

Supporting information on

Mechanistic insights into the optical limiting performance of carbonaceous nanomaterials embedded with core-shell type graphite encapsulated Co nanoparticles

Rajeev Kumar^a, Ajay Kumar^b, Nancy Verma^b, Reji Philip^b and Balaram Sahoo^{a,†}

^aMaterials Research Centre, Indian Institute of Science, Bangalore, India -560012

^bRaman Research Institute, Bangalore, India-560080

Details of the instruments used in characterization

The synthesized samples were characterized by Electron microscopy (SEM, TEM), powder X-ray diffraction (XRD), UV-DRS spectroscopy and Raman spectroscopy. SEM images were recorded in Ultra 55 Scanning electron microscope. JEOL-350 kV TEM was used to obtain the transmission electron micrographs of the samples drop-cast onto carbon-coated Cu grids (300 mesh size). XRD patterns were obtained by PANalytical X-Ray diffractometer in the 2θ range of $5-90^\circ$. UV-DRS spectra were recorded using powder samples in Lamda 750-Perkin-Elmer UV-Vis-NIR spectrometer. Raman spectra were recorded using 532 nm laser on LabRam HR instrument.

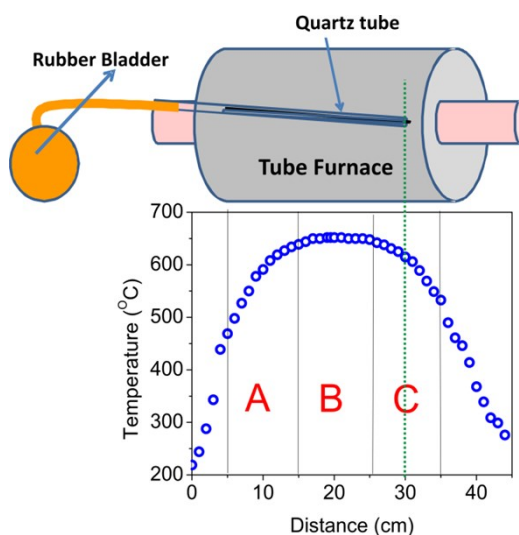


Figure S1. Schematic of the synthesis setup.

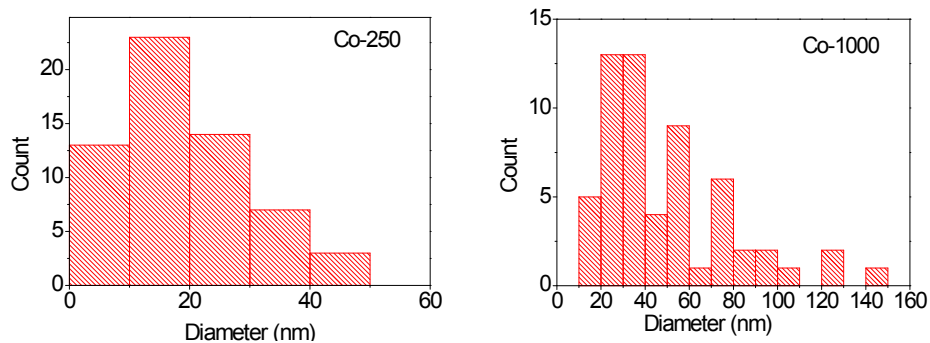


Figure S2. Particle size distribution of the core-nanoparticles in Co-250 and Co-1000 samples, calculated from TEM images.

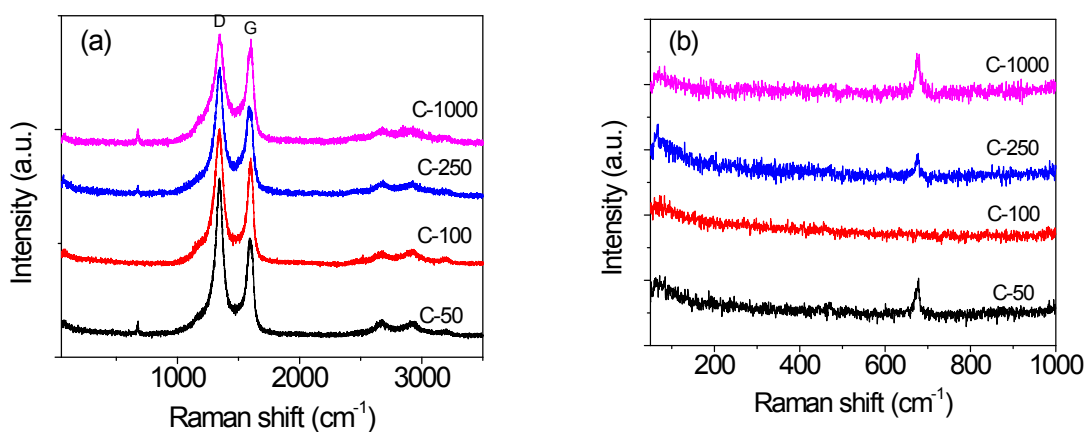


Figure S3. (a) Raman spectra for the synthesized samples. (b) Zoomed-in view of the Raman spectra showing CoO peak.

Table S1. I_G/I_D ratios and graphitic crystallite size (L_a) obtained from Raman spectral peak-fits.

Sample	I_G/I_D	I_G/I_{D2}	I_G/I_{D3}	L_a (nm)
Co-50	0.241	3.06	1.04	4.63
Co-100	0.277	3.03	1.54	5.32
Co-250	0.294	2.70	1.28	5.65
Co-1000	0.331	2.71	3.46	6.36

L_a was calculated using the equation ¹:

$$L_a = (2.4 \times 10^{-10})(\lambda^4)(I_D/I_G)^{-1}$$

Ref:

(1) Cañado, L. G.; Takai, K.; Enoki, T.; Endo, M.; Kim, Y. A.; Mizusaki, H.; Jorio, A.; Coelho, L. N.; Magalhães-Paniago, R.; Pimenta, M. A. *Appl. Phys. Lett.* **2006**, 88 (16), 2–5.

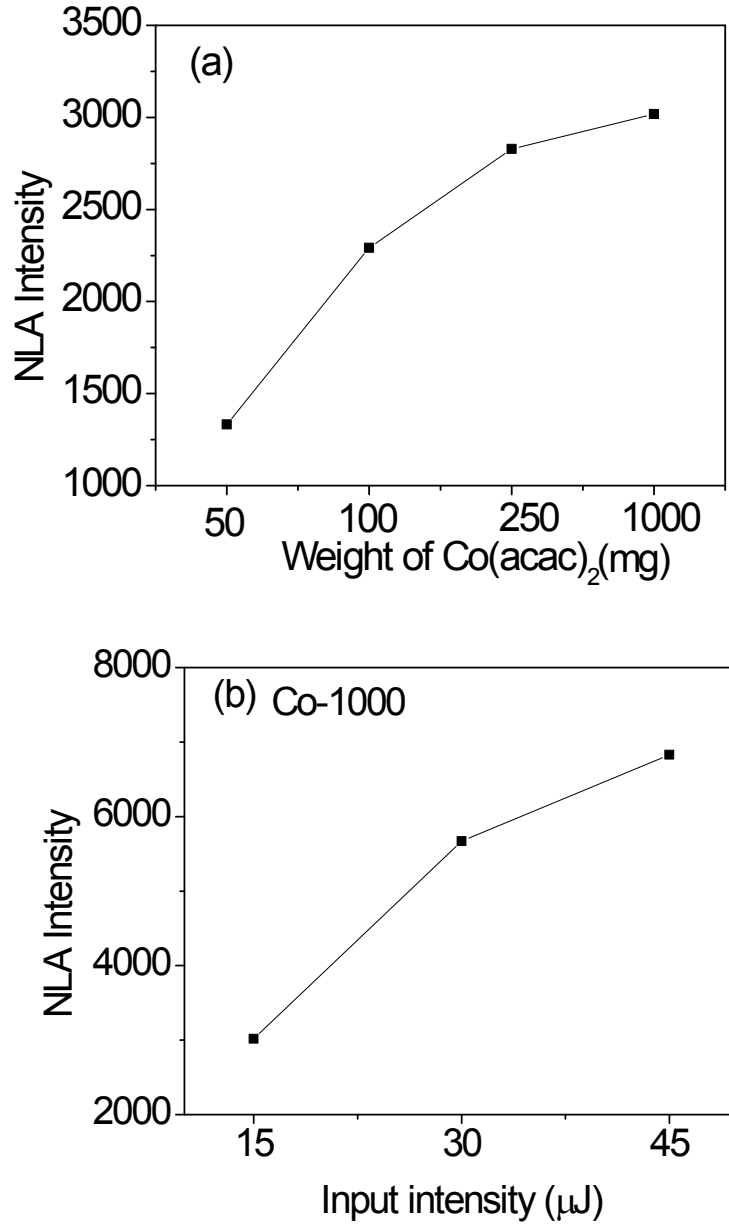


Figure S4. Variation of the strength of absorptive nonlinearity with (a) weight of Co(acac)₂ precursor, and (b) input intensity (for the Co-1000 sample).

Calculation of Urbach energy (E_u) using Kubelka-Munk plots

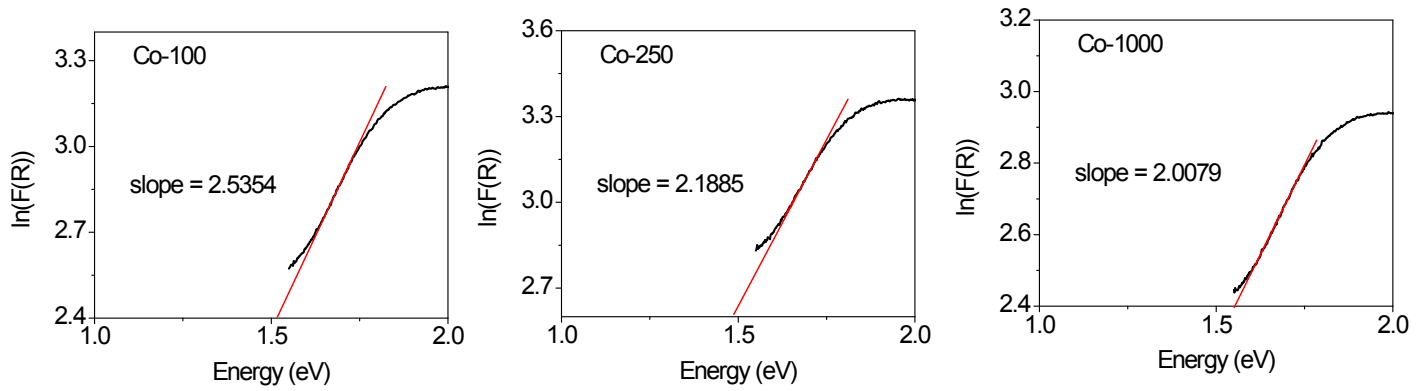


Fig S5. $\ln(F(R))$ versus energy plots for the calculation of Urbach energy.

For Co-100 sample: $E_u = 1/(2.5354) = 394$ meV

For Co-250 sample: $E_u = 1/(2.1885) = 457$ meV

For Co-1000 sample: $E_u = 1/(2.0079) = 498$ meV

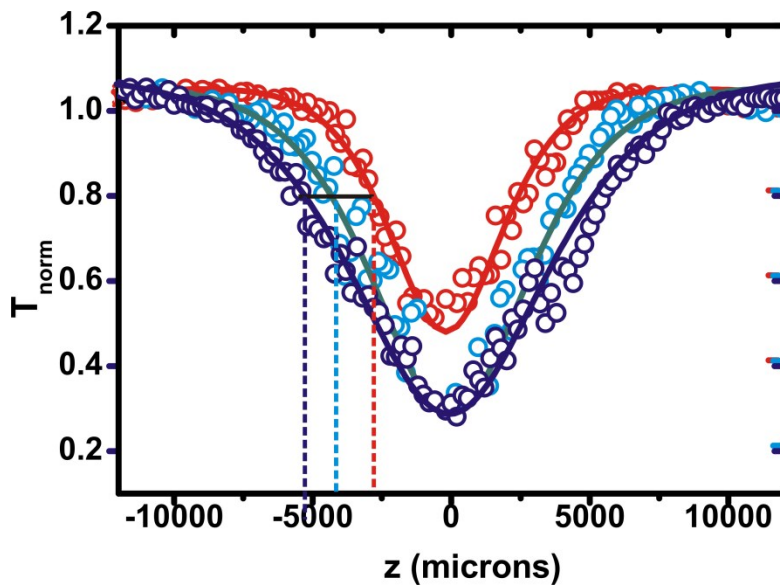


Fig S6. Overlapped Z-scan spectra for Co-1000 sample at different laser intensities. The Z-scan curves corresponding to 15, 30 and 45 μJ are shown in red, blue and purple respectively.