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Contribution to multi-physical study and characterization of ceramic materials for power electronics

Abdellatif Rashed (PhD student)

Directeur de thèse : Paul-Etienne Vidal

Co-directrice : Veronika Gavrilenko



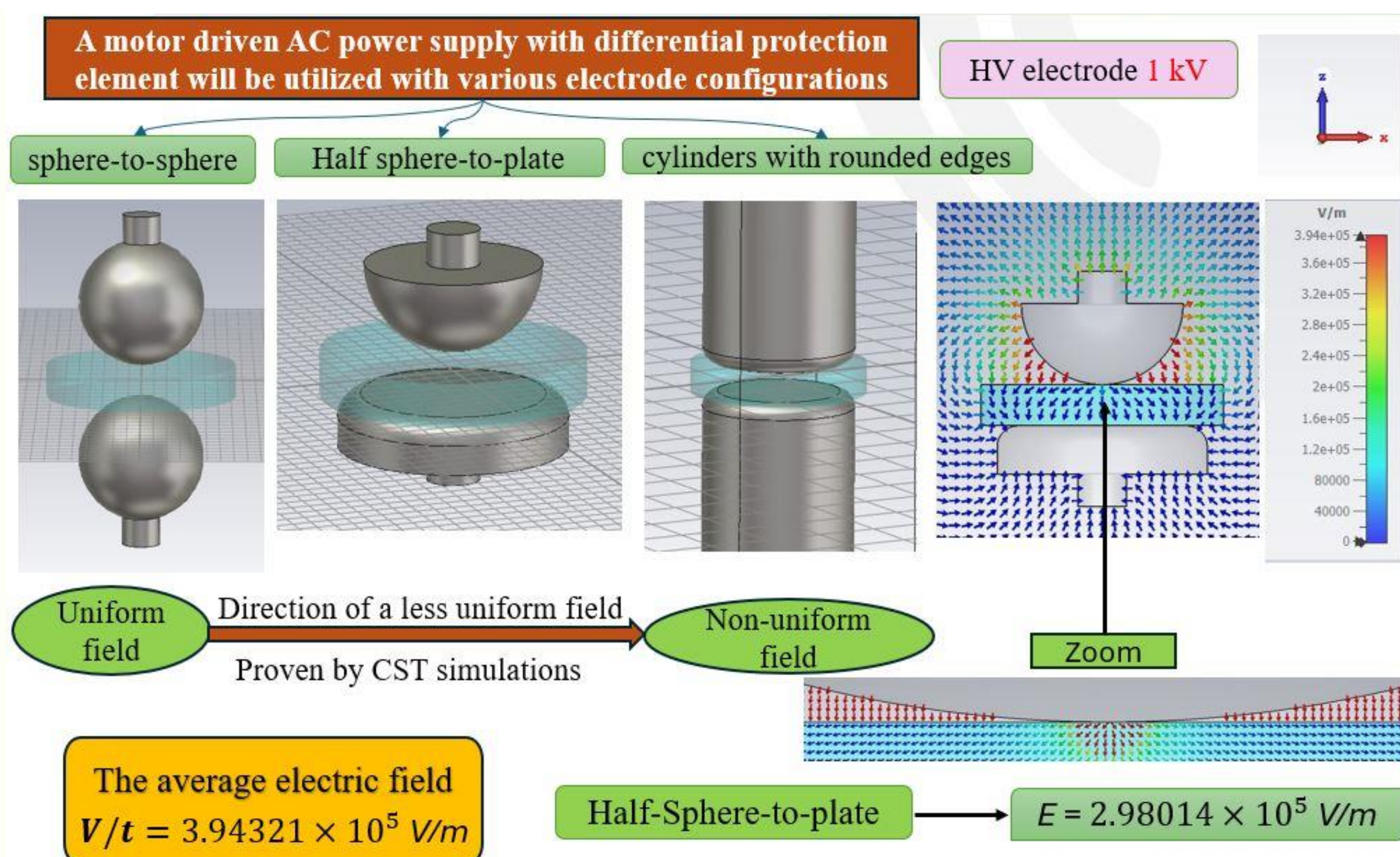
The supervising consortium has developed a common knowledge around the characterization of functionalized ceramic materials, which by means of an integration strategy allows the miniaturization of electrical energy conversion devices, especially power modules. This research project aims to develop a method of multi-physical characterization – from model to object – of metalized ceramics for their further application in power electronic modules. In this regard, high permittivity BaTiO₃ prepared by spark plasma sintering (SPS) in CIRIMAT laboratory is tested for its integration in power electronic modules.

Keywords Energy transition, clean mobility, power electronic module, multifunctional ceramic substrates, multi-physical characterization, integrated capacitors

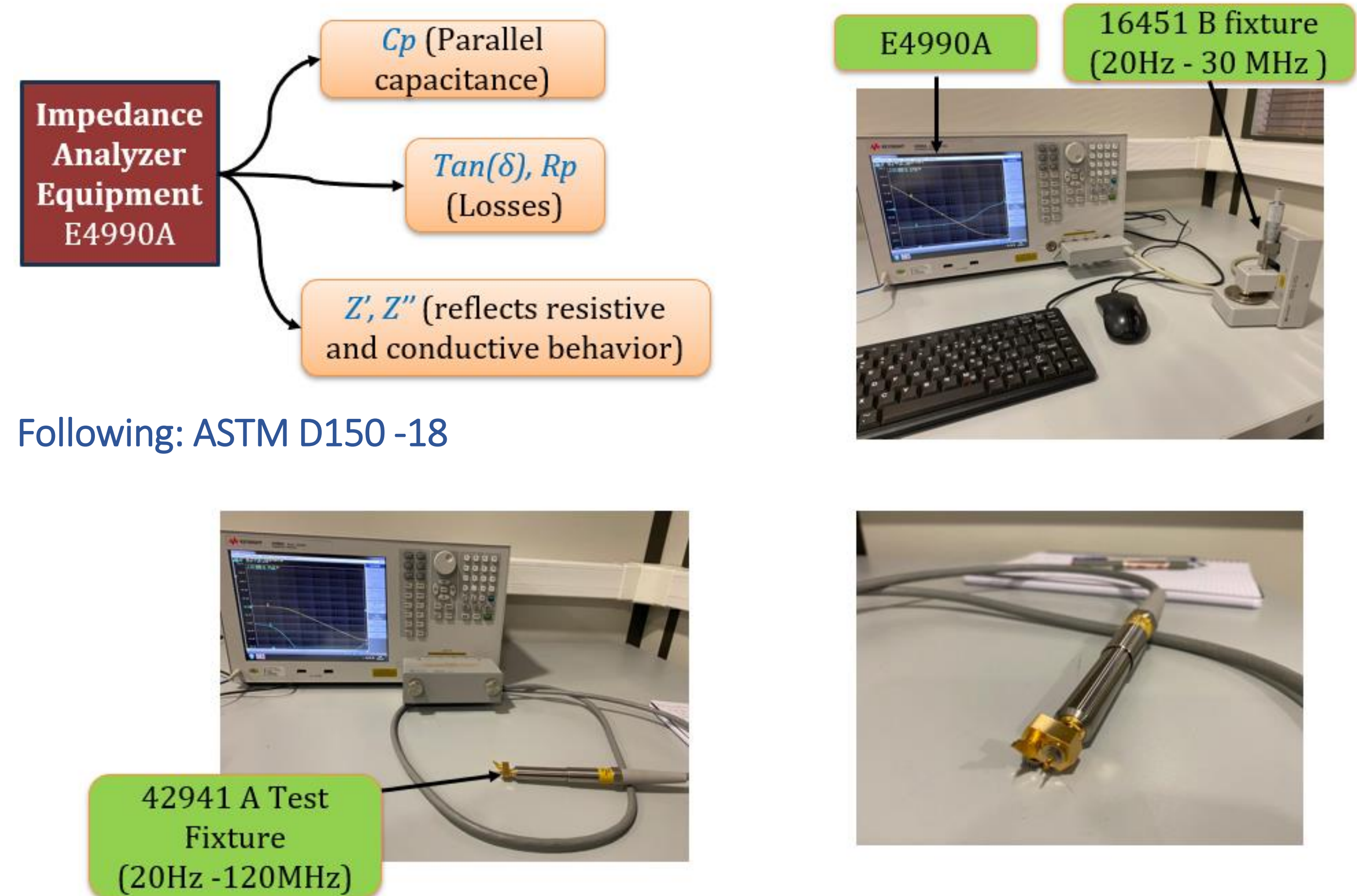
Multi-physical Characterization: Proposed Standards

	ASTM	IEC	ISO
Dielectric Strength E (kV/mm)	ASTM D149-20	IEC 60243-1:2013 (AC) IEC 60243-2:2013 (DC) IEC 60243-3:2013 (Impulse)	
Permittivity ε'	ASTM D150-18 ASTM D2149-13(2021) (10 MHz, 500 C)	IEC 62631-2-1:2018 (up to 10MHz) IEC 62631-2-2:2022 (up to 300MHz)	
Thermal Conductivity	Coefficient of thermal expansion ASTM D696		ISO 22007-2:2015 (Hot Disc Method)
Electrical Conductivity σ	ASTM D257-14(2021)e1	IEC 62631-3-1:2023 (Volume Resistivity) IEC 62631-3-2:2015 (Surface Resistivity) IEC 62631-3-3:2015 (Insulation Resistance) IEC 62631-3-4:2019 (Volume R at High T)	
Mechanical Strength	ASTM D790-19		ISO 178-2019

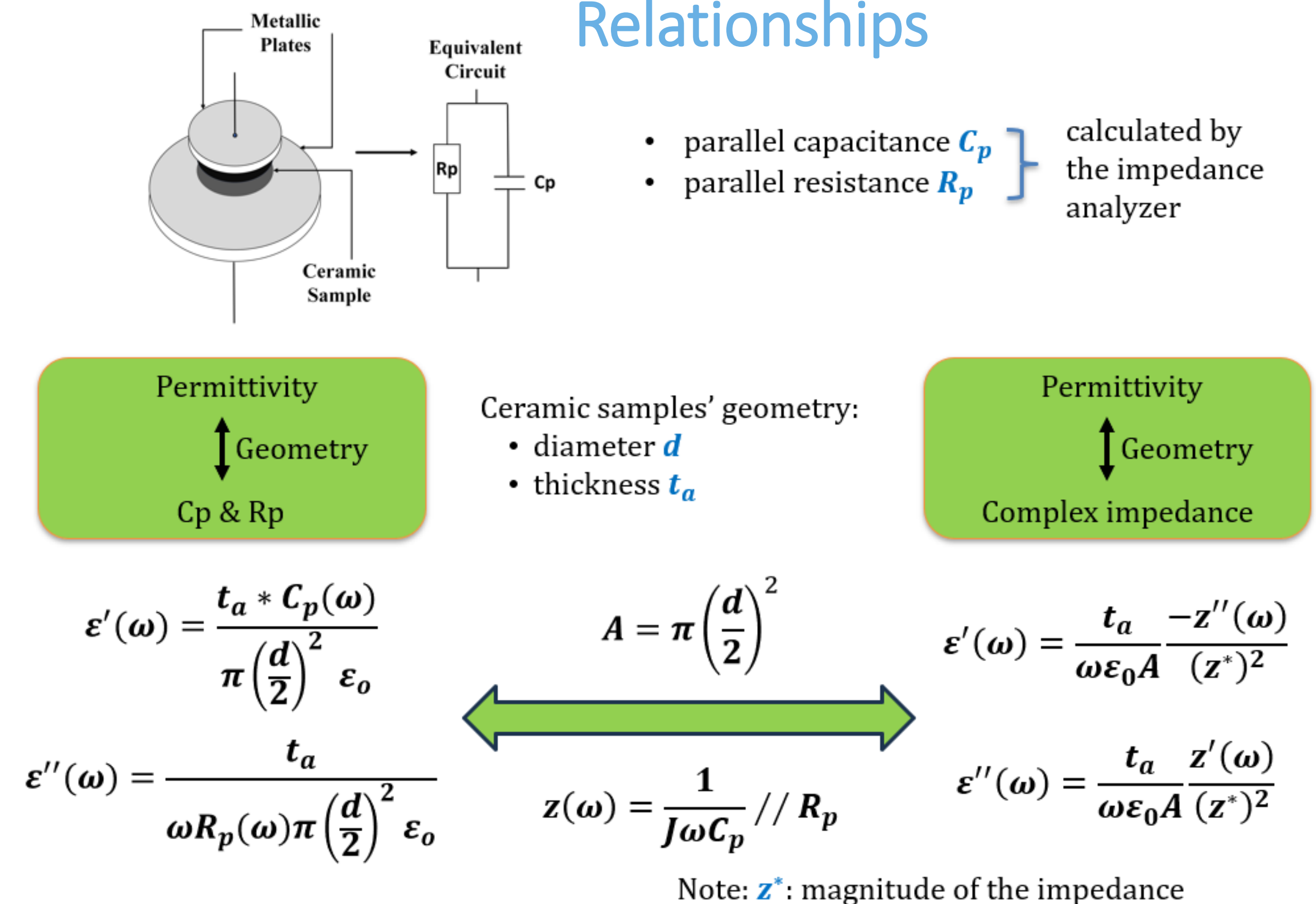
Dielectric Strength Study (IEC 60243)



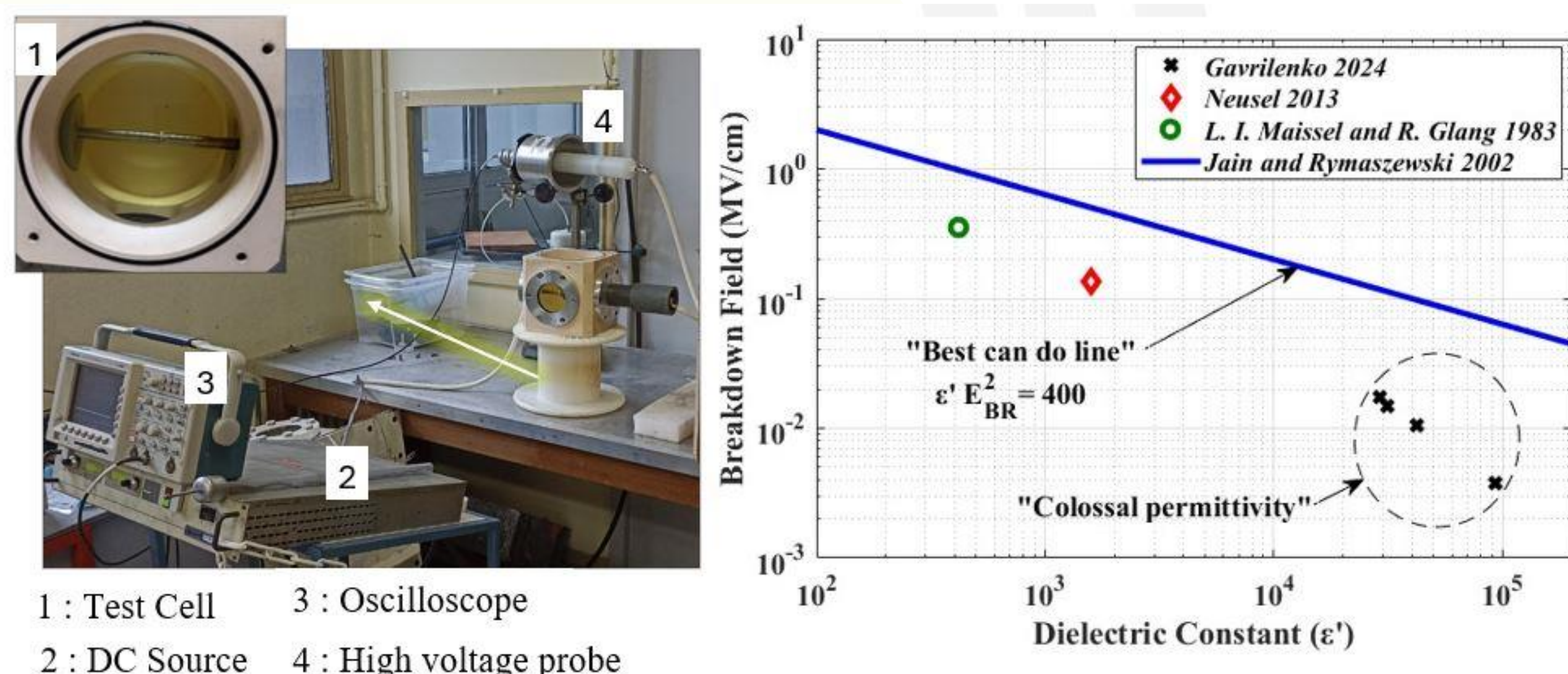
Experimentation and Broadband Dielectric Analysis : Setup



Experimentation and Broadband Dielectric Analysis Relationships



Literature Breakdown Results for BaTiO₃



[I] V. Gavrilenko et al., "Breakdown Strength Study of Barium Titanate Ceramics for Power Electronics Applications," in 2024 IEEE 5th International Conference on Dielectrics (ICD), IEEE, Jun. 2024, pp. 1–4.

[II] C. Neusel and G. A. Schneider, "Size-dependence of the dielectric breakdown strength from nano- to millimeter scale," J. Mech. Phys. Solids, vol. 63, no. 1, pp. 201–213, 2014.

[III] L. I. Maissel and R. Glang, Handbook of Thin Film Technology, 1st ed. New York: McGraw-Hill, 1983.

[IV] P. Jain and E. J. Rymaszewski, "Embedded thin film capacitors - Theoretical limits," IEEE Trans. Adv. Packag., vol. 25, no. 3, pp. 454–458, 2002.

Obtained Permittivity & Conductivity Plots

