Sandia National Laboratories

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Capacitor Edge Margin

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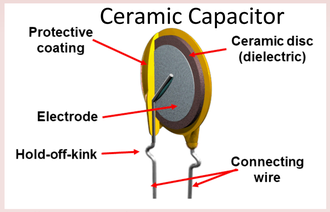
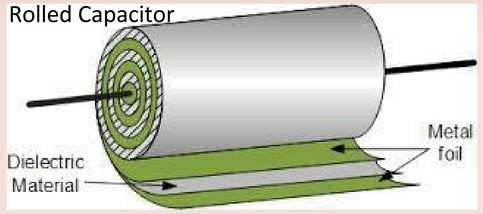
Background

- Capacitors store energy in an electric field between two conductive plates separated by an insulating dielectric
- Several applications in circuit design include filtering, smoothing, and stabilizing electronic signals or power flow
- Manufacturing defects can lead to high localized electric fields and dielectric breakdown, resulting in failure
- Various forms of capacitors include ceramic, rolled, plate, and embedded

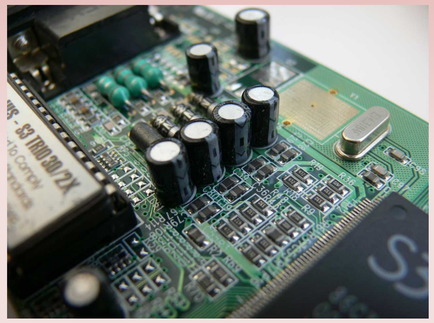


https://en.m.wikipedia.org/wiki/File:Ceramic_disc_capacitor.png



https://www.quora.com/Do-typical-capacitors-contain-more-than-one-pair-of-plates-If-not-why-are-they-cylindrical-in-shape

Capacitors on a circuit board



https://www.pcmech.com/article/how-capacitors-on-a-motherboard-work/

Problem Addressed

- Edge margin refers to the accentuated edge that is either higher or lower than the electrodes
- This increases the likelihood of dielectric breakdown
- This project focused on fabrication methods to reduce the edge margin

Materials Used

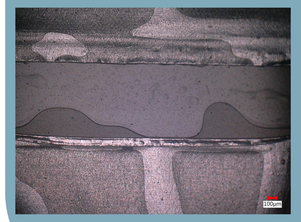
- Two inks were chosen, polystyrene(PS) and polyester(PE)
- 75 gauge Mylar with a thickness of 19 microns was chosen as a substrate
- 40 gauge aluminum foil with a thickness of ~10.5 microns was used as the electrodes

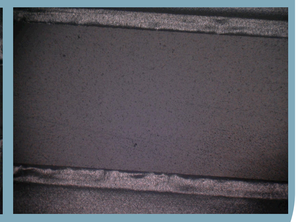
Initial Work

- A selection matrix was used to down select the dielectric materials from over 25 candidates
- Dielectric constant and dielectric strength were the deciding factors
- The substrate was also selected based on its compatibility with the dielectric materials

Results

- Direct application of the dielectric ink coupled with a compression step was determined to be more promising
- Drying was slow, and resulting in voids and bubbles within the dielectric material
- Vacuum drying accelerated fabrication
- Process variables included temperature, vacuum level, time, and application of dielectric material
- Temperature was varied from 90-140°C
- Time was increased up to two hours
- An optimized combination of these variables ultimately resulted in a uniform film





Experimentation

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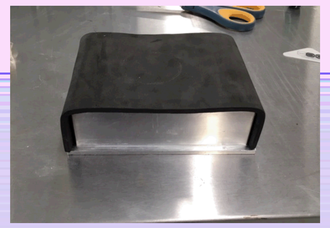
- Capacitors were made using two strips of foil, Mylar, and the dielectric material
- Challenges in achieving a uniform dielectric film motivated experiments to identify reliable methods

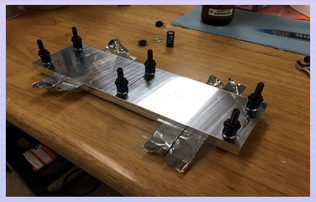
Mayer Rod Coating

- Mayer rod coating using an RK coater gave a predictable film thickness, but it was determined that the film thickness was independent of pressure and speed
- The Mayer rods were used without the machine, yielding similar results to that of the RK coater
- The two methods resulted in high edge margins due to the coffee stain effect, a drying effect caused by increased evaporation flux from film edges resulting in increased material deposition at the edges
- Cosolvents were added to slow or increase drying, but did not alleviate the problem

Direct Application

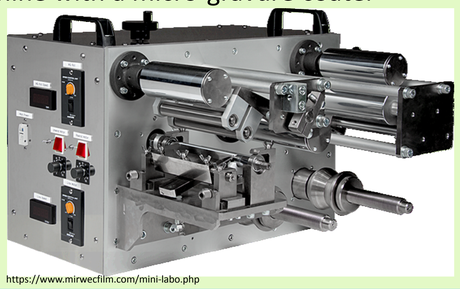
- Direct deposition of excess dielectric ink was combined with compression as a second method for film application
- Two aluminum compression plates compressed the capacitor assembly to a uniform thickness
- Because the solvents were trapped between two nonporous pieces of Mylar, drying was very slow and resulted in nonuniformities in the dielectric film leading to failure





Conclusion

- This project demonstrated feasibility in reducing the edge margin with a tailored combination of process parameters
- With the data collected the process can be upscaled to a roll to roll machine with a micro-gravure coater



https://www.mirwecfilm.com/mini-labo.php

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a picture or diagram would be good here - you could probably replace the Mayer rod pictures shown

Secor, Ethan Benjamin, 7/19/2018