Supporting information

Role of Zinc Oxide in the Compounding Formulation on the Growth of Non-stoichiometric Copper Sulfide Nanostructures at Brass-Rubber Interface

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Table of contents

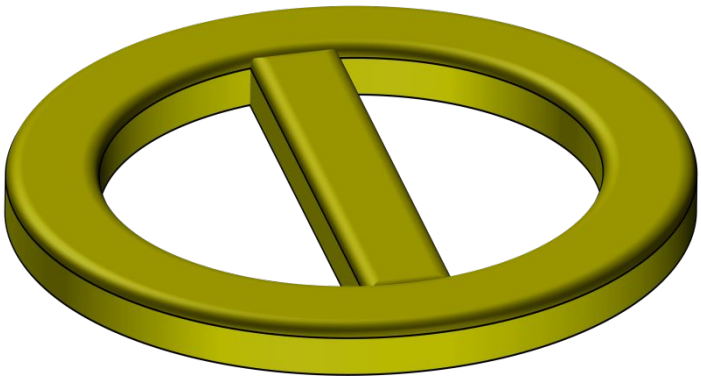


Figure S1. Schematic image of a laser cut mesh from brass foil that was used for interfacial thickness measurement.

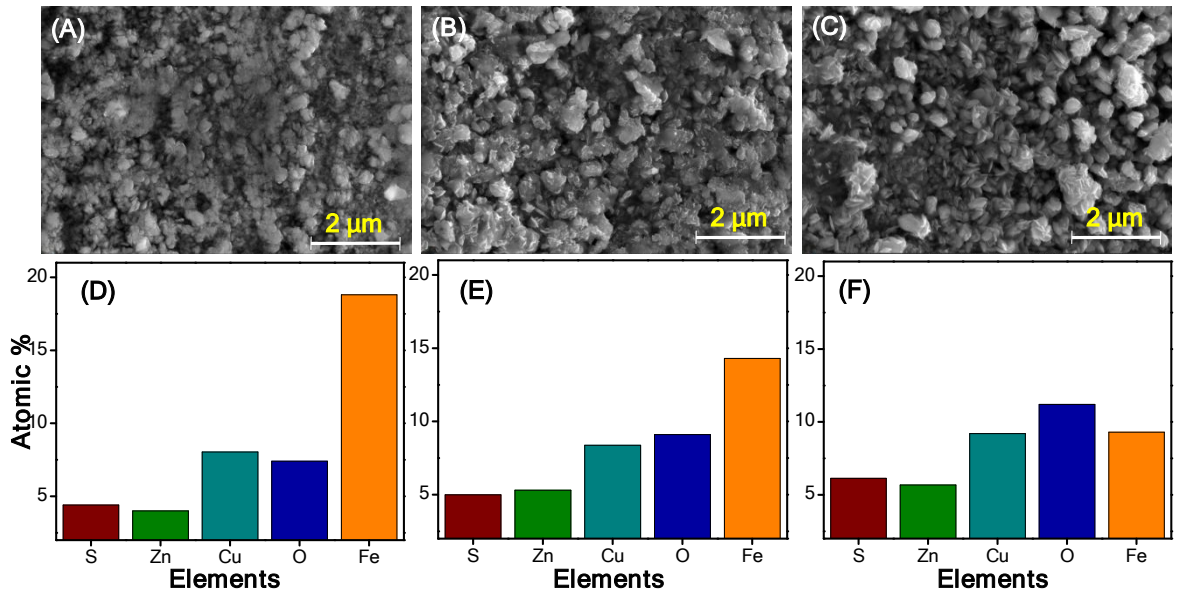


Figure S2. Large area SEM images at (A) 6, (B) 9, (C) 12 PHR ZnO and their corresponding EDX spectra at (D) 6, (E) 9, (F) 12 PHR ZnO.

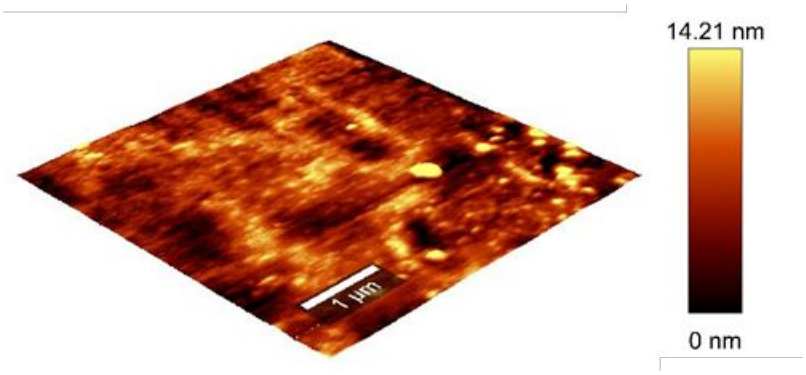


Figure S3. AFM of bare BCSC showing the surface roughness.

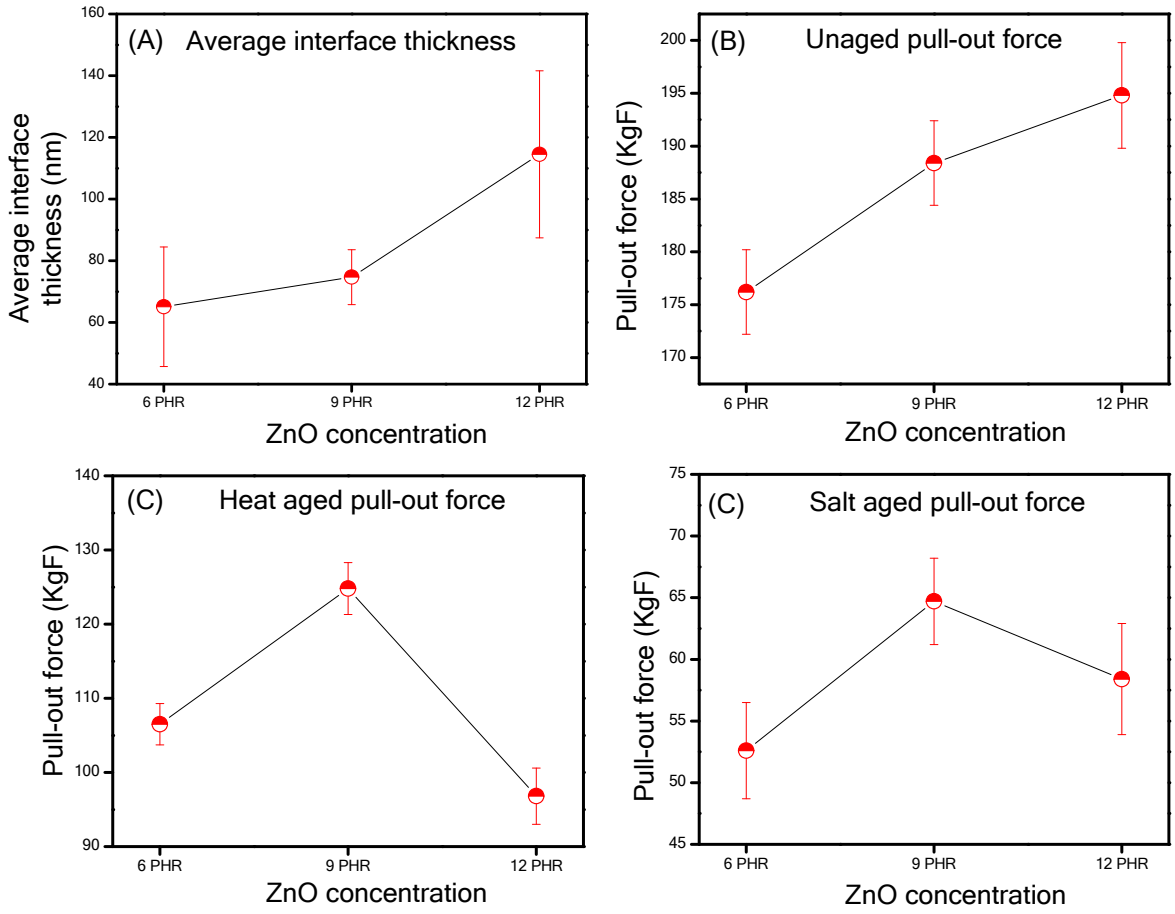


Figure S4. Graphical representation (A) showing the brass-rubber interface thickness with different ZnO concentrations, (B) un-aged, (C) salt-aged and (D) heat-aged pull-out force as a function of ZnO concentrations.

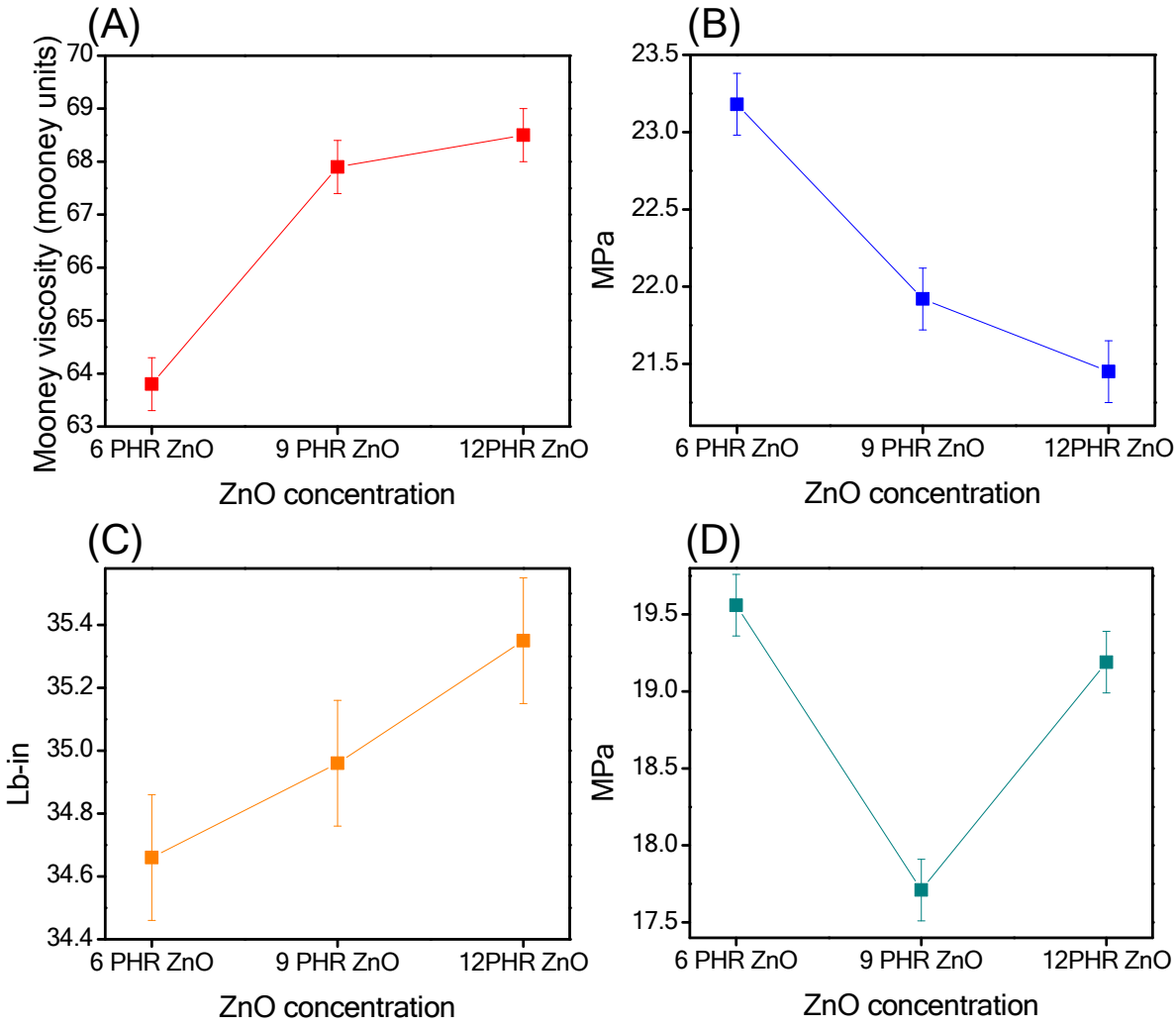


Figure S5. Physical properties of rubber compound with increasing ZnO concentration: (A) Mooney viscosity, (B) tensile strength, (C) moment highest (MH) and (D) 300 % modulus.

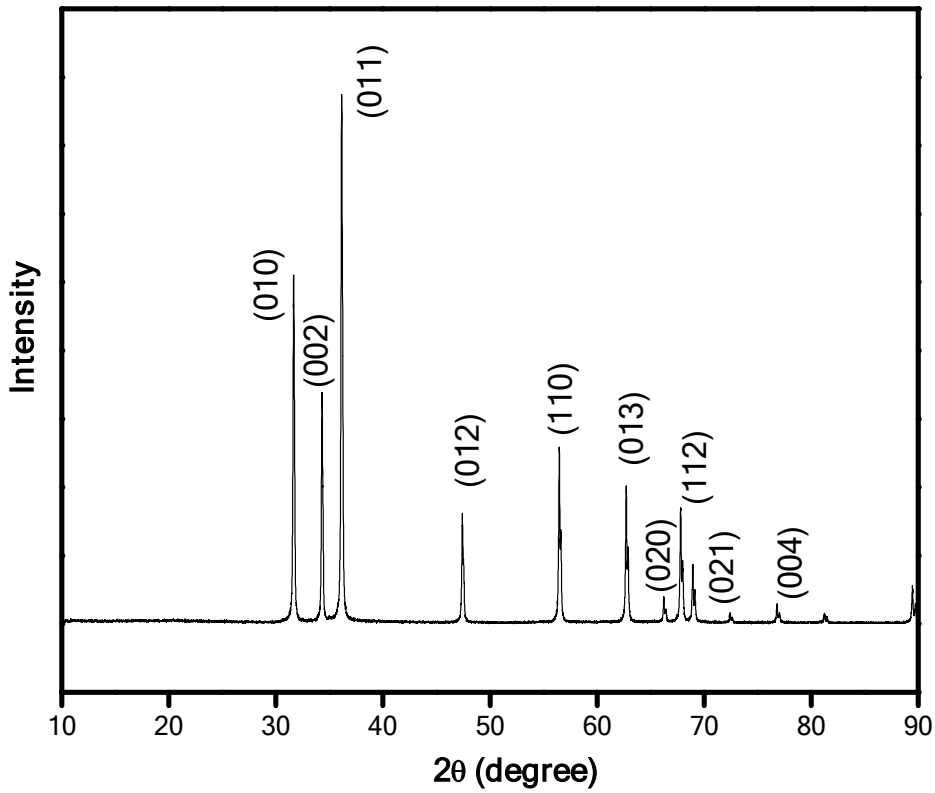


Figure S6. XRD pattern of the ZnO added to the rubber compound.

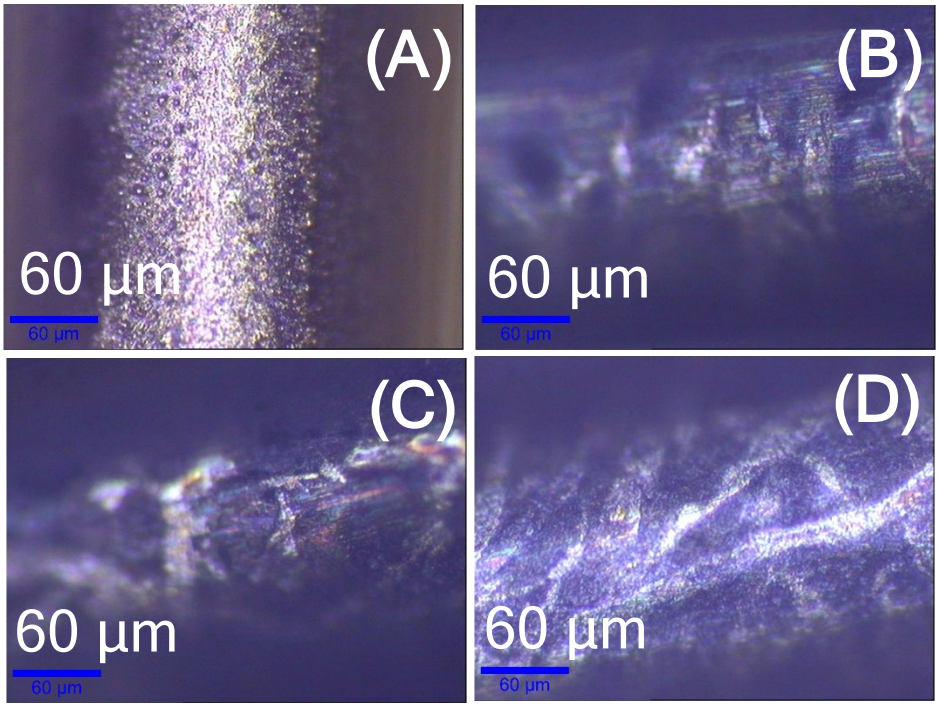
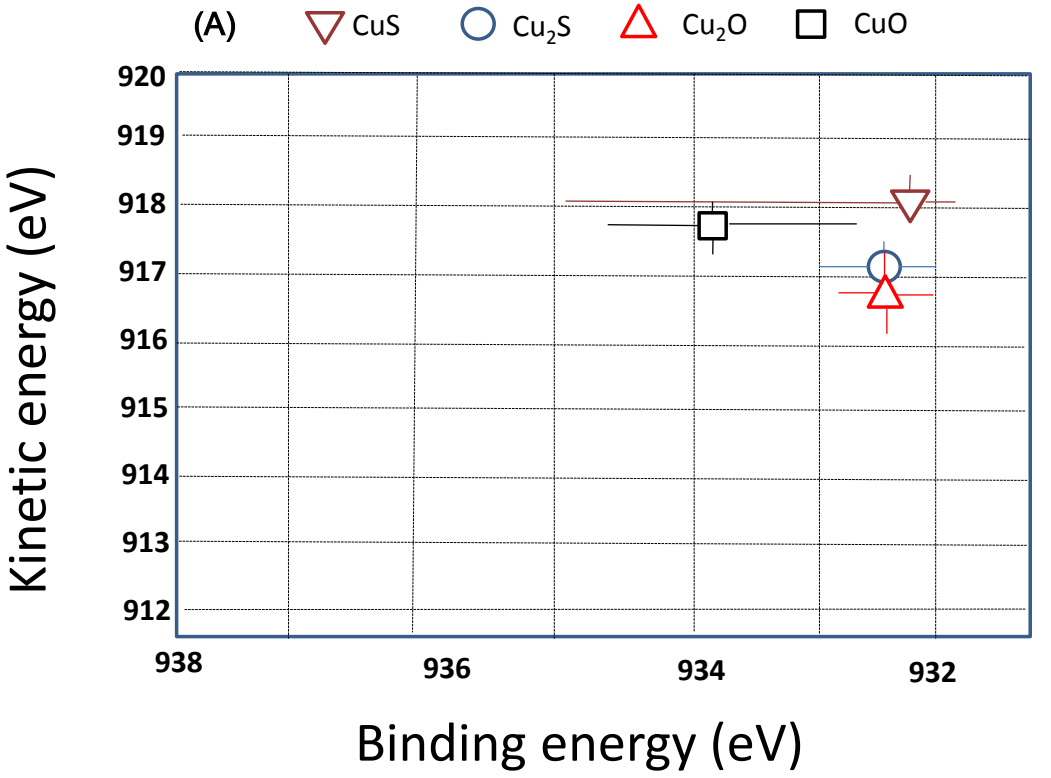


Figure S7. LED white light image of (A) unreacted (B), (C) and (D) vulcanized BCSC with 6, 9 and 12 PHR ZnO.


(A)
CuS
Cu2S
Cu2O
CuO
920
919
918
917
916
915
914
913
912
938
936
934
932
Kinetic energy (eV)
Binding energy (eV)

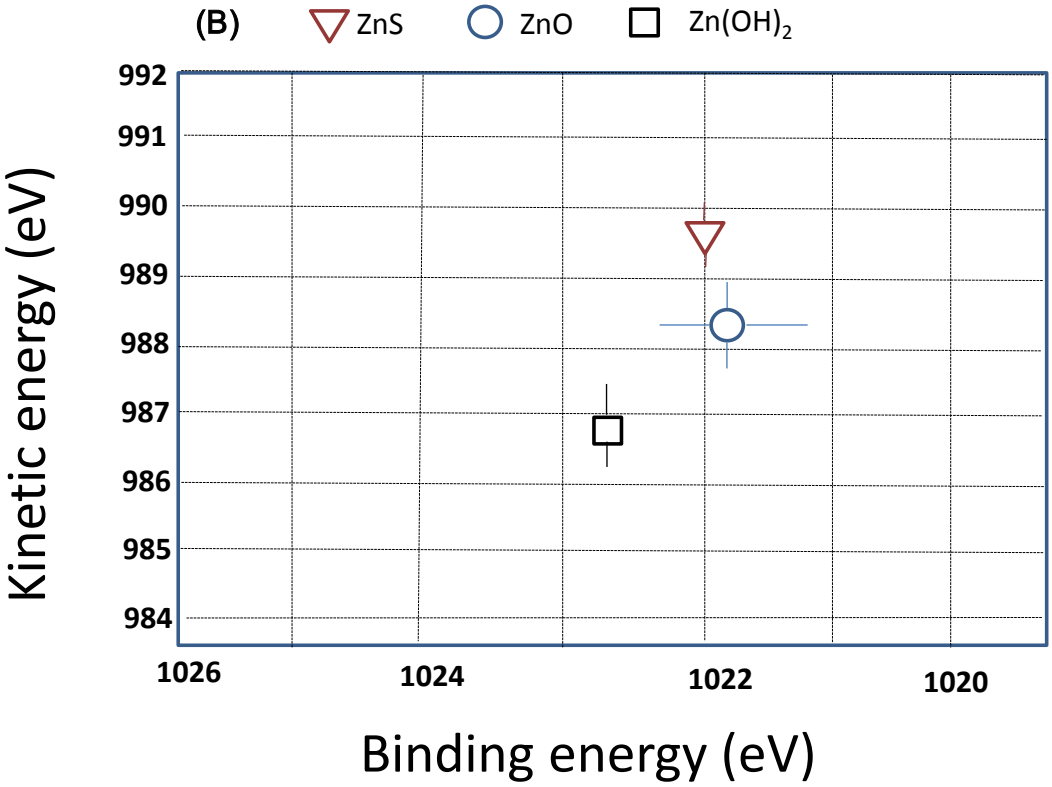

(B)
ZnS
ZnO
Zn(OH)2
992
991
990
989
988
987
986
985
984
1026
1024
1022
1020
Kinetic energy (eV)
Binding energy (eV)

Figure S8. Wagner plots of (A) $Cu2p_{3/2}$ and (B) $Zn2p_{3/2}$ regions for compound identification at brass-rubber interface. Adapted from references 35 and 36 in the main text.

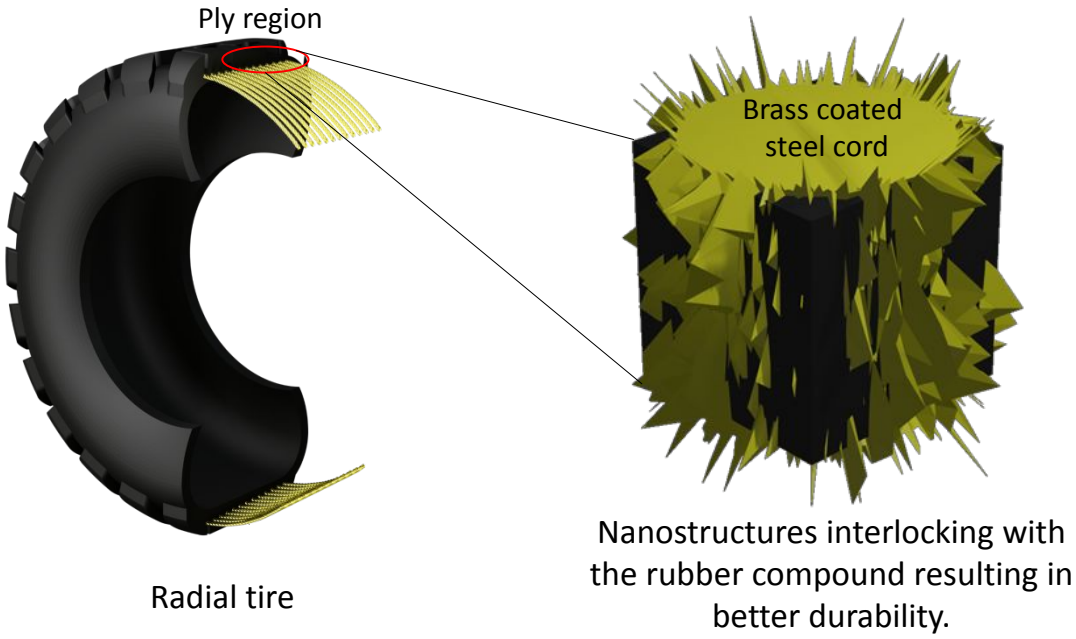


Figure S9. Schematic showing ply region of a radial tire and an enlarged image of the ply region showing the nanostructures interlocking with the rubber compound.

Table S1. Total crosslink density of rubber compound at different ZnO concentration.

ZnO concentration (PHR)	Total crosslink density (mol/cc)
6	2.61 E-5
9	3.09 E-5

12	3.44 E-5

Table S2. Relative atomic % obtained from XPS.

Element	6PHR ZnO	9PHR ZnO	12PHR ZnO
Cu	1.43	1.46	1.77
Zn	1.92	2.15	2.93
S	1.64	1.68	1.87
O	9.27	12.25	13.33