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Supporting Information

Copper Submicrospheres Induced by Pulsed Laser-irradiation with Enhanced Tribology Properties

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1, Experimental details extended

Five different lubricating oils were adopted to fully evaluate the dispersion stability of such Cu submicrospheres, e.g. two kinds base lubricants (pure PAL, PAO4) and three types of automotive engine oils (SAE 5W/30, SN/GF-5, SE 15w-40). The pure PAL is a kind of mineral oil. The PAO is Polyalpha-alkene synthetic oils, the most commonly used synthetic base oil. The number represents the viscosity type, and “4” is a low viscosity. In SAE 5W/30, “SAE” is an abbreviation for Society of Automotive Engineers. “5w/30” is the label of lubricating oil, which is the universal expression of lubricating oil viscosity in the world. In SN/GF-5, “S” stands for lubricating oil for gasoline engines. “N” for grade. Currently, the highest level is N. “GF-5” is the test specification for engine oil. In SE 15w-40, “SE” has the same meaning as “SN” in SN/ gf-5. “15w-40” is a viscosity expression similar to “5W/30” in SAE 5W/30.

2, Experimental results extended

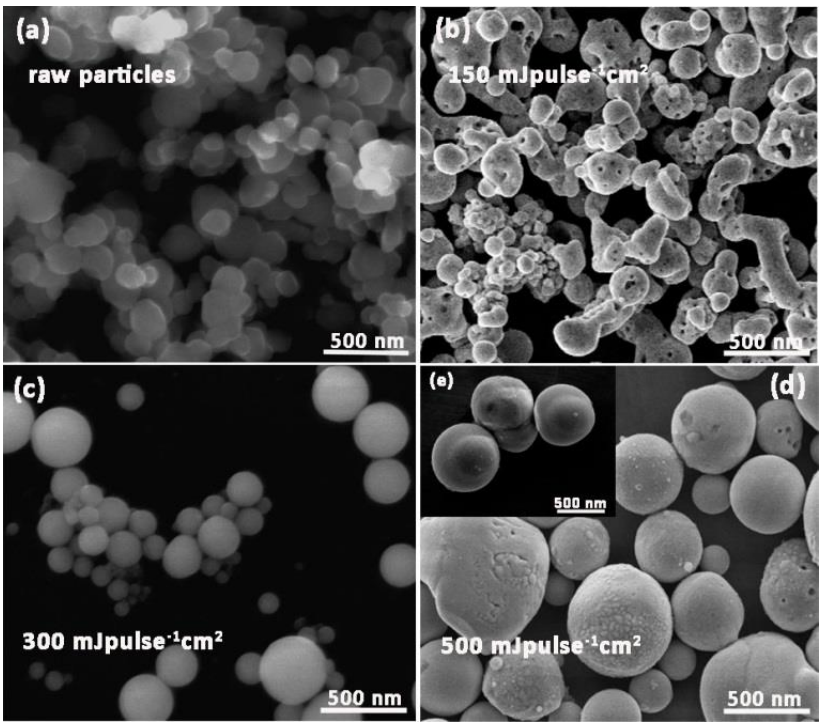

Fig. S1 SEM images of Cu particles irradiated with laser under different energy densities for 5min (a) raw particles, (b) 150 mJ pulse^{-1} cm^{-2}, (c) 300 mJ pulse^{-1} cm^{-2}, and (d,e) 500 mJ pulse^{-1} cm^{-2}.

As show in (a), the raw particles are irregular. When the irradiation energy are insufficient, the raw particles melted incompletely, So there is no perfect sphere in the process of reforming (b). The ablated area of the raw particles increased under higher energy, which resulted to the enlargement of spherical particles and granules coalesce (d,e). Therefore the optimized laser energy is 300 mJ pulse^{-1} cm^{-2} (c).

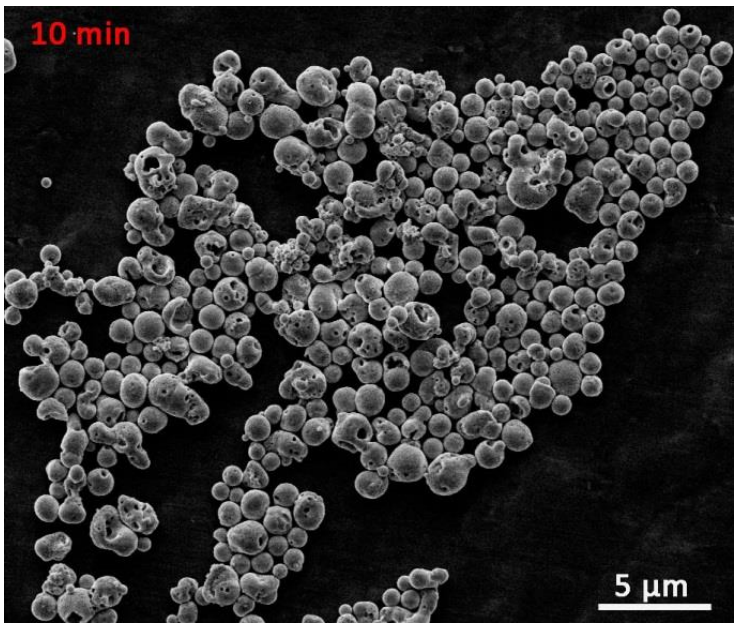

Fig. S2 SEM image of the raw Cu particles after laser irradiation with a fluence of 300 mJ pulse^{-1} cm^{-2} for 10 min. When the laser irradiation time is too long, the Cu spherical particles will be destroyed by laser.

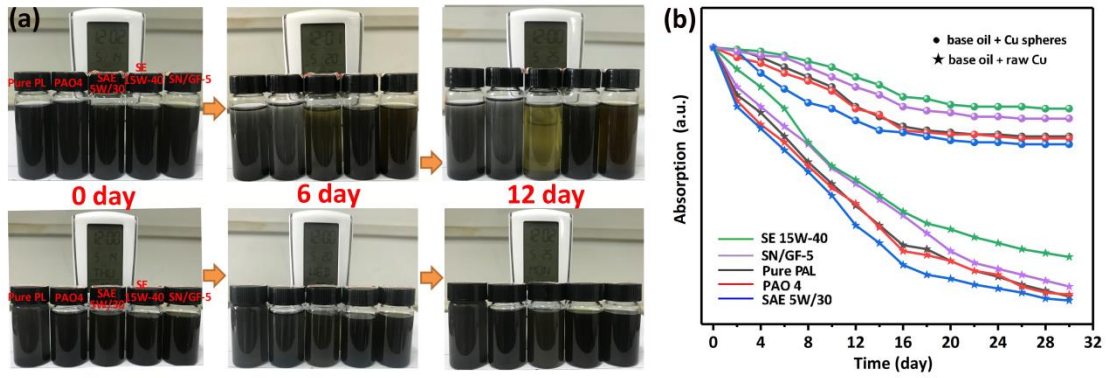

Fig. S3 (a) The optical images of different base oils with raw particles and Cu submicrospheres let stand for 0 day, 15 days and 30 days. (b) The UV-vis absorption intensity of Cu raw particles and submicrospheres with different static times in different base oils.

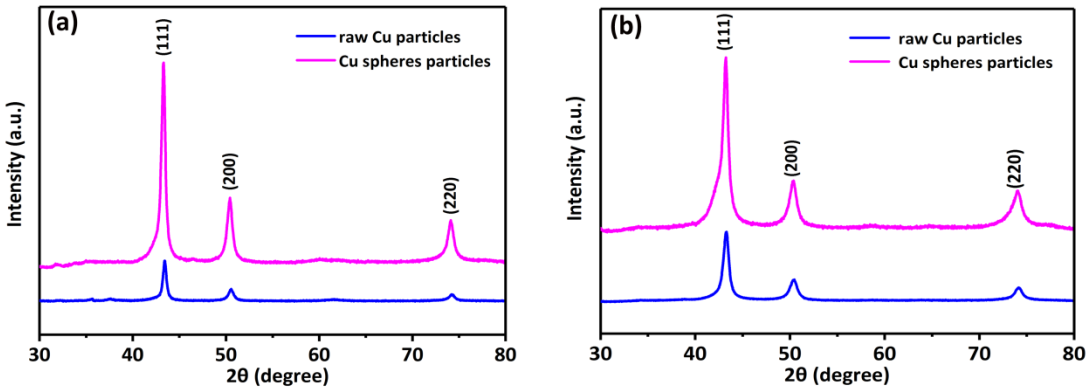

Fig.S4 (a, b) X-ray diffraction spectra of Cu raw particles and submicrospheres before dispersing into pure PAL and dispersing into pure PAL after 3 months.

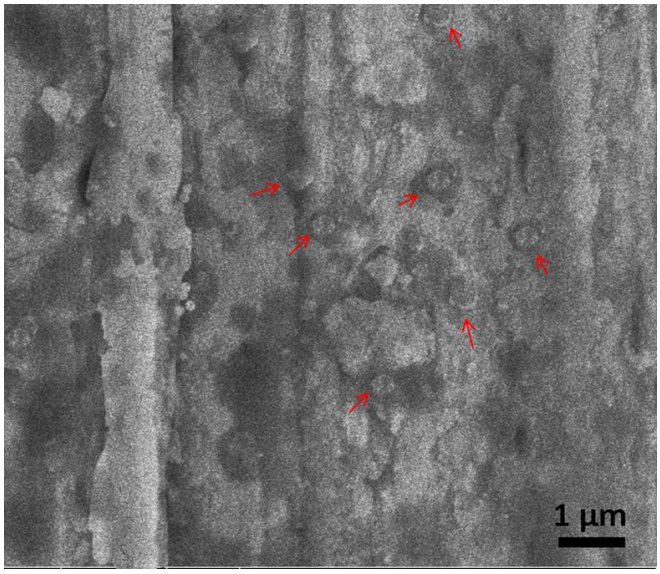

Fig. S5 SEM images of the wear metal surface lubricated by PL containing 0.025 wt% Cu submicron spheres under the load about 500N in the four-ball tribotester. The Cu spherical structure is damaged due to the excessive pressure.

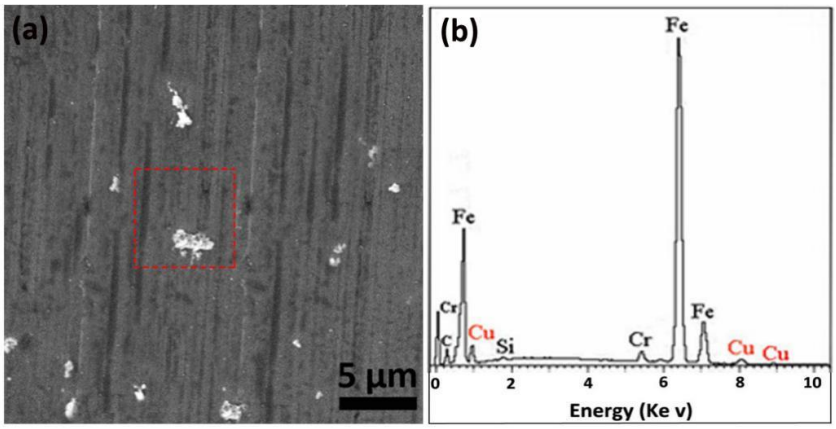

Fig. S6 (a) SEM images of the wear metal surface lubricated by PL containing 0.025 wt% raw Cu particles under the load about 400N in the four-ball tribotester. (b) the EDS from the rectangular region in (a). it is obvious that the raw copper particles agglomerated on the friction surface.