Microwave Characterization of Nanocomposite based on Lithographically Defined Nanoparticles

Y.F. Wang, Y.Q. Su, J. Stang, M. Moghaddam, W. Wu*
Viterbi School of Engineering, University of Southern California, Los Angeles, CA 90089
**wu.w@usc.edu*

In recent years, microwave-absorbing nanocomposites have attracted a great number of interests in applications such as microwave heating and electromagnetic interference shielding. Comparing to traditional materials, nanocomposites can achieve high absorption efficiency with very low loading of the fillers; while the matrix can provide light and even flexible substrates with high strength. However, the microwave absorption efficiency of nanocomposites significantly depends on the morphology of the nanoparticles, which are usually limited by the chemical synthesis process. We proposed a solution to this problem by using top-down lithography to fabricate nanoparticles. Our experiments have shown that the nanocomposites based on lithographically defined particles (LDPs) greatly enhance microwave absorption effects, with much larger absorption efficiency than synthesized-nanoparticle-based nanocomposites.

Numerical studies showed that within such deep sub-wavelength range (*e.g.* 8 μm geometry limitations), magnetic dipoles can obtain two orders of magnitude higher absorption efficiency than electrical dipoles. Thus disk-shaped magnetic dipoles have been chosen as our LDPs. The fabrication and release process of the gold microdisks as magnetic dipoles is depicted in Figure 1. The gold microdisks were first lithographically patterned on parylene layer and LOL 2000 layer. Then O_2 plasma was used to etch the parylene layer in order to expose the LOL 2000 layer as sacrificial layer. Finally the gold nanoparticles were completely released from wafers by using LOL stripper to dissolve the LOL 2000 layer. Figure 2 shows the SEM image of released gold LDPs with diameter of 8 μm, and gold thickness of 300 nm.

The process to transfer and collect gold LDPs into DI water using centrifugation methods has been developed. Figure 3 shows the results of heating enhancement measurements based on different concentrations of LDPs in Agarose matrix within 1.9 GHz 20 W microwave illumination. Larger concentration would achieve higher heating enhancement, and significant enhancement occurred in the first brief period due to huge localized heating. From the perspective of dielectric loss, the heating enhancement comes from the larger real/imaginary part of permittivity or permeability of the composite. We further studied the fundamental factors by using PDMS as a lossless matrix to measure the permittivity value of the nanocomposite sample. Figure 4 shows that both real part and imaginary part of permittivity have been enhanced after adding gold LDPs, leading to larger microwave absorption efficiency. Further studies of permeability and samples with different LDPs concentrations will be present.

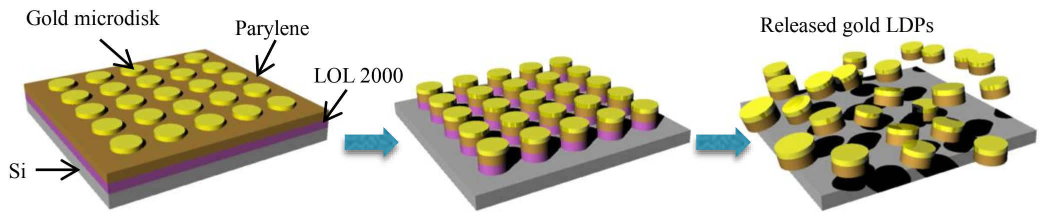

Figure 1. Fabrication and release process of gold LDPs.

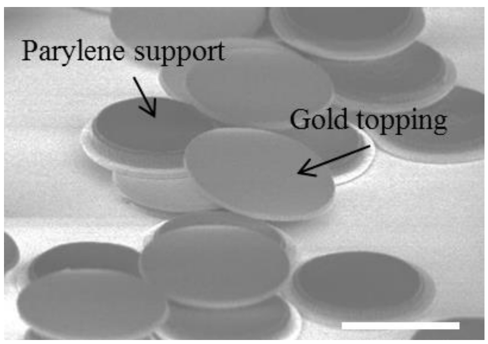

Figure 2. SEM image of released gold LDPs with parylene support. The scale bar is 5 μm.

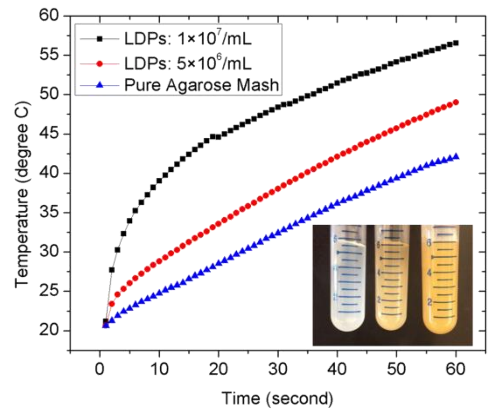

Figure 3. Heating enhancement measurements with different concentrations of LDPs in Agarose composites.

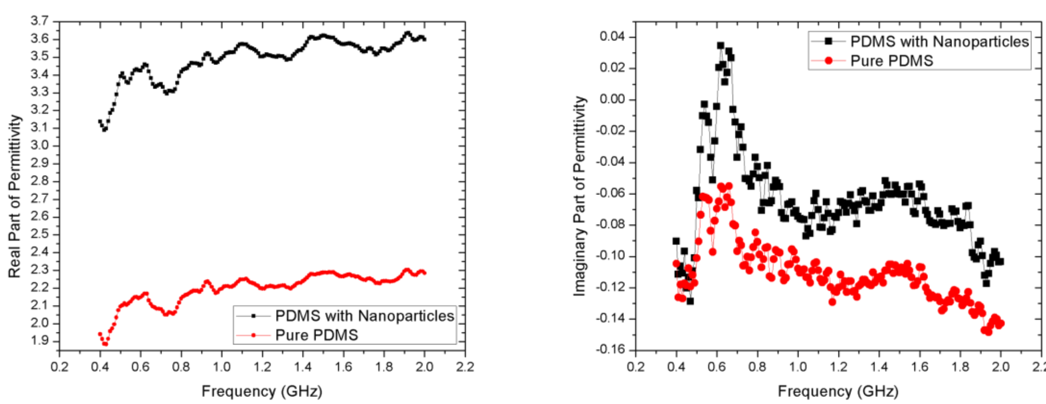

Figure 4. The results of dielectric constant measurement of pure PDMS and PDMS with LDPs.