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Application News

EPMA-8050G/EPMA-1720HT Electron Probe Microanalyzer

Analysis of Printed Circuit Boards for 5G Communication Equipment

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User Benefits

- EPMA enables observation and analysis of the layer interface and layer surfaces of multilayer printed circuit boards for 5G communications and other high frequency applications.
- Can be used in research and development of electronic substrates, reliability evaluation, and failure analysis.

■ Introduction

Fifth-generation mobile communication systems (5G) are wireless communication systems for realizing high speed and large capacity, massive connectivity, high reliability, and low latency. In Japan, the frequency bands allocated for use in 5G communications are the 3.7 GHz and 4.5 GHz bands, which are called the “sub-6” bands, and the 28 GHz band called the “millimeter wave (mmW)” band. All three of these bands achieve higher speed, larger capacity communication in comparison with conventional 4G communications by utilizing higher frequency bands.

However, signal deterioration due to dielectric loss is a problem in these high frequency bands. As a solution to this problem, fluoropolymers (e.g. PTFE) and liquid crystal polymers (LCP) have attracted attention as insulating materials for printed circuit boards (PCBs).

This article introduces an example of analysis of the interface and surfaces of copper clad laminate (CCL) for 5G applications, which utilizes a low dielectric material, using an EPMA-8050G/EPMA-1720HT Shimadzu EPMA™ electron probe microanalyzer.

■ Analysis of Multilayer PCBs with Low Transmission Loss

The basic structure of the CCLs that form the electronic substrate for mounting 5G terminals is manufactured by heating and pressing a resin sheet between two cooper foil sheets. The resin sheet layer includes an LCP insulating layer and a flame-retardant layer, which is reinforced with a filler. Because the copper foils play the role of wiring, multiple wires are incorporated in the foil layers. The sample analyzed here is an electronic substrate used in smartphone antennas. Smartphone antennas must be thin and compact, but must also be bendable and have excellent heat resistance. Laminated multilayer PCBs with low transmission loss are also used in these antennas.

Fig. 1 is an example of a mapping analysis of the cross section of an electronic circuit board in which a multilayer CCL was used. These data are presented as a color-coded image showing the elements in each layer, where the color red indicates the copper (Cu) foil layers. In this sample, four Cu foil layers with a thickness of approximately 10 µm each can be observed. Green shows the distribution of carbon (C) and represents the resin layers, and the blue layers, which contain aluminum (Al), are considered to be the filler-reinforced layers. The pink layer at the left edge is a protective film and shows the distribution of nitrogen (N) in the protective film. On the right edge, a silicon (Si) filler is mixed in the resin layer and is thought to be used to improve heat resistance.

Fig. 2 shows the mapping data for each element. From these data, it can be understood that phosphorous (P) exists in the same layers as Al and Si, suggesting that an organic phosphorous flame- retardant agent was used in this electronic circuit board to meet halogen-free requirements.

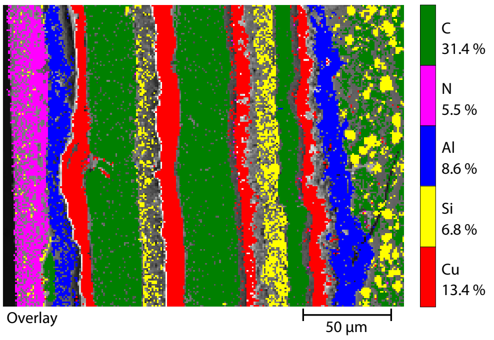

Fig. 1 Mapping Data of Laminated Multilayer Board (Overlay Image)

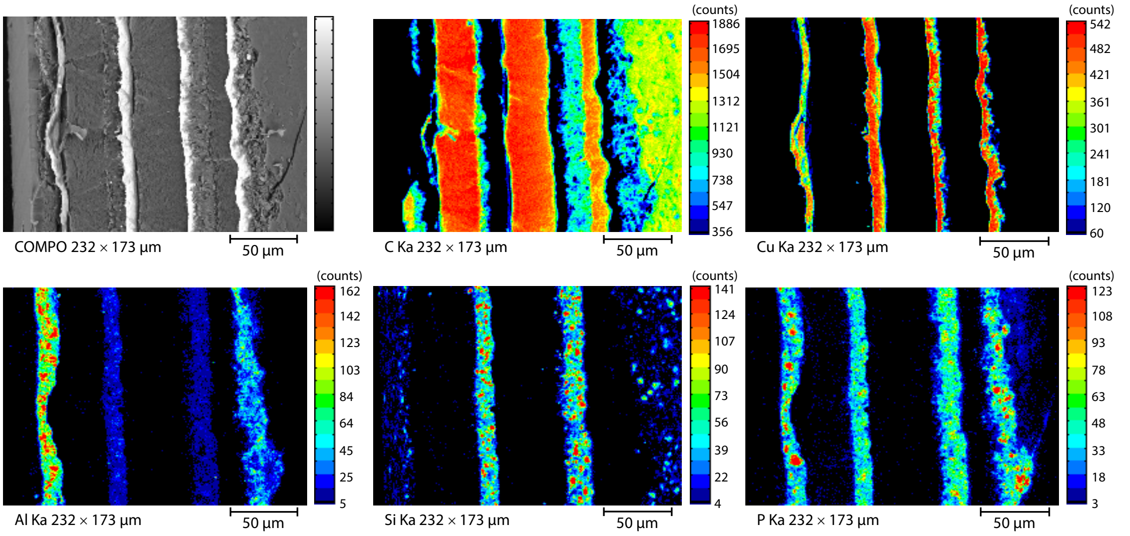

Fig. 2 Mapping Data of Laminated Multilayer Board (Images of Elemental Distribution)

■ Analysis of Cu Foil/Resin Interface of Laminated Board

The laminated board was cut, and the interface between the copper wiring (Cu foil) and the resin layer exposed in this process was analyzed. The interface has been delaminated, and the respective surfaces of the Cu foil and resin layer can be observed. Fig. 3 shows the mapping analysis data for the delaminated interface. In the COMPO image, the left side of the interface centerline (blue dashed line) is the Cu foil surface, and right side is the resin surface. A fine irregular feature called "snowballs" (approx. φ 0.3 µm) can be seen on the Cu foil side, and concave areas corresponding to the convex areas on the Cu foil side can be observed on the resin surface. The overlay mapping image shows a clear distribution of Cu (shown in red) to the left side and C (shown in blue) to right with the boundary near the center. A residue of the resin exists on the Cu foil surface, and a residue of Cu (green) can also be confirmed on the resin surface. This delamination residue indicates the degree of adhesive strength.

Fig. 4 shows enlarged SEM images of various parts of the Cu foil surface. Although signals travel through the Cu foil in an electronic PCB, transmission loss occurs in the high frequency region due to the phenomenon called the "skin effect." This transmission loss is affected by the irregular topography of the Cu foil surface, and increases when irregularity is large, but conversely, inadequate adhesive strength becomes an issue when surface irregularity is small. Research is being carried out to determine the optimum surface processing.

■ Conclusion

A circuit board for antenna modules used in 5G communication devices was analyzed by using a Shimadzu EPMA electron probe microanalyzer. When evaluating parts for 5G applications, not only elemental analysis, but also morphological observation is an important element, and there are also increasing needs for analysis of micro regions to evaluate nanotechnology techniques accompanying the progressive downsizing of communication terminals. The EPMA introduced here addresses these needs by enabling both high resolution observation of micro regions and high sensitivity elemental analysis.

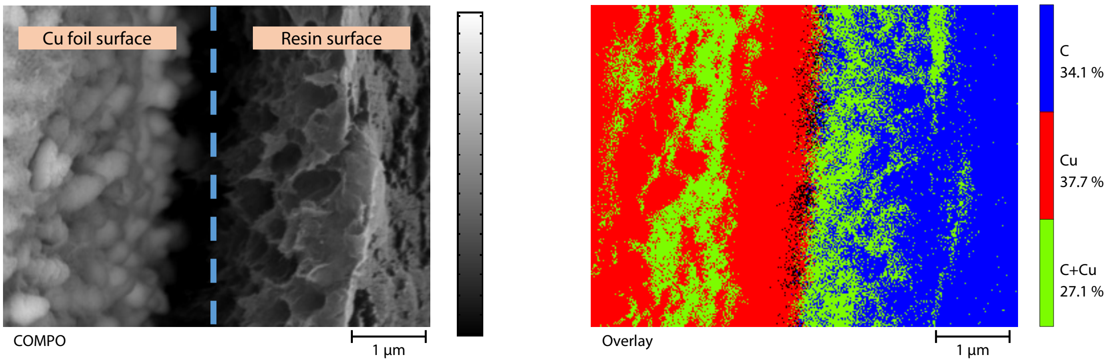

Fig. 3 Mapping Data of Cu Foil and Resin Interface

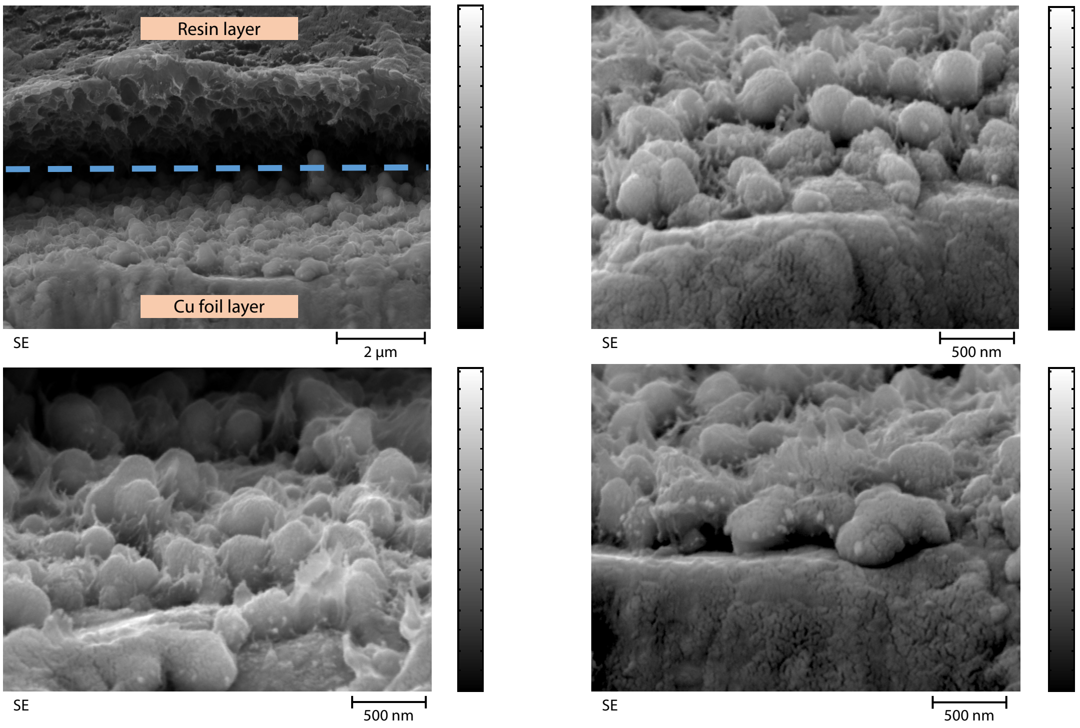

Fig. 4 SEM Images of Cu Foil Surface

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