Imaging of microwave electric- and magnetic-fields by optical indicator microscopy

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High-resolution imaging techniques of microwave E-field and H-field can be powerful tools for visualization of the electromagnetic (EM) field distributions of materials and devices. Using the suggested method based on the optical microscopy one can visualize the E-field or H-field and temperature distributions through the thermo-elastic effect utilizing optical indicator films. Depending on the absorption properties of the indicator films, the system can visualize either the distributions of the temperature, E-field or H-fields.

The optical indicator microscopy technique uses a polarized light microscope method. Figure 1(a) shows the illustration of the visualization system. Probing green light is modulated to be circularly polarized by using a linear polarizer (0º) and quarter waveplate (45º). The reflected light passed through the stressed medium changes the polarization from circular to elliptical due to the photo-elastic effect in the glass substrate. The EM signal generated by the device under test (DUT) interacts with the optical indicator heating up ITO thin film. The detected heat distribution corresponds to the initial EM field distribution of the DUT. Finally, by using the analyzer (linear polarizer sheet) a CCD camera recorded the temperature or EM field distribution images[1)].

Figure 1(b) demonstrates the DUT representing a microwave lowpass (LP) filter and the optical indicator microscopy system and the representative measurement results of the microwave H-field and E-field distribution images at 4 GHz. We used ITO glass for the H-field visualization owing to the rather good conductive properties of the ITO ensuring a strong interaction with the H-field of the DUT. As a result, the ITO film heats up due to the surface currents induced by the H-field and the corresponding thermal distribution appears. On the contrary, for the E-field visualization, we used an indicator consisting of aluminum nanoparticles coated by a poly (methyl methacrylate) (PMMA) thin film since it is well known that metal nanoparticles embedded in glass and polymer give a large increase in the dielectric loss.

The present technique provides a practical approach for high-resolution visualization of the E-field and H-field, as well as thermal distributions, which are valuable in investigations related to the influence of thermal variations on the properties of microwave electronic devices or materials.

Reference

1) Baghdasaryan, Z. *et al.* Thermal distribution in unidirectional carbon composite material due to the direct heating and microwave influence visualized by a thermo-elastic optical indicator microscope. *J. Measurement.* **151**, 107189 (2020).

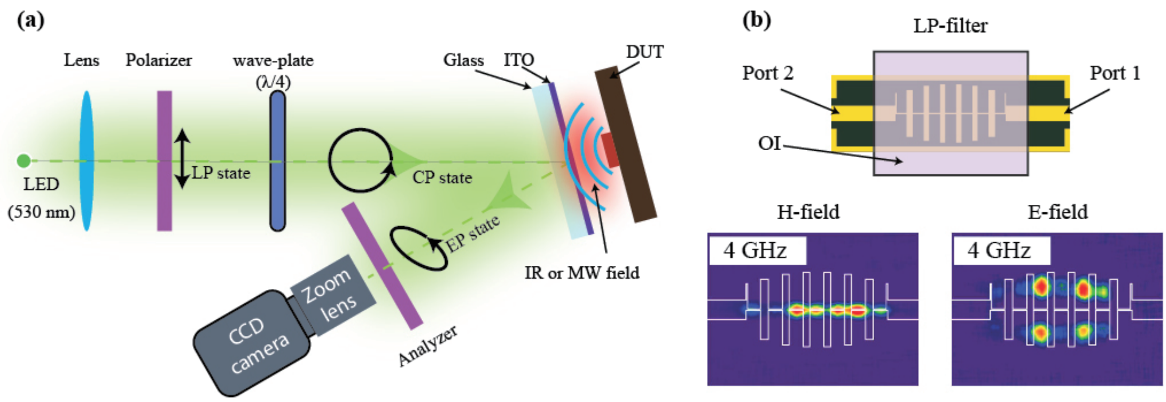

Figure 1. (a) Illustration of measurement principle of the TEOIM system. (b) The top shows the schematic of the tested lowpass filter and the optical indicator. The bottom images depict the visualized microwave H-field and E-field distribution images of the DUT at 4 GHz.

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