Study of Radiation Hard Dielectric Materials for the High Luminosity LHC

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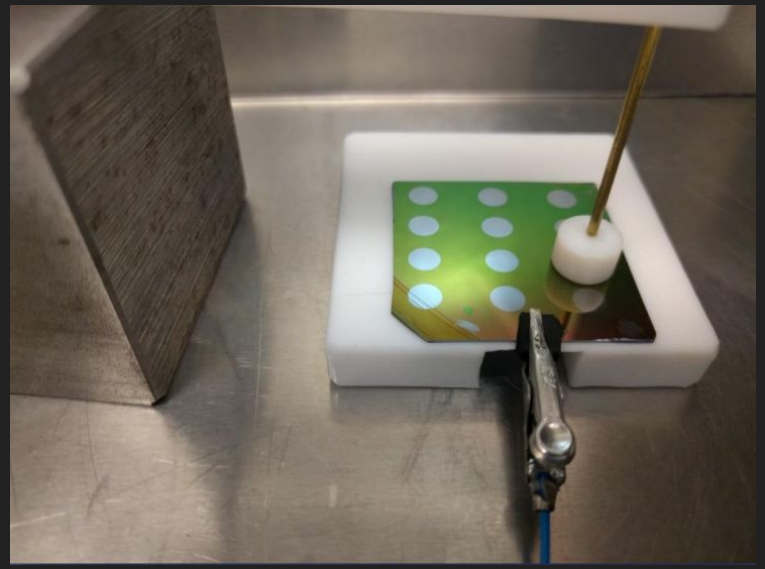
Objective: Find a suitable dielectric for the LHC Upgrade

A good dielectric candidate should have the following properties:

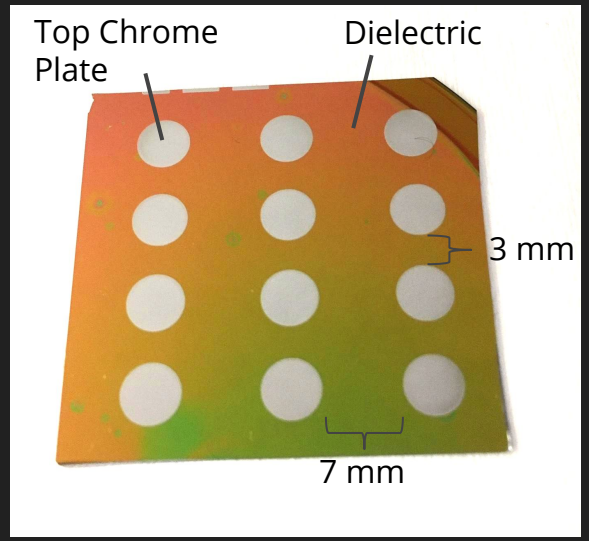
1. Excellent radiation hardness
2. High Resistivity
3. High dielectric strength
4. Low dielectric constant
5. Easy processing properties

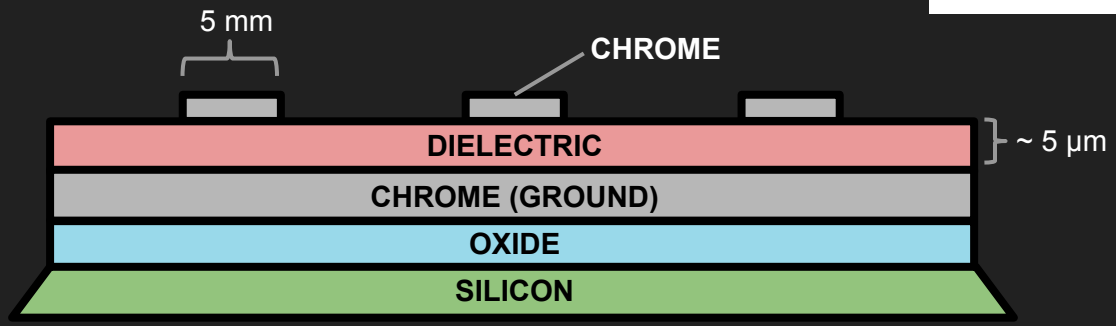


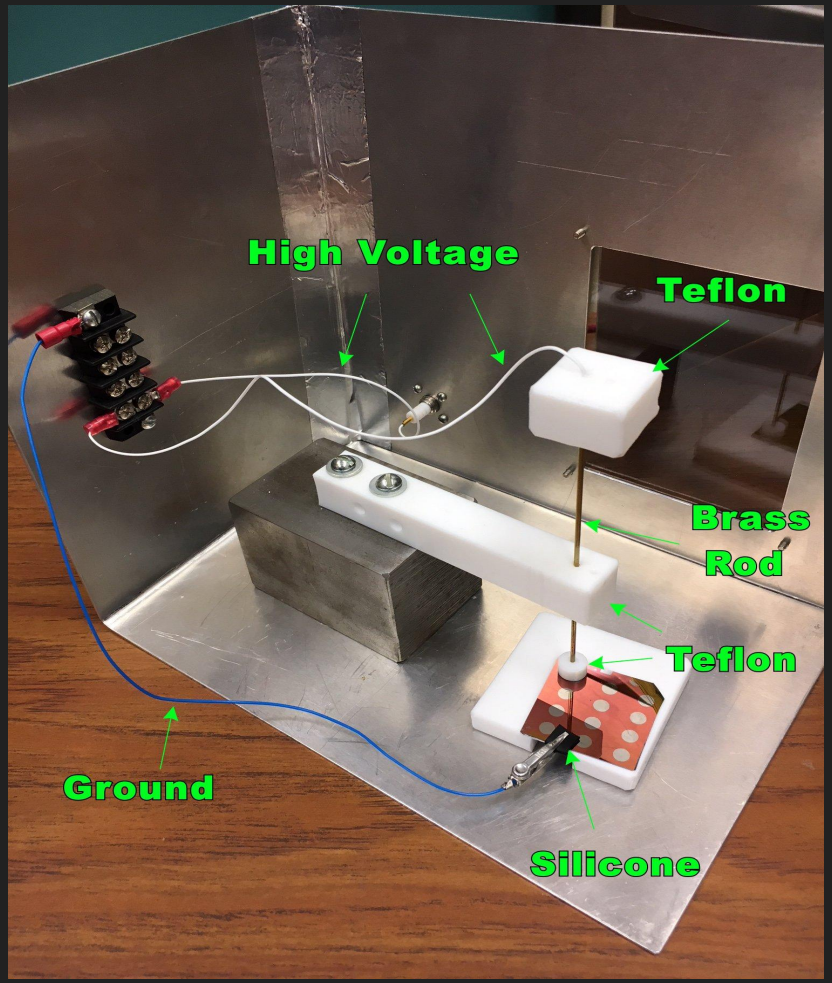
Phase 1 consisted of studying the effects of radiation on dielectric materials and testing suitable dielectrics to prevent electrostatic discharge (ESD)

Test Samples: Thin Film Parallel Plate Capacitor

- **Silicon**: convenient and radiation tolerant substrate
- **Oxide**: resistive and provides isolation
- **Chrome**: provides good adhesion, is great for profilometry (measuring the dielectric thickness), and provides a common ground plane



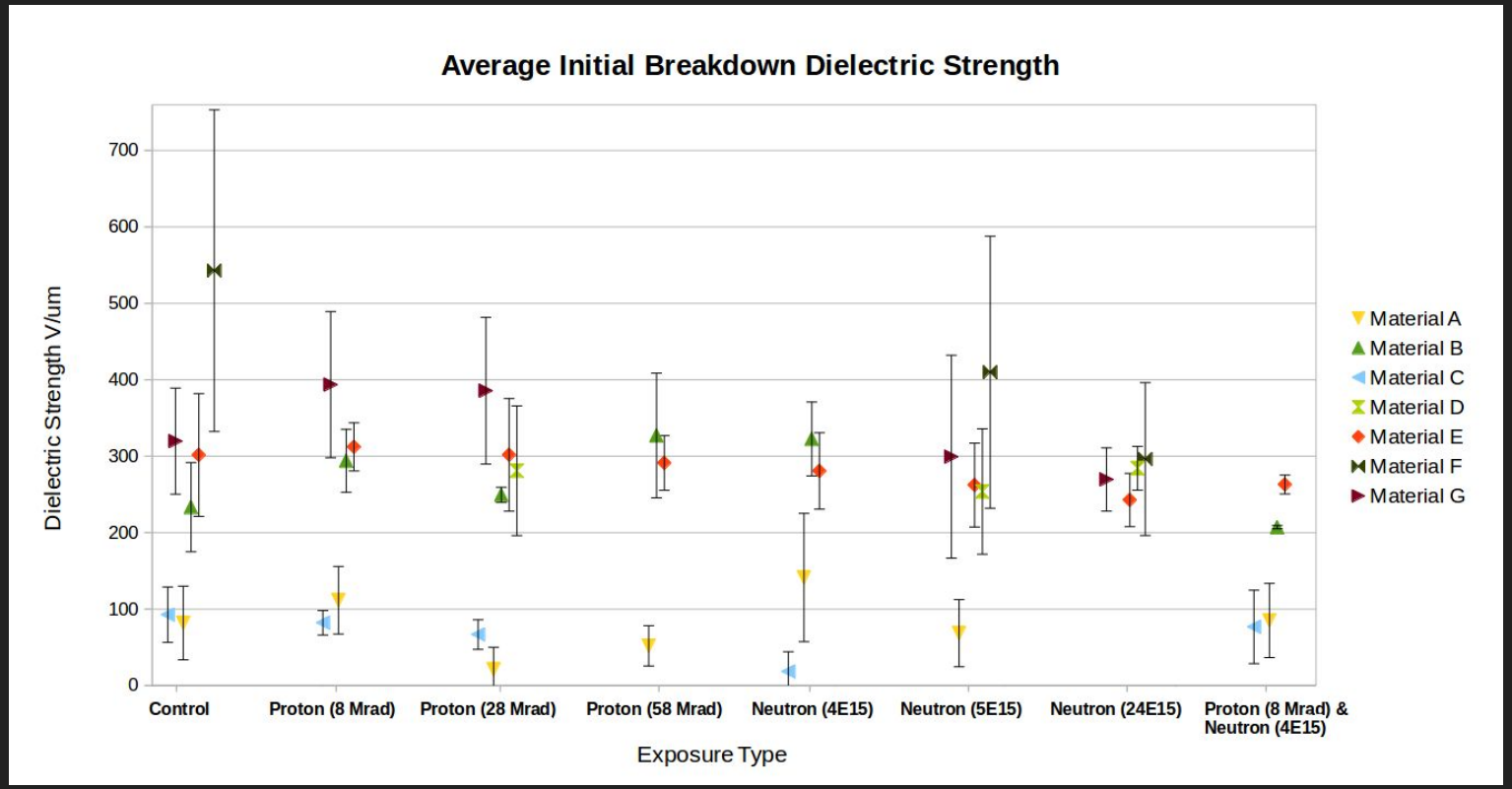




Testing Apparatus

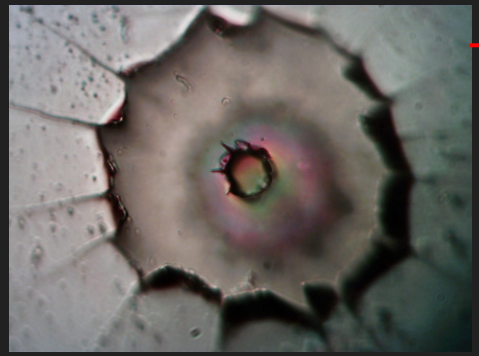
- A custom made jig was constructed to test capacitance, resistance, and breakdown voltage.
- A power supply was used to slowly ramp up the voltage through a brass rod above the top electrode of the capacitor until the material hits its "**breakdown voltage**" (designated as a current trip of 10 μA)
- The above tests were then repeated after being exposed to radiation damage

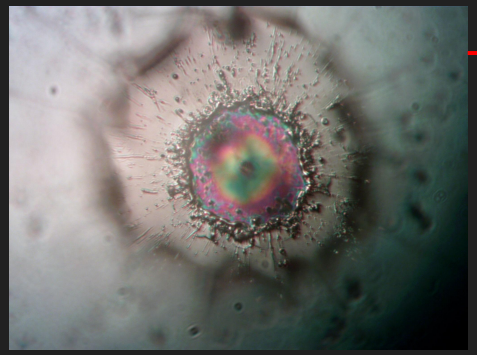
Initial Breakdown Results

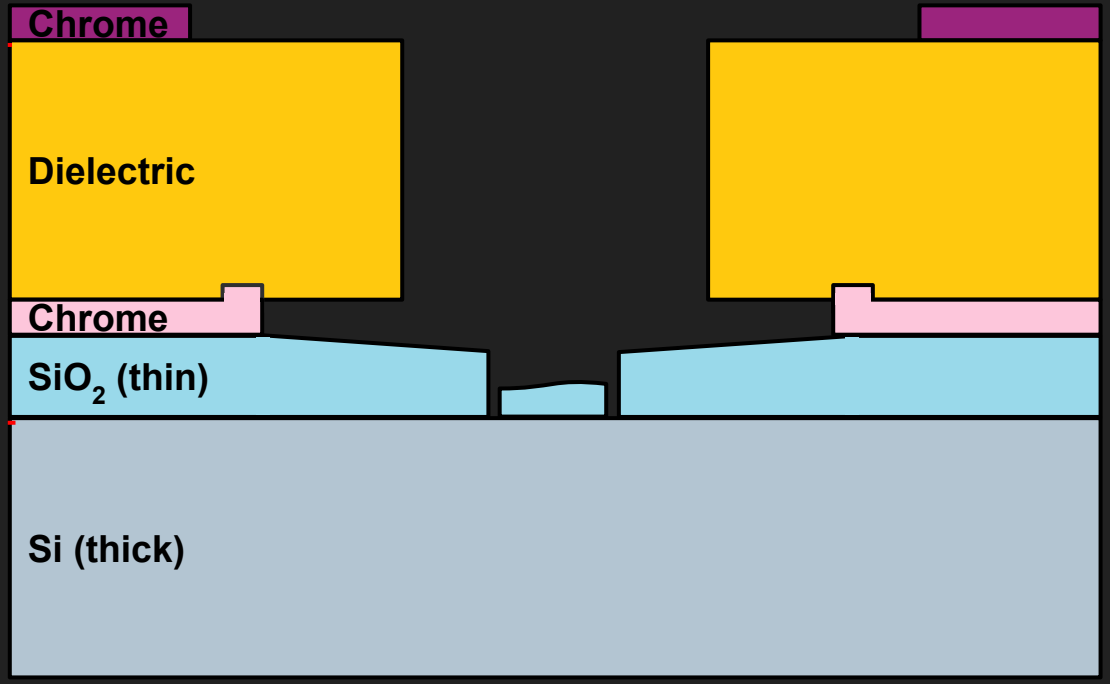


- Summary of initial breakdown voltages for various Polyimide and Epoxy materials
- Error bars were obtained from standard deviations of repeated measurements

Initial Breakdown: Structure of Blast Crater



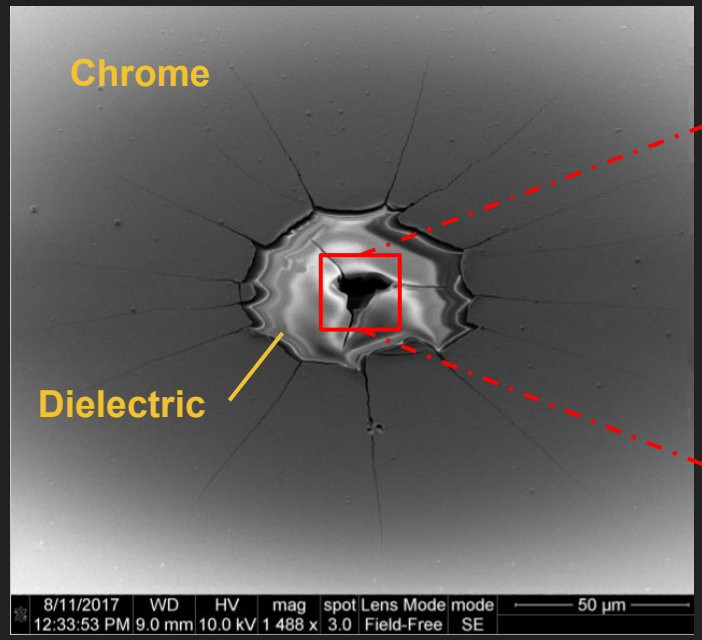




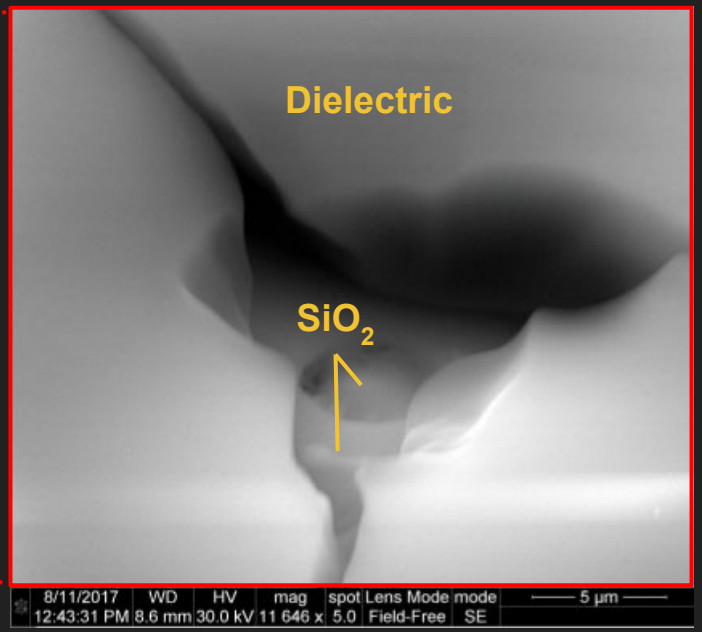
- Initial breakdown voltage is energetic enough to vaporize a hole straight down to the thin layer of oxide

Subsequent Breakdowns

After the initial breakdown, a partial air path was created. This resulted in subsequent breakdowns measuring the dielectric strength of air instead of the intended dielectric.



Crater caused by initial breakdown



Center of blast crater

Conclusion

- Materials that yielded an average dielectric strength above 100 V/um were considered suitable dielectrics to continue on to the next phase of testing
- Most of the materials were heavily damaged by the initial breakdown voltage; as a result, their subsequent breakdown voltages decreased dramatically
- Some materials did not weaken however, indicating that if ESD were to occur, certain materials would still be able to maintain functionality in tracker chips at the LHC

The End

Questions?