

Supporting Information

A Tb and Ag Co-doped Borate Compound Forms a High Sensitive X-ray, Gamma-ray and Neutron Luminescence Dosimeter

Leonardo V. S. França^{a,}, Elisabeth Müller^b, Eduardo G. Yukihara^c and Oswaldo Baffa^a*

^a Departamento de Física, FFCLRP, Universidade de São Paulo, Av. Bandeirantes, 3900, 14040-900, Ribeirão Preto, Brazil.

^b Electron Microscopy Facility, Paul Scherrer Institute, Forschungsstrasse 111, 5232, Villigen PSI, Switzerland

^c Department of Radiation Safety and Security, Paul Scherrer Institute, Forschungsstrasse 111, 5232, Villigen PSI, Switzerland.

* Email: leofranca@usp.br

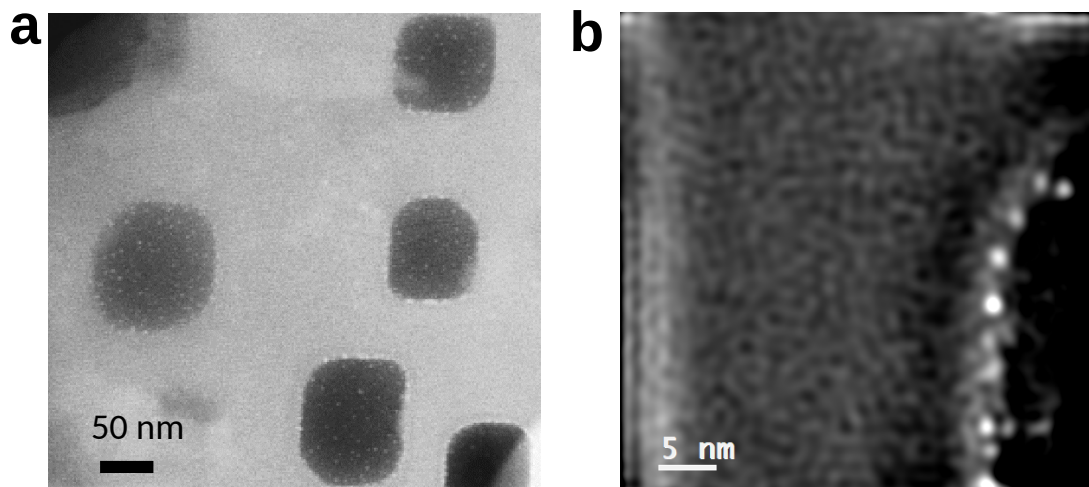


Figure S1: STEM images of a CBO:Tb³⁺,Ag⁺ crystal obtained through annular dark field (ADF) mode. Brighter contrast is due to larger thickness or heavier atomic species, i.e., the bright dots at the edges and within the areas of the (dark) voids can be interpreted as single atoms or clusters of the dopant atoms (Tb, Ag).

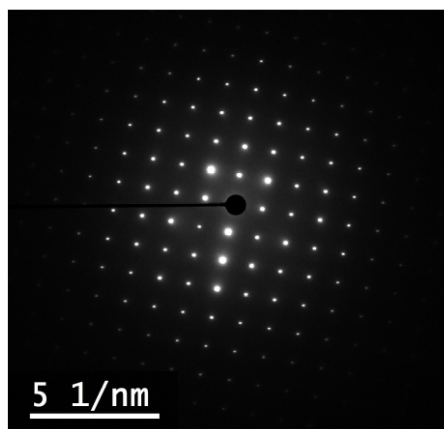


Figure S2: Electron diffraction pattern of an intermediately thin crystal area: here the (100) and the (010) directions cannot be easily distinguished due to multiple diffractions.

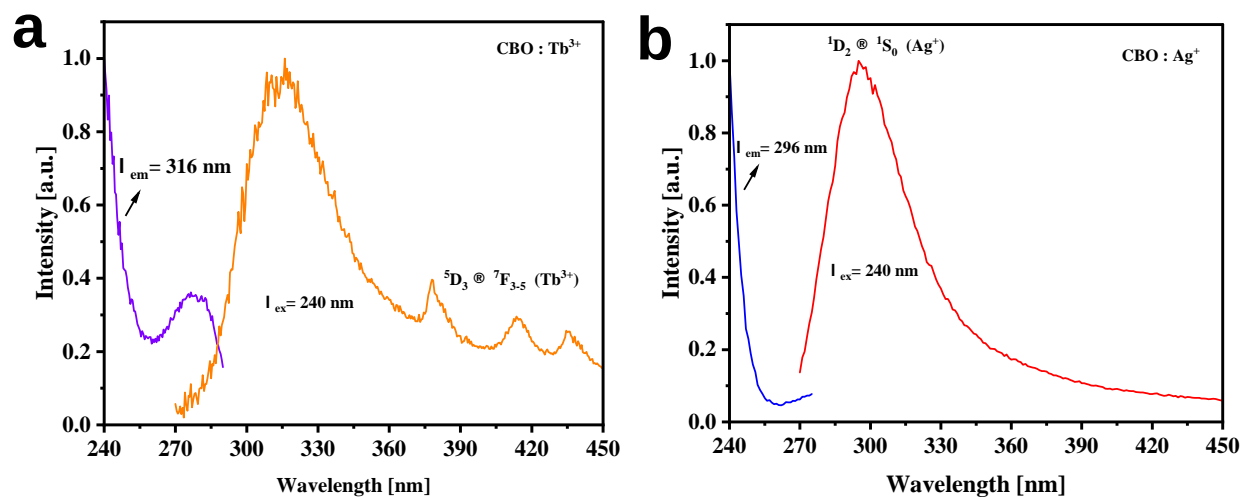


Figure S3: Steady-state PL and PLE spectra of singly-doped CBO: a) CBO:Tb³⁺ and b) CBO:Ag⁺.

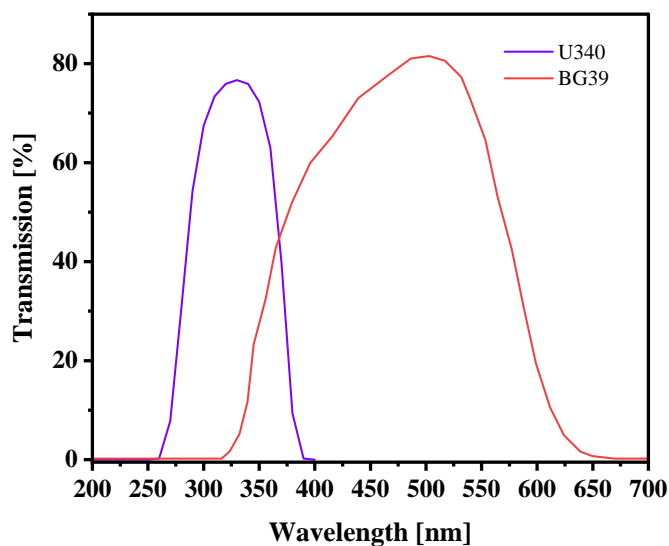


Figure S4: Comparison of the typical transmittance curves of the filters used for acquisition of the OSL and TL curves.

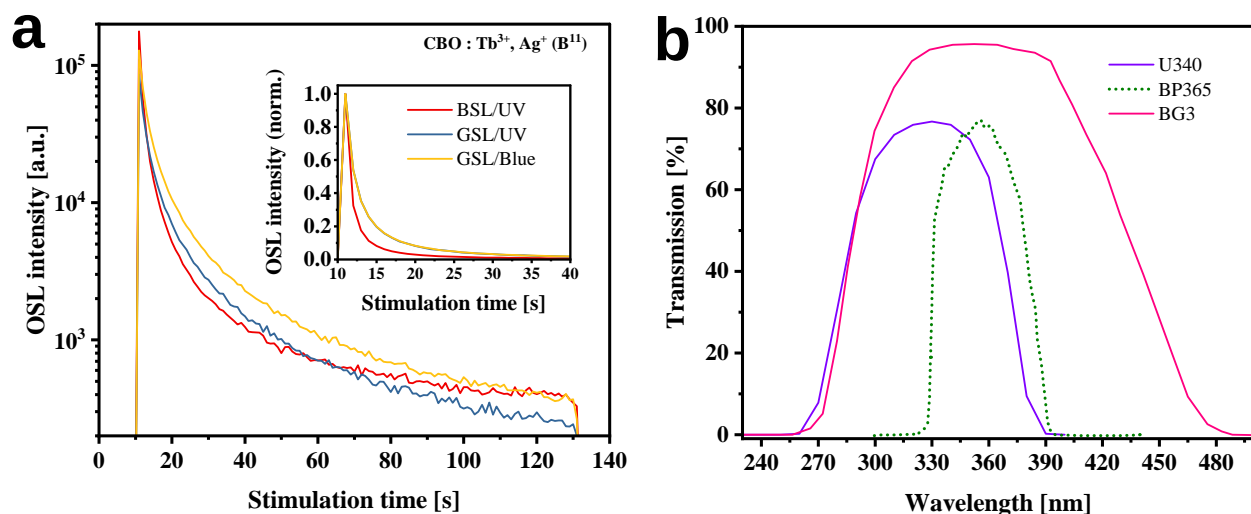


Figure S5: a) Comparison of OSL curves obtained using a Lexsyg reader using blue (458 nm) and green (525 nm) stimulations with detection at UV or UV-blue extended ($m = 2.0$ mg and dose = 50 mGy). b) Comparison of the filters used: UV = U340 + BP365 filters; UV-Blue extended = BG3 + BP365 filters.

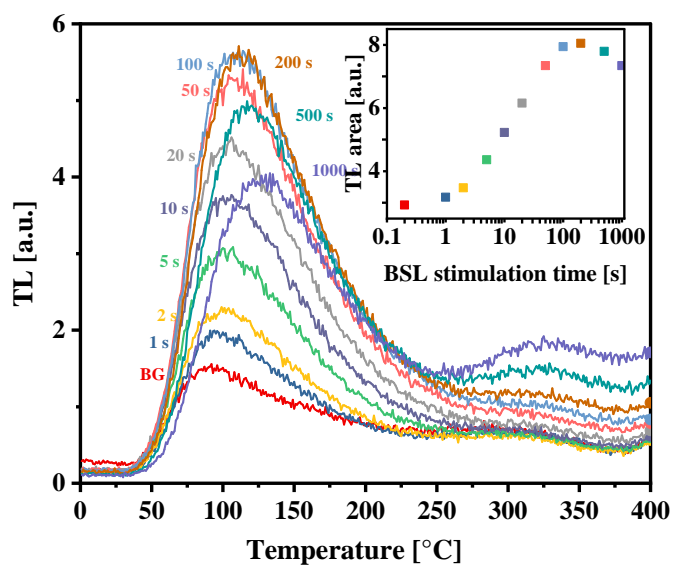


Figure S6: Effect of increasing blue stimulation times on TL performed right after annealing (TL heating rate = $5\text{ }^{\circ}\text{C s}^{-1}$). The curve assigned as “BG” refers to the background. Inset: TL area integrated from $50\text{ }^{\circ}\text{C}$ to $400\text{ }^{\circ}\text{C}$.

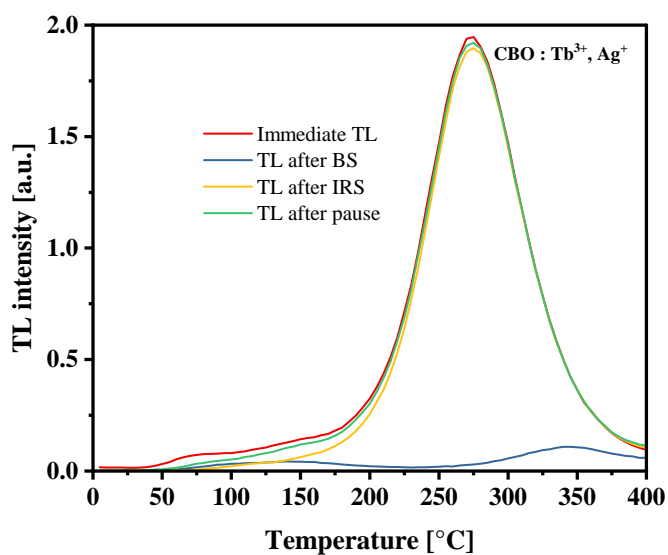


Figure S7: Comparison of TL curve right after irradiation (Immediate TL) with TL obtained after different conditions: after blue or IR stimulations (20 s without stimulation and 120 s of stimulation) and after pause (140 s). Dose = 185 mGy.

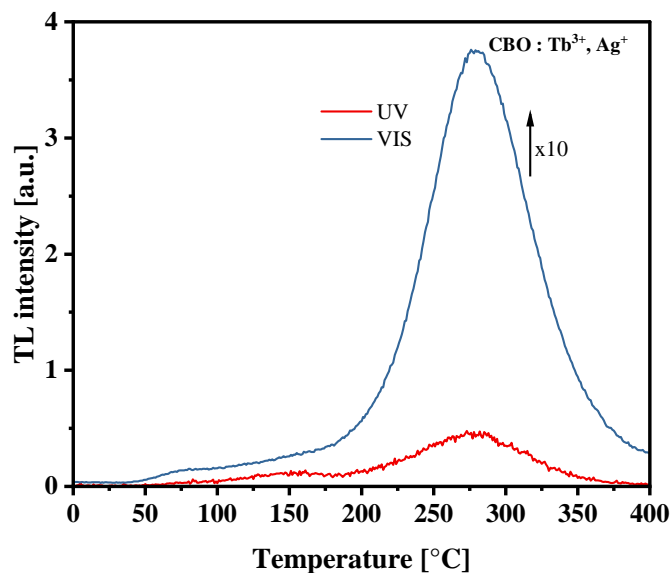


Figure S8: TL comparison recorded with UV and visible transmission filters. Dose = 185 mGy.

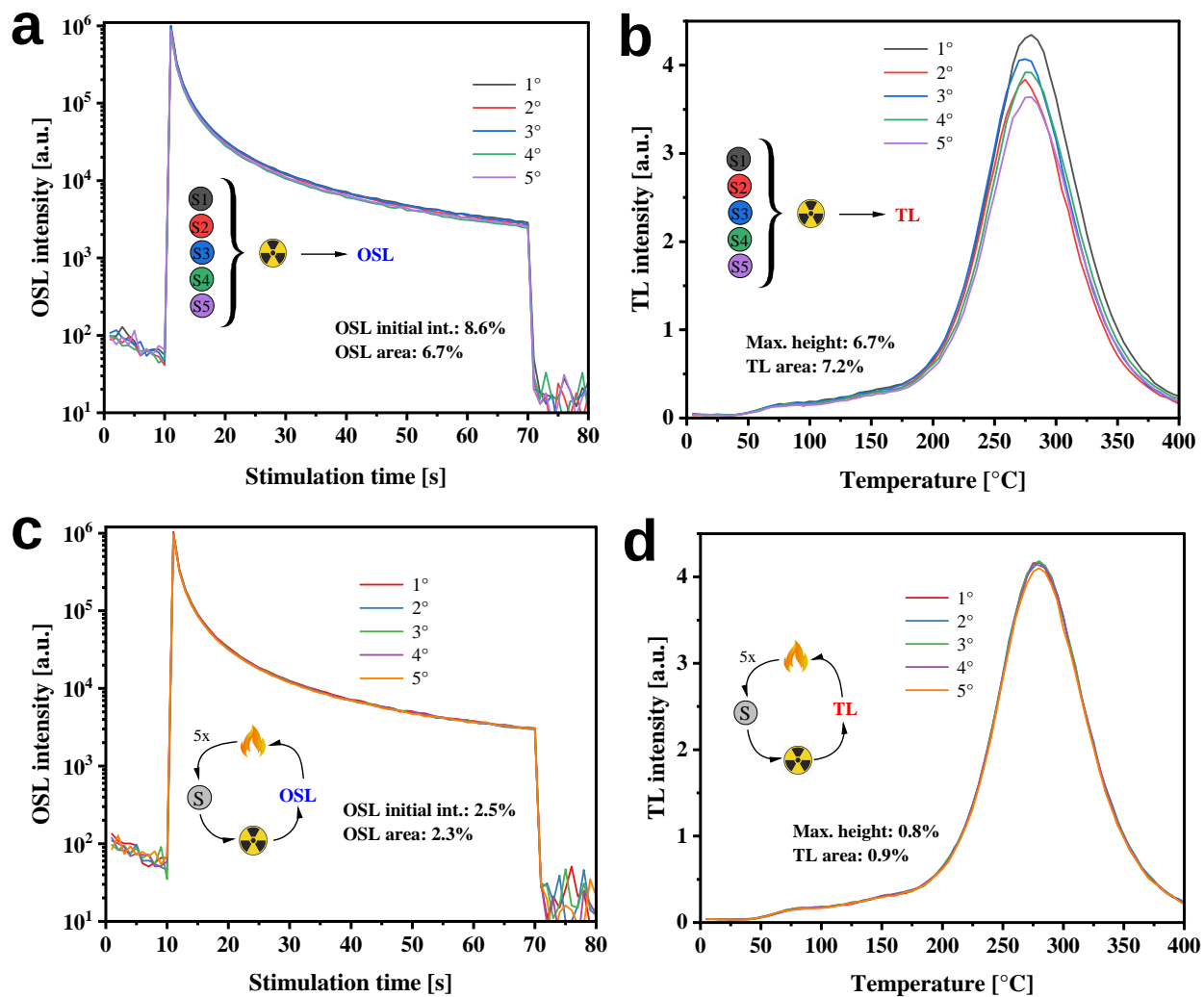


Figure S9: Reproducibility tests for five different aliquots for a) OSL and b) TL. Repeatability tests of the same aliquot (five times) for c) OSL and d) TL. OSL and TL areas were calculated during 60 s of stimulation and from 100 °C and 400 °C, respectively. In all graphs, the percentages represent the standard deviation for the five tests. Dose = 37 mGy.

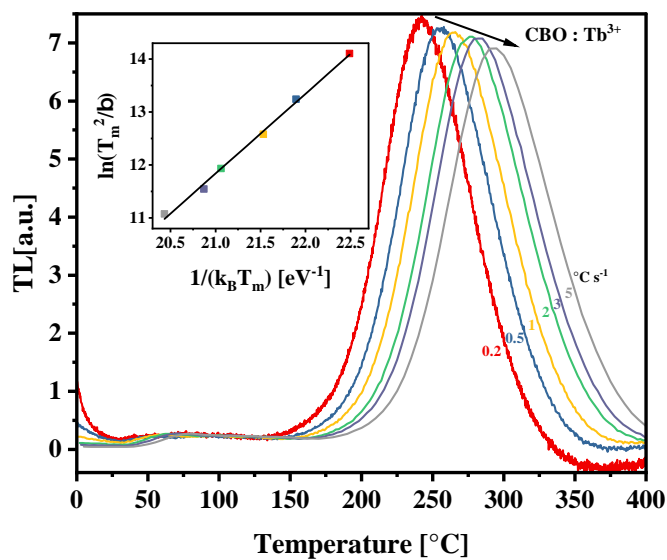


Figure S10: TL curves at increasing heating rates for the CBO:Tb³⁺ compound. The intensities were normalized by the corresponding heating rates. The inset shows the plot of $\ln(T_m^2/\beta)$ against $1/(k_B T)$ for determination of the trap depth corresponding to the main TL peak. The estimated values for the energy trap depth and frequency factor were: $E = 1.51(5)$ eV and $s = 7.0 \times 10^{12} \text{s}^{-1}$. Dose = 185 mGy.

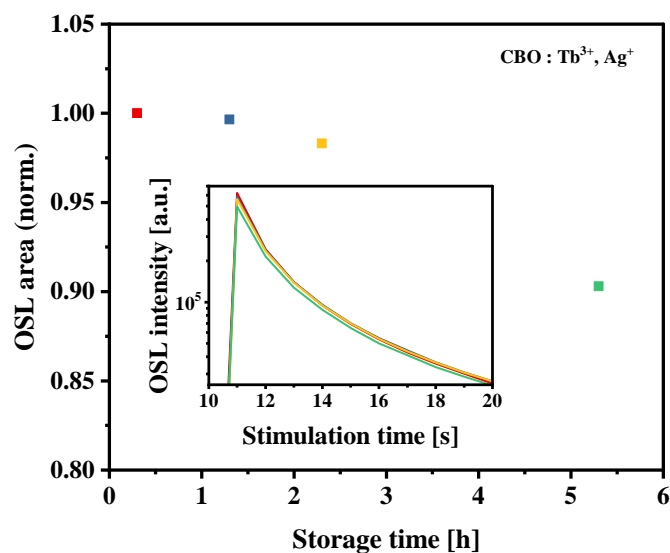


Figure S11: Short OSL fading within the first 5.5 h after irradiation. OSL area was calculated using 120 s of stimulation. The inset shows the OSL curves for the first 10 s of stimulation. Dose = 37 mGy.

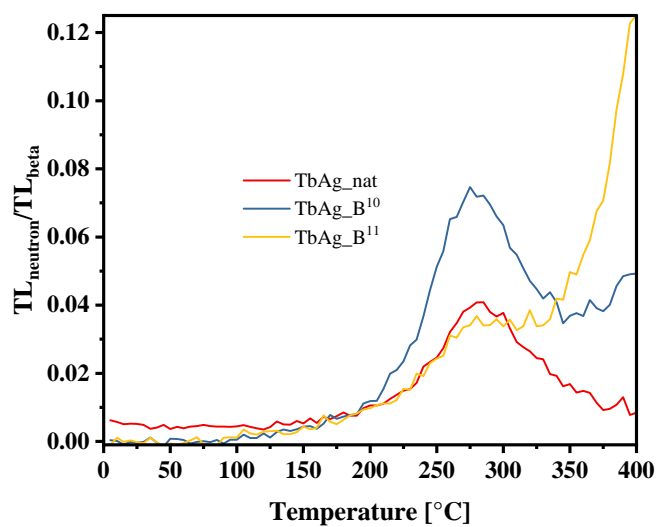


Figure S12: TL neutron response normalized by a reference beta dose (37 mGy) for different isotopic boron compositions of CBO:Tb³⁺,Ag⁺. The same neutron irradiation conditions for the OSL neutron tests apply.