

Challenges in Manufacturing 0402 Multilayer Ceramic Capacitors

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As the electronics industry moves toward using higher density circuit board assemblies, the capacitor industry, in turn, must produce smaller and higher quality chips in order to meet market needs. 1206, 0805, and other veteran chip sizes are already being replaced by 0603 and 0402 chip sizes for use in such applications as portable pagers, cellular phones, hearing aids, and other small electronic devices. This trend towards miniaturization of multilayered ceramic capacitors (MLCCs) poses many new challenges to capacitor manufacturers, as the demand for smaller chips drives the need for innovative engineering solutions.

Processing Challenges

In the past, production of a smaller ceramic chip size required only slight modification to existing equipment and processes. However, with chip sizes now reaching the 0402 size (1.0mm x 0.5mm), capacitor manufacturers, including KEMET, are being forced to develop new and more creative manufacturing methods.

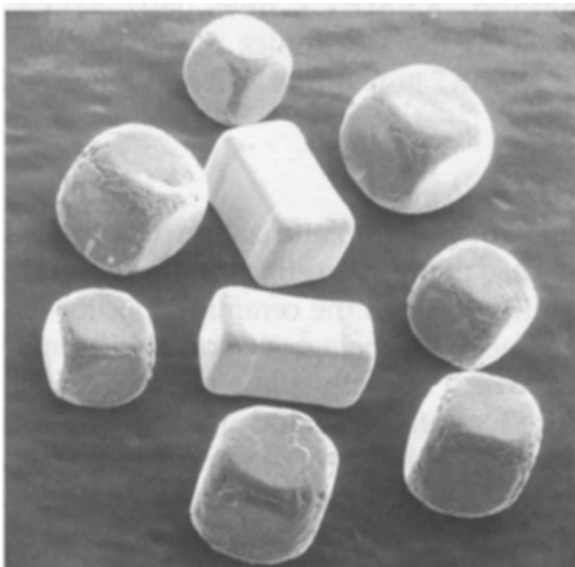


Figure 1: 0402 MLCCs are approximately the size of salt grains.

Accuracy and handling are the most critical and most challenging aspects of KEMET's 0402 manufacturing process. Machine variation is magnified when processing these tiny chips, and the 0402 is unforgiving to printing and stacking errors. Dicing errors of just a few mils, while posing little threat to a larger chip, will result in critical defects in 0402 chips. Therefore, almost perfect accuracy is essential to their manufacture, especially in the screen printing, dicing, and termination processes. KEMET has developed new, innovative screen printing and lamination techniques to reduce the risk of defects due to printing and stacking errors. Additionally, KEMET's new chip making process, known as the KEMET Tape Process or KTP, supported by the use of state-of-the-art termination equipment, will make the production of high quality 0402 chips significantly less challenging.

Because of their restrictive case size, 0.008" margins are required to increase the volumetric efficiency and capacitance of the 0402 chip (Figure 2). The KEMET Tape Process provides the equipment accuracy necessary to make the 0.008" green margins controllable. KEMET is also investigating the use of thinner dielectrics to further increase volumetric efficiency while gaining even more capacitance in small case sizes.

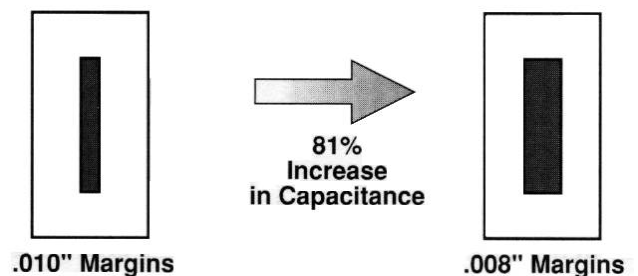


Figure 2. 0402 Chip Size

The KEMET Tape Process utilizes a special vision system to ensure alignment accuracy during both the lamination and dicing operations. Figure 3 illustrates the stacking capability of the KTP process, using .008" green margins (.0066" fired margins).

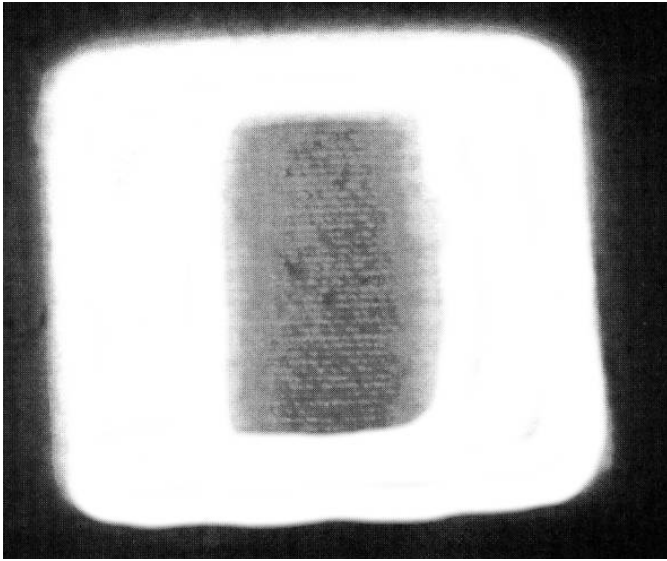


Figure 3.

In addition to improving equipment and process accuracy, KEMET utilizes a silver termination paste with a specialized rheology to increase 0402 MLCC bandwidth accuracy. Silver band separation must be between .30mm and .60mm (approximately the thickness of 3-4 sheets of paper) in order to satisfy termination bandwidth and separation specifications (Figure 4). Designed paste rheology, improved process control methods, and mistakeproofing techniques allow KEMET to meet EIA specifications on both bandwidth (.20mm-.40mm) and separation (>.30mm) for the 0402 ceramic chip.

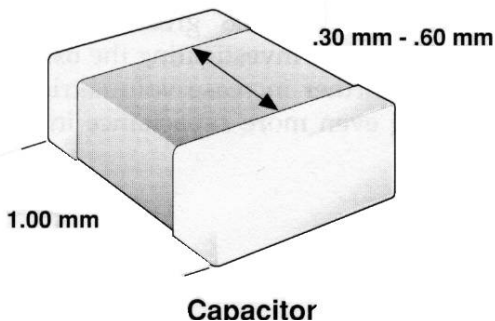


Figure 4.

Bulk cassettes will supplement tape and reel for packaging of KEMET's 0402 chips. While significantly reducing packaging volume, this also creates a need for much tighter machine and capacitor dimensional tolerances.

Handling Challenges

The size of the 0402 ceramic chip results in many interesting handling challenges throughout the capacitor production process. Once again, new and creative solutions for handling of 0402 MLCCs have been developed by KEMET to overcome these obstacles.

Separation of the 0402 chips from media during several process steps presented the greatest challenge to KEMET. Sloped planes, directional vibration, and specialized materials are used to separate chips from media at the firing, corner rounding, and electroplating process operations. However, the small dimensions and low mass of 0402 chips prevented the use of most traditional separation equipment and methods. The firing sand used to process larger chips is approximately the same size as the 0402 chips, making their separation virtually impossible. Additionally, static electricity effects not encountered with larger chips pose problems for the 0402. To overcome this, new equipment and processing techniques have been developed, as well as using specialized media to promote proper separation and to prevent firing sand from traveling downstream to the chip termination process. Because of the unique methods and equipment necessary for their production, KEMET has established a manufacturing line dedicated solely to the production of 0402 ceramic chips.

Platform Team Concept

KEMET's commitment to improved process technology such as the KEMET Tape Process and new termination processes were major building blocks in the 0402 manufacturing success. Additionally, KEMET's use of a platform team concept greatly reduced the time to market for our newest case size, the 0402 MLCC. The platform team consists of a small, highly focused core team and a cross-functional support team. Using negotiation techniques, the core team developed a "contract" with management, including a detailed project plan with specific deliverables and critical milestones defined. Using this method, KEMET's new 0402 MLCC was introduced to the electronics market in just eight months. KEMET now offers X7R and NPO 0402 chip sizes.

The Real Challenge

The trend toward miniaturization of ceramic chips has presented many interesting challenges to engineers and manufacturers in the ceramic capacitor industry. These obstacles are being overcome with innovative solutions which not only allow chips as small as the 0402 to be manufactured and used in the electronics industry, but also improve ceramic chip quality across the board. The real difficulty of chip miniaturization, however, lies not with the manufacturers, but with the capacitor users. While the small chip size offers many advantages such as higher circuit board density, placement accuracy of these tiny components remains a challenge for the users to conquer.

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