



Microwave Evaluation of Moisture Content of Polymeric Filaments Used in Additive Manufacturing (AM)

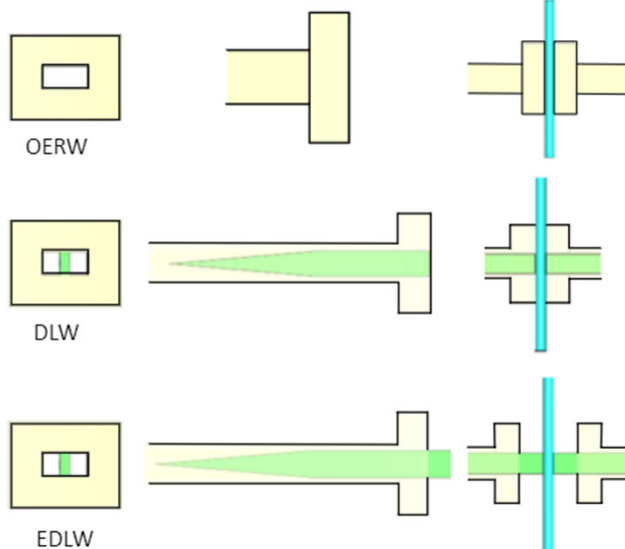
Farzaneh Ahmadi, Mohammad Tayeb Al Qaseer, and Reza Zoughi – ECpE Department

Center for Nondestructive Evaluation - CNDE

Objective: To evaluate the efficacy of microwave nondestructive testing (NDT) to detect moisture content absorbed by polymeric AM filaments.

Introduction

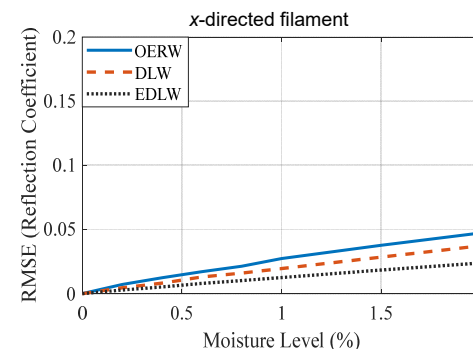
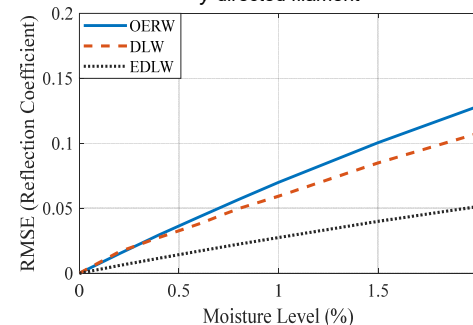
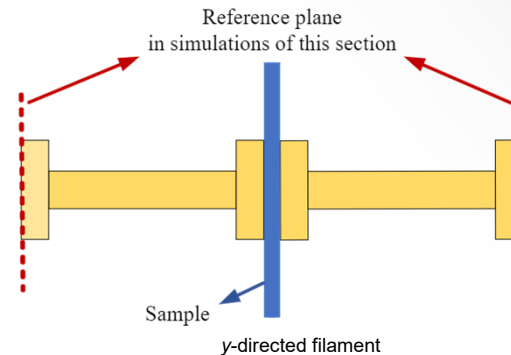
- For polymeric AM, presence of moisture in the filament can decrease the quality of the final part.
- This research investigates the efficacy of millimeter-wave near-field probes to detect moisture content of polylactic acid (PLA).
- An open-ended rectangular waveguide (OERW) probe is very common in NDE space.
- We investigated the effect of loading an OERW probe with a dielectric slab (DLW) and extending the slab outside the waveguide to an optimum value (EDLW) on the detection sensitivity.



- Effect of moisture content was simulated as a change in complex permittivity.
- Complex permittivity of water is a function of frequency.
- Root-mean-squared-error (RMSE) was used to compare the efficacy of the probes.

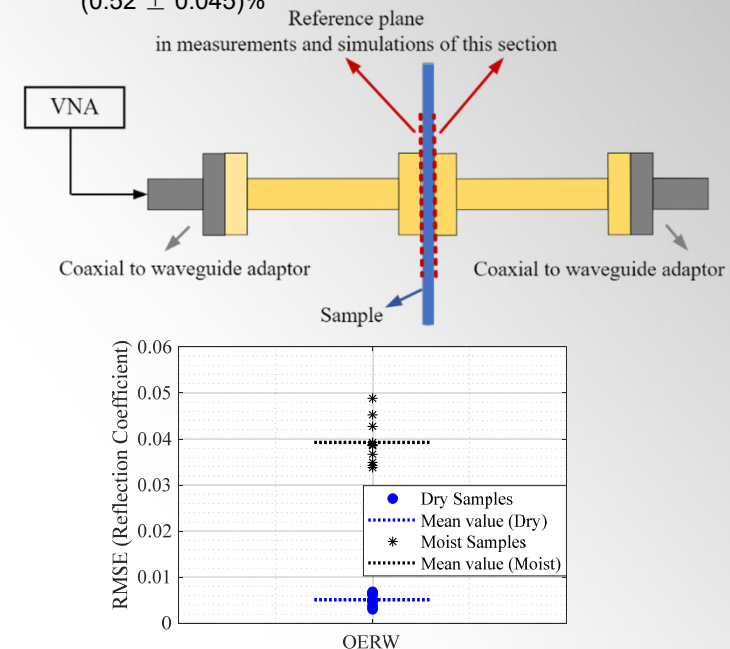
Simulations

- Simulations were conducted in CST Studio Suite®, at Ka-band (26.5-40 GHz).
- The polymeric material :PLA ($\epsilon_r = 2.71 - j0.027$)



Measurements

- 20 samples (from the same spool of PLA) were dried in the oven for 40 hours (55° C).
- 10 samples were considered as "Dry samples".
- 10 samples were immersed in ASTM II water for 9 days.
- Measured level of absorbed moisture by weight: $(0.52 \pm 0.045)\%$



Conclusion

The results show that open-ended rectangular waveguide probe is a good candidate to detect moisture content of the feedstock polymeric filaments used in polymeric AM process.

References

- [1] T.D. Ngo, A. Kashani, G. Imbalzano, K. T. Q. Nguyen, and D. Hui, "Additive Manufacturing (3D Printing): A Review of Materials, Methods, Applications and Challenges", Composites Part B, vol. 143, pp 172-196, 2018.
- [2] A. D. Banjo, V. Agrawal, M. L. Auad, and A. D. N. Celestine. "Moisture-induced changes in the mechanical behavior of 3D printed polymers." Composites Part C: Open Access, vol. 7, 2022.