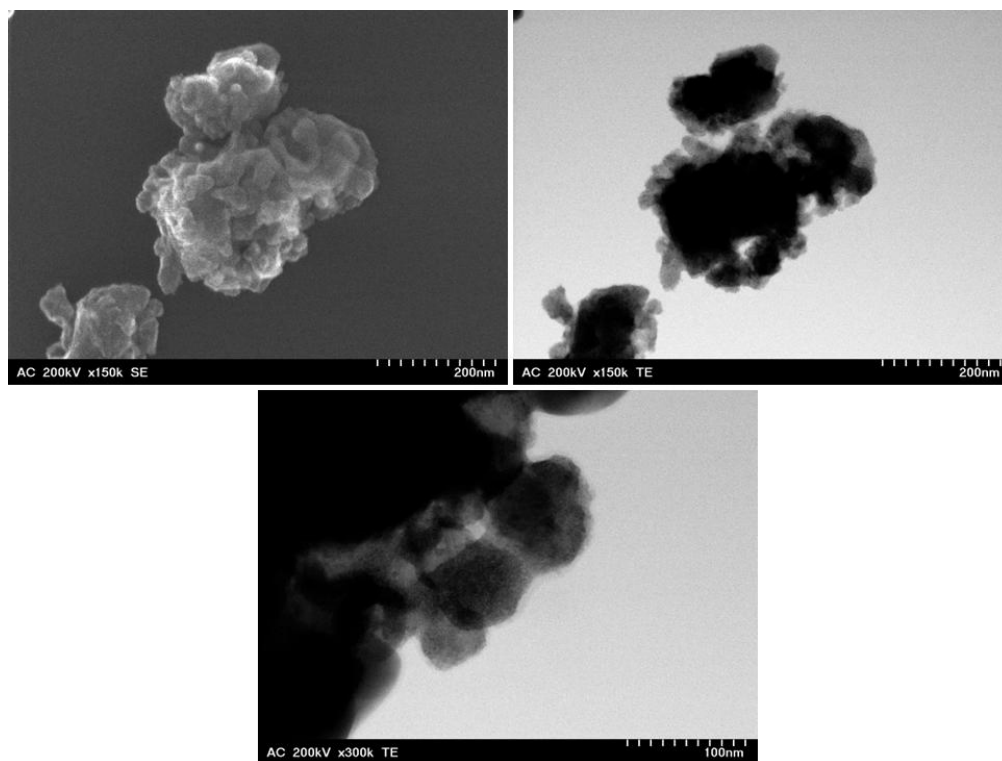




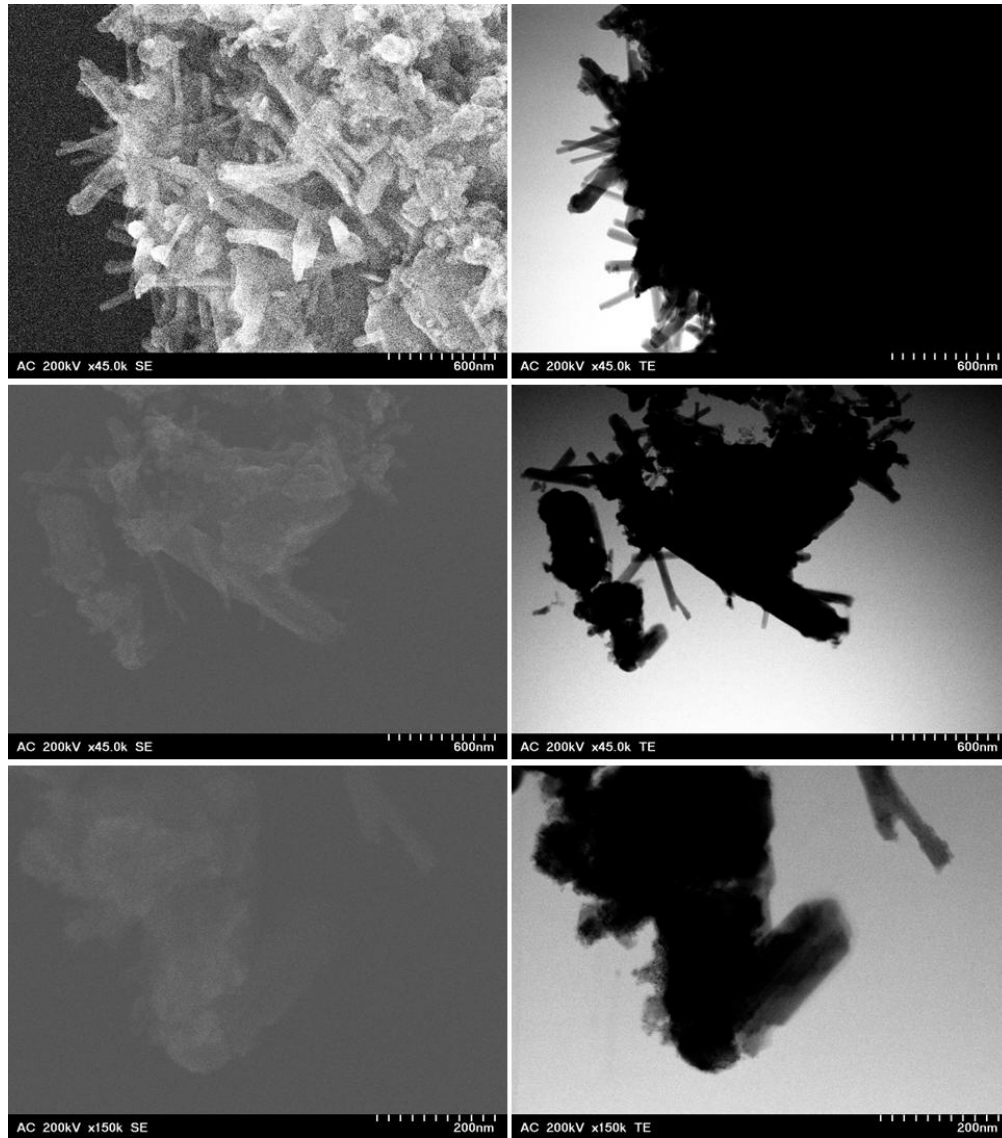
**Figure S6** – STEM images at various magnification of the SrSnO<sub>3</sub> calcined at 700 °C.



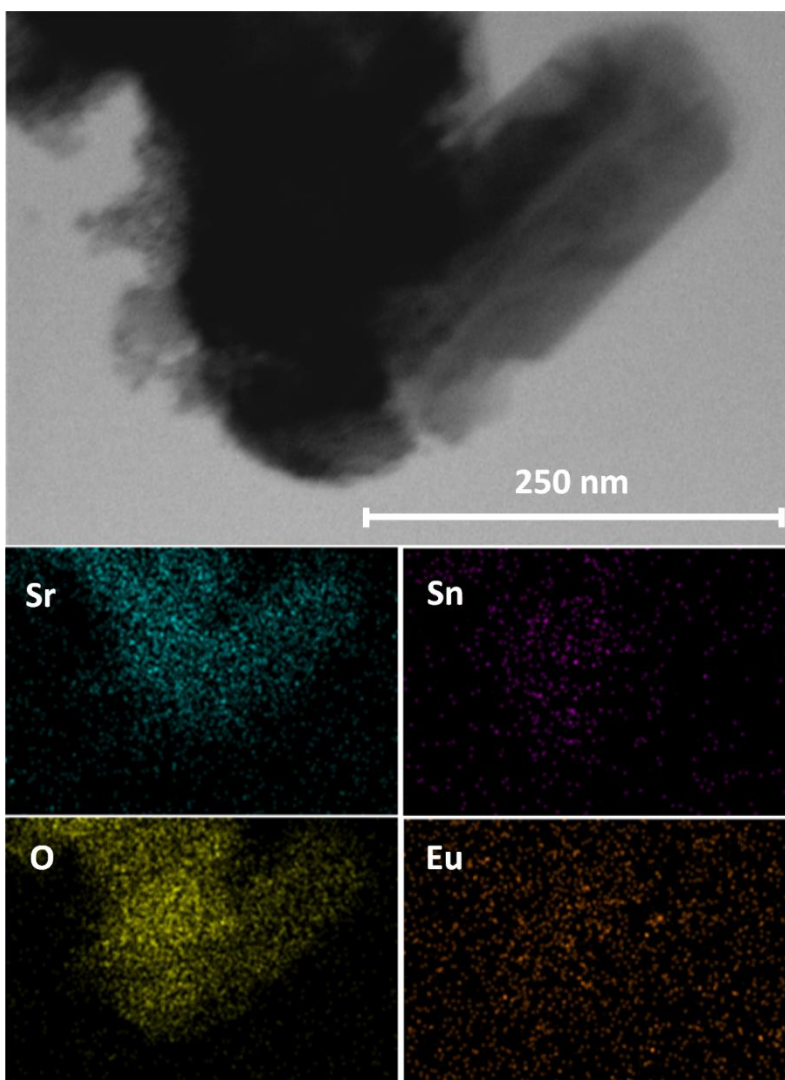
**Figure S7** – STEM images at various magnification of the  $(\text{Sr}_{0.99}\text{Eu}_{0.01})\text{SnO}_3$  calcined at 700 °C.



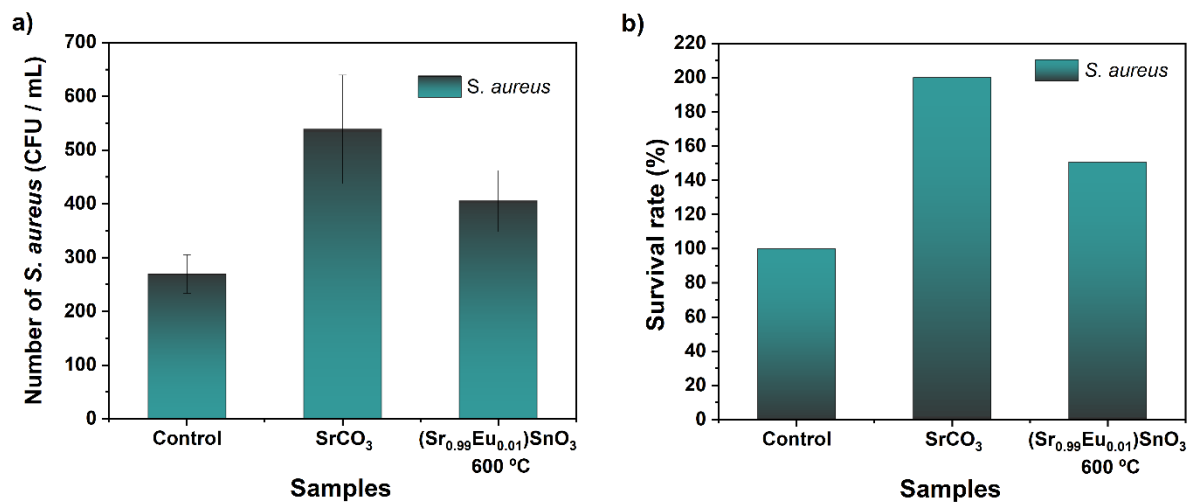
**Figure S8** – STEM images at various magnification of the  $\text{Sr}(\text{Sn}_{0.99}\text{Eu}_{0.01})\text{O}_3$  calcined at 700 °C.



**Figure S9** – STEM elemental mapping of the  $\text{Sr}(\text{Sn}_{0.99}\text{Eu}_{0.01})\text{O}_3$  sample calcined at 700 °C.



**Figure S10** – Colony counting to quantify bacteria and survival rate (%) of the *S. aureus* strain.



**Table S1.** Results obtained from the band emission components deconvoluted from PL spectra of SrSnO<sub>3</sub>, (Sr<sub>0.99</sub>Eu<sub>0.01</sub>)SnO<sub>3</sub> and Sr(Sn<sub>0.99</sub>Eu<sub>0.01</sub>)O<sub>3</sub> samples calcined at different temperatures.

SAMPLES	T (°C)	BC(%) <sup>a</sup>		GC(%) <sup>a</sup>		YC(%) <sup>a</sup>		OC(%) <sup>a</sup>		RC(%) <sup>a</sup>	
		Center (nm)	%	Center (nm)	%	Center (nm)	%	Center (nm)	%	Center (nm)	%
<b>SrSnO<sub>3</sub></b>	400	445	1.5	-	-	-	-	618.2	94.8	763.6	3.7
	500	446	3.9	-	-	-	-	591.7	93.5	663.6	2.6
	600	455.2	4.7	-	-	585	87.9	-	-	699.5	7.4
	700	472.5	8.9	-	-	584	71.3	-	-	673.3	19.8
<b>(Sr<sub>0.99</sub>Eu<sub>0.01</sub>)SnO<sub>3</sub></b>	400	450	4.7	521	17.2	-	-	597/601/621	78	702	0.28
	500	421/455	16.7	520	34.8	-	-	595/618/621	35.2	699/722	13.3
	600	410/448	18.6	497/556	44	-	-	587/599/621	2.98	627/706/755	34.4
	700	445	8.6	529/584	32.3	-	-	599/621.3/621.4	41.3	661/703/717	17.8
<b>Sr(Sn<sub>0.99</sub>Eu<sub>0.01</sub>)O<sub>3</sub></b>	400	446	10.1	511	27.5	-	-	594/597/621	52.1	678/702	10.3
	500	448	11.0	505	25.5	-	-	597/601/621	55	704/735	8.5
	600	409/453	12.5	503	28.8	-	-	595/601/604/620	52.8	660/706/776	5.9
	700	449	6.9	523	13	586	0.6	599/621/623	71	662/704/767	8.5

<sup>a</sup>Band emission components (color components): BC – blue; GC - green; YC - yellow; OC- orange; RC – red.

**Table S2.** Results obtained from the band emission components deconvoluted from PL spectra of SrSnO<sub>3</sub>, (Sr<sub>0.99</sub>Eu<sub>0.01</sub>)SnO<sub>3</sub> and Sr(Sn<sub>0.99</sub>Eu<sub>0.01</sub>)O<sub>3</sub> samples calcined at different temperatures.

<b>Sample</b>	<b>T (°C)</b>	<b>Shallow defects* (%)</b>	<b>Deep defects** (%)</b>
SrSnO <sub>3</sub>	400	1.5	98.5
	500	3.9	96.1
	600	4.7	95.3
	700	8.9	91.1
(Sr <sub>0.99</sub> Eu <sub>0.01</sub> )SnO <sub>3</sub>	400	21.9	78.1
	500	51.5	48.5
	600	62.6	37.4
	700	40.9	59.1
Sr(Sn <sub>0.99</sub> Eu <sub>0.01</sub> )O <sub>3</sub>	400	37.6	62.4
	500	36.5	63.5
	600	41.3	58.7
	700	20.5	79.5

\* Shallow defects are calculated as the sum of the BC and GC

\*\* Deep defects are calculated as the sum of the YC, OC, and RC