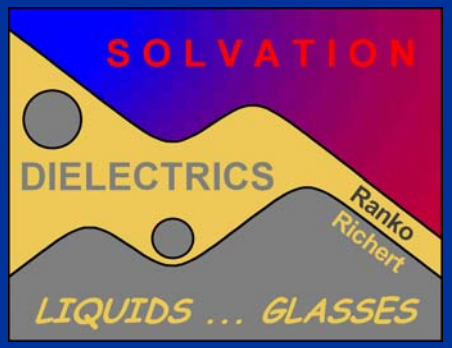
Hide-and-seek below the dc-conductivity signal

Ranko Richert



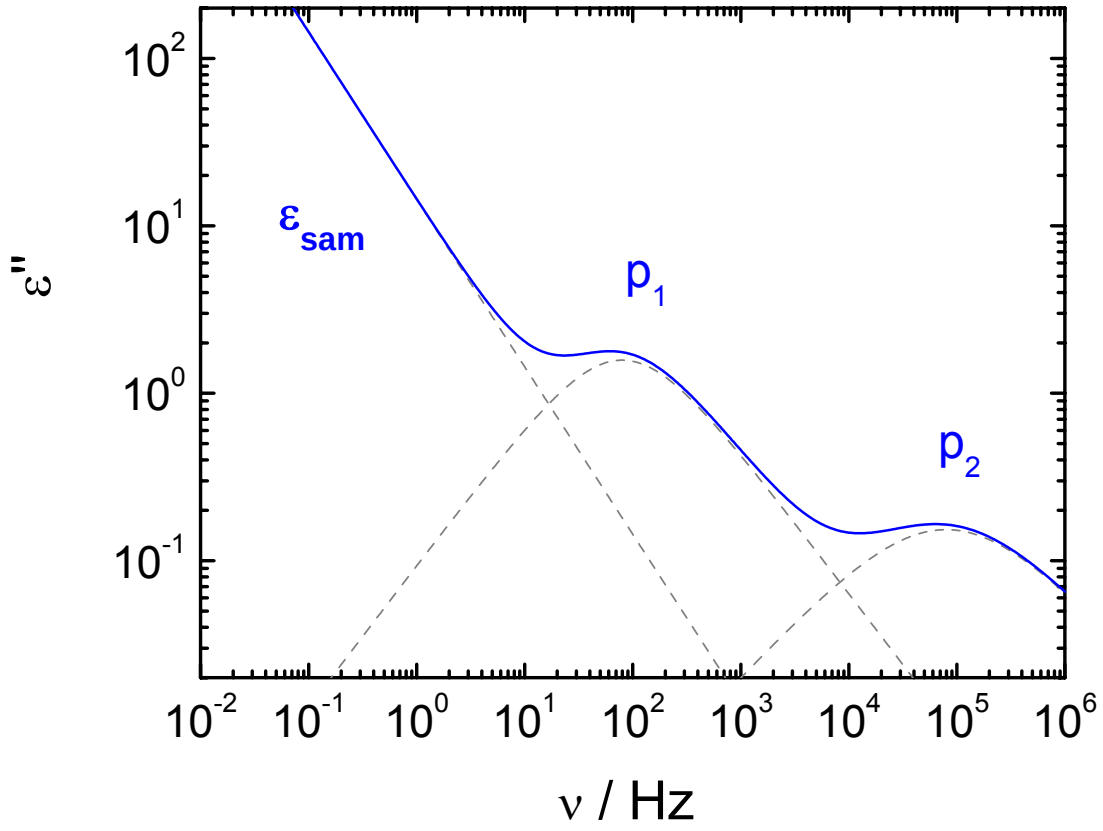
Roma, Dielectric Tutorial
30 August 2009

motivation

insulating electrodes

how much do we gain ?

motivation



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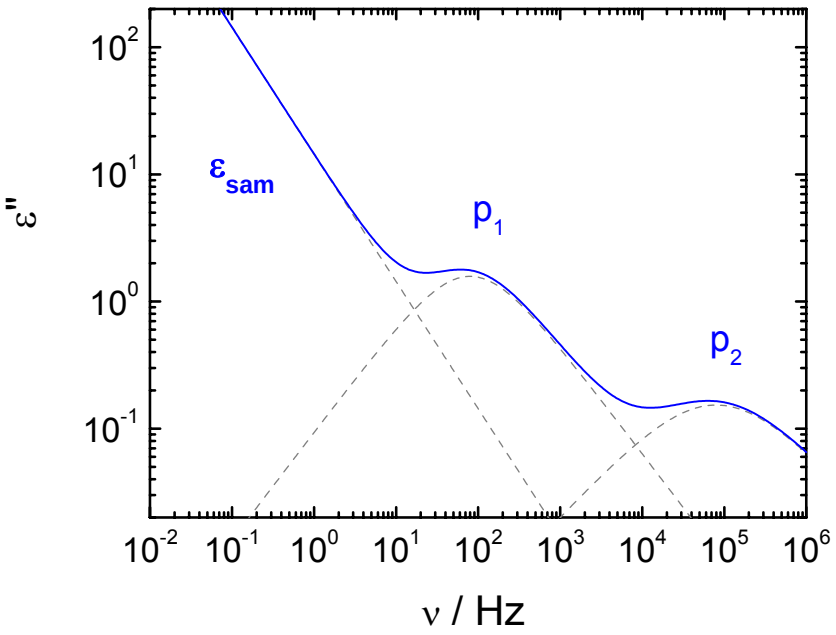
all by synthetic data



$\varepsilon_\infty = 2,$

$\alpha_1 = 0.85,\ \tau_1 = 2$ ms, $\Delta\varepsilon_1 = 4,$

$\alpha_2 = 0.70,\ \tau_2 = 2$ µs, $\Delta\varepsilon_2 = 0.5,$

$\sigma_{dc} = 8\times10{-}12$ S/cm

$$\varepsilon^*_{sam}(\omega) = \varepsilon_\infty + \frac{\Delta\varepsilon_1}{1+(i\omega\tau_1)^{\alpha_1}} + \frac{\Delta\varepsilon_2}{1+(i\omega\tau_2)^{\alpha_2}} + \frac{\sigma_{dc}}{\varepsilon_0 i\omega}$$

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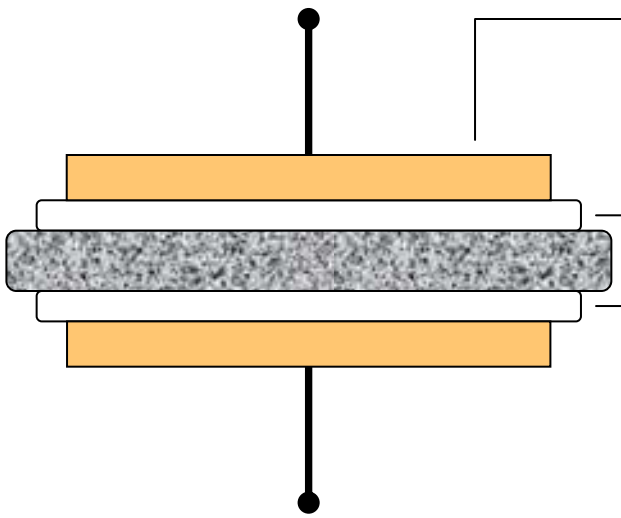
insulating the electrodes



electrodes:
area A

insulators:
total thickness d_{ins}
permittivity ε_{ins}

sample:
thickness d_{sam}
permittivity ε_{sam}

typical insulator: Teflon, PTFE (polytetrafluorethylene), $\varepsilon_s = 2.04$

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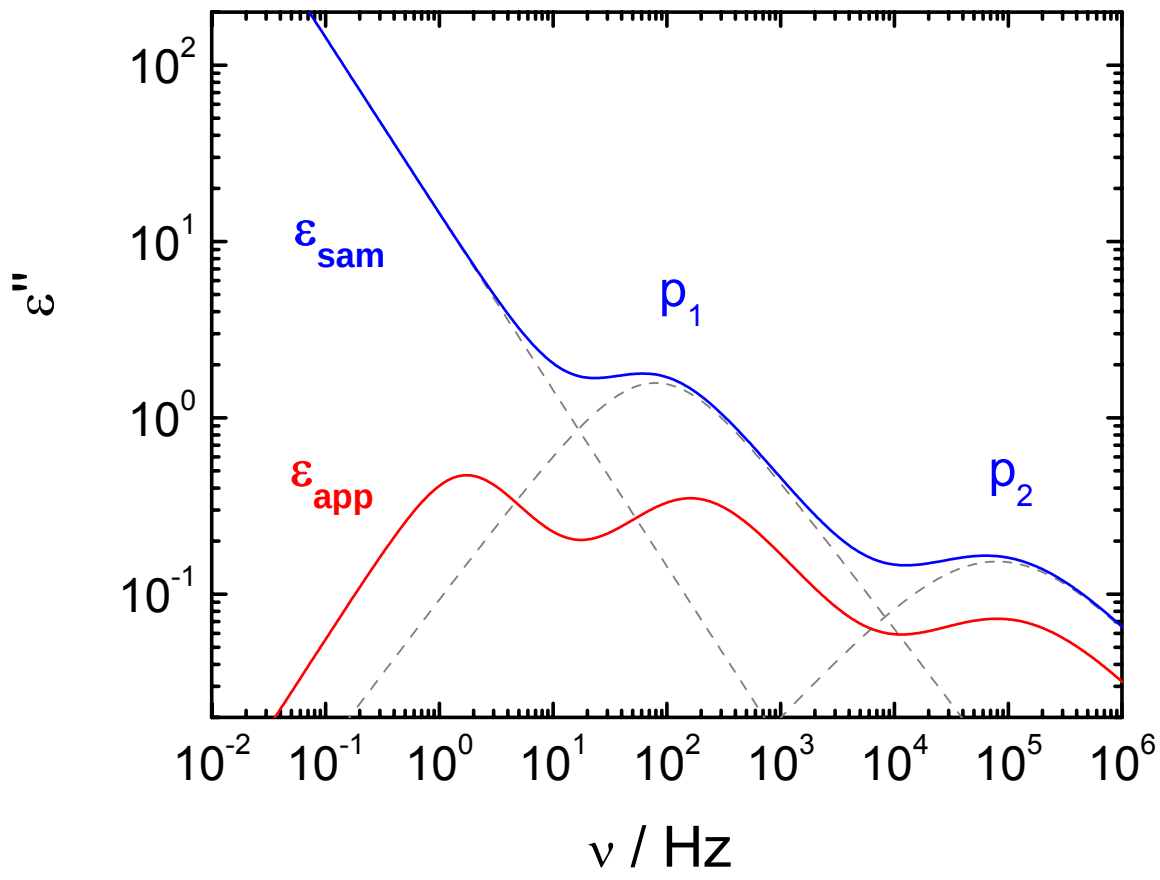
eureka ?



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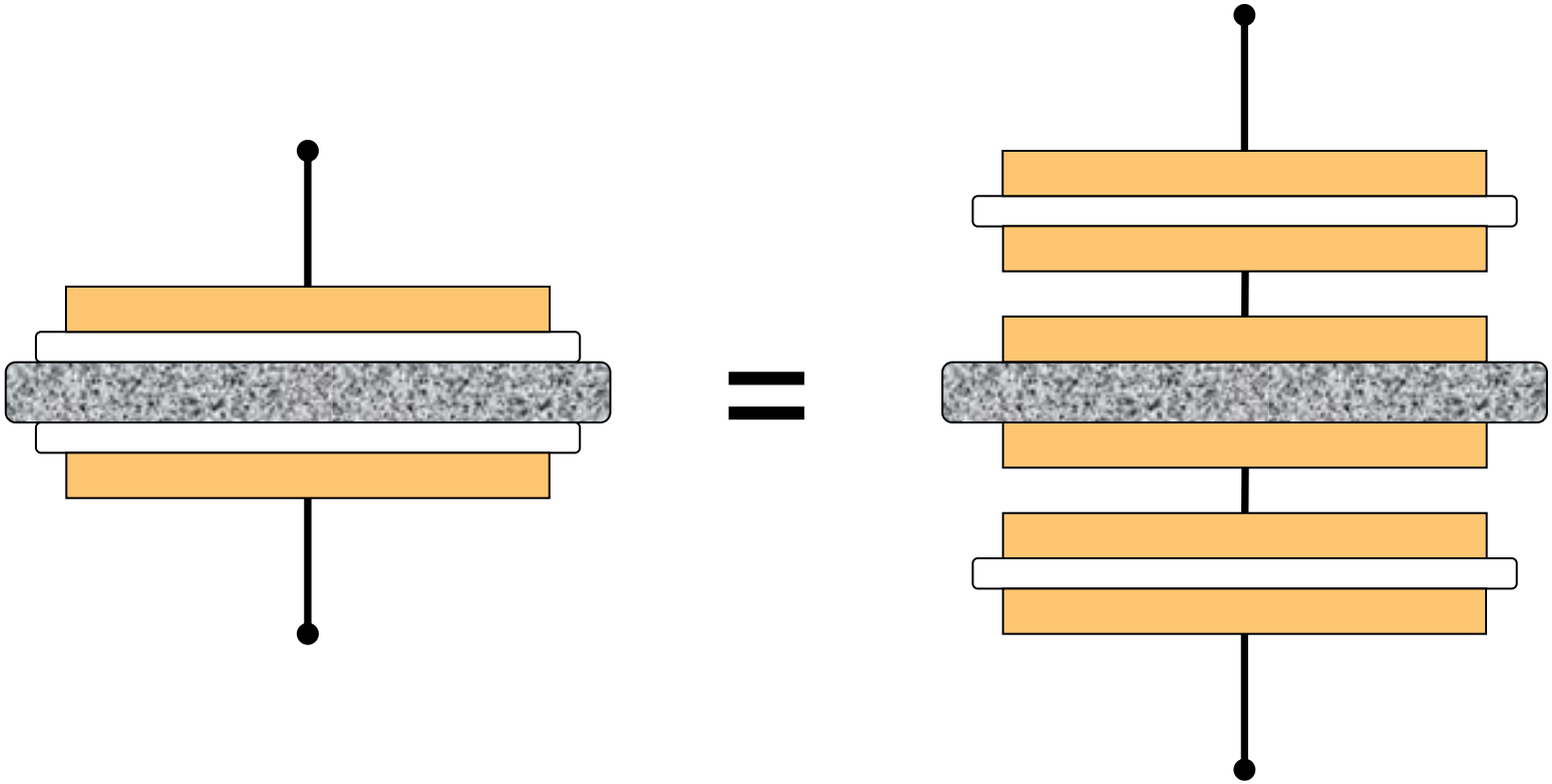
need to subtract the two 'Teflon-burgers'



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correction relations

$$Z_{app} = Z_{sam} + Z_{ins} \quad \text{with} \quad Z_x = \frac{1}{i\omega C_x} = \frac{d_x}{i\omega\varepsilon_0\varepsilon_x A}$$

$$\varepsilon_{app} = \left(d_{sam} + d_{ins}\right)\frac{\varepsilon_{sam}\varepsilon_{ins}}{d_{sam}\varepsilon_{ins} + d_{ins}\varepsilon_{sam}}$$

$$\varepsilon_{sam} = d_{sam}\frac{\varepsilon_{app}\varepsilon_{ins}}{\left(d_{sam} + d_{ins}\right)\varepsilon_{ins} - d_{ins}\varepsilon_{app}}$$

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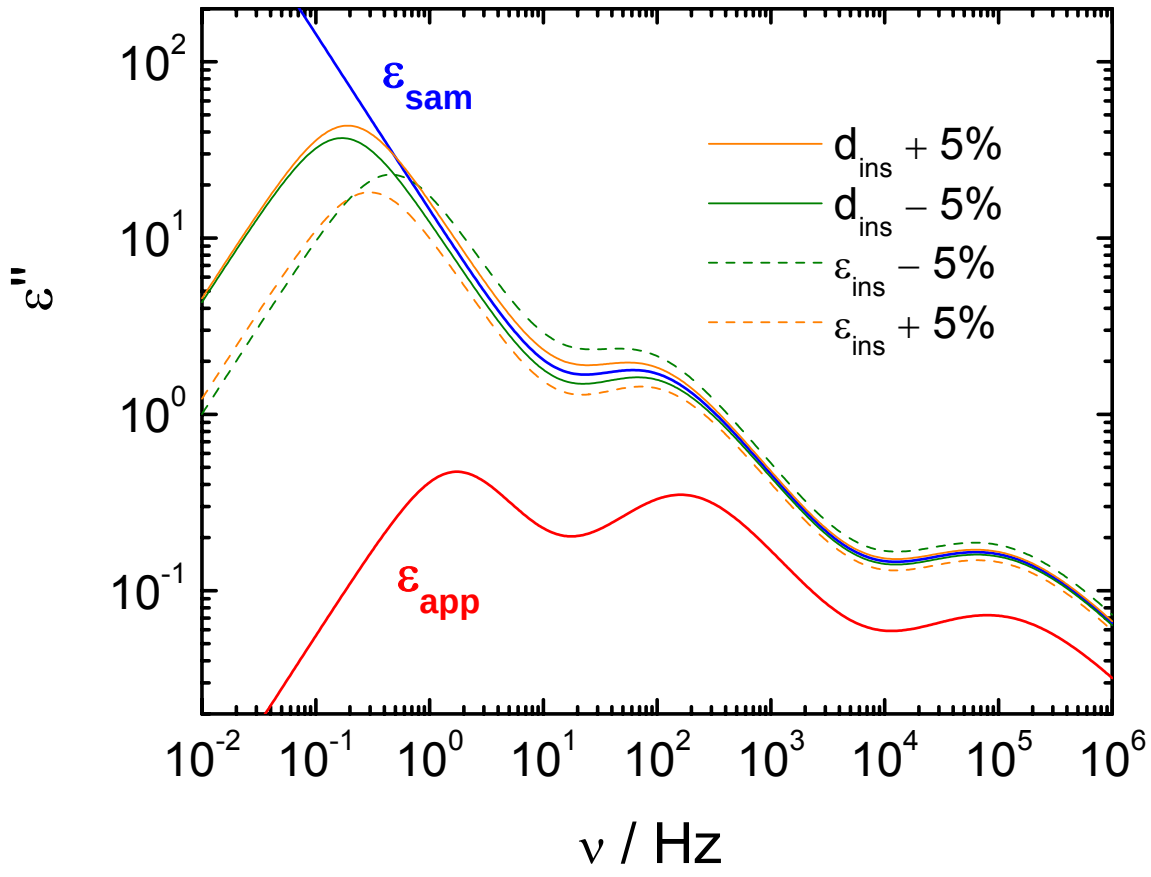
corrected data



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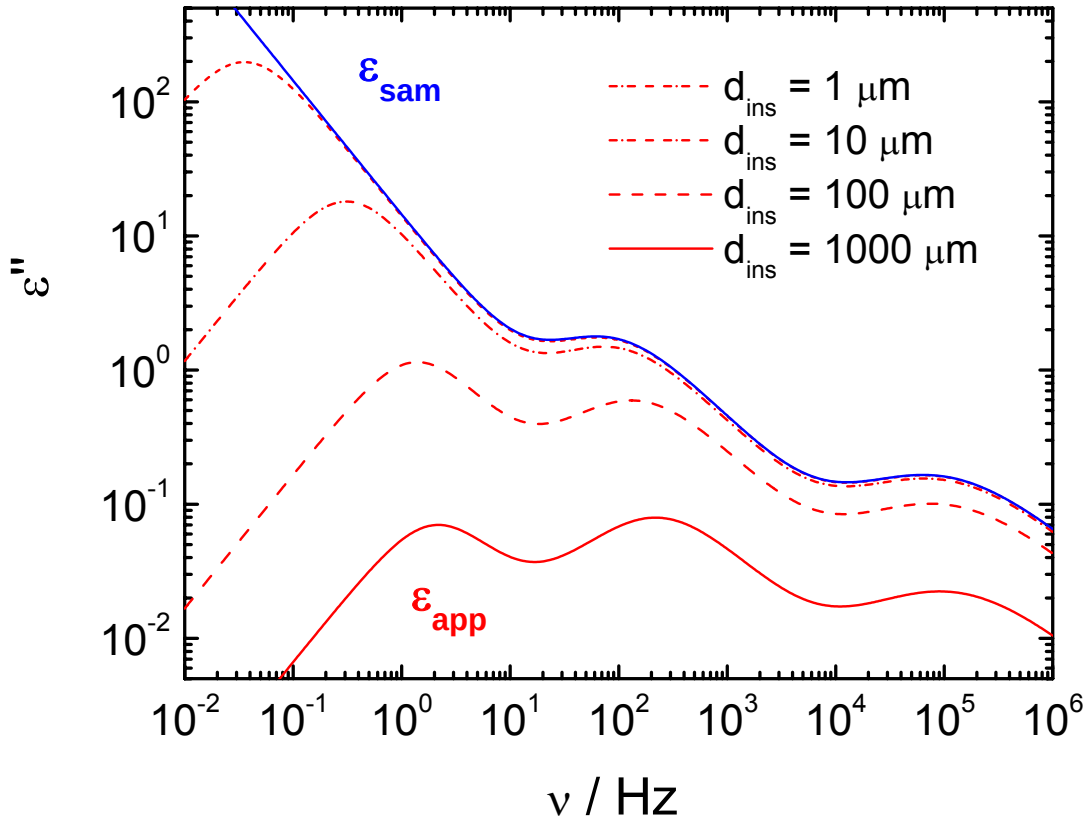
thickness is more relevant than insulating



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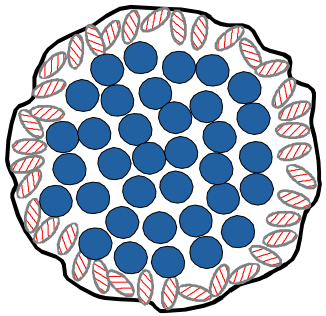
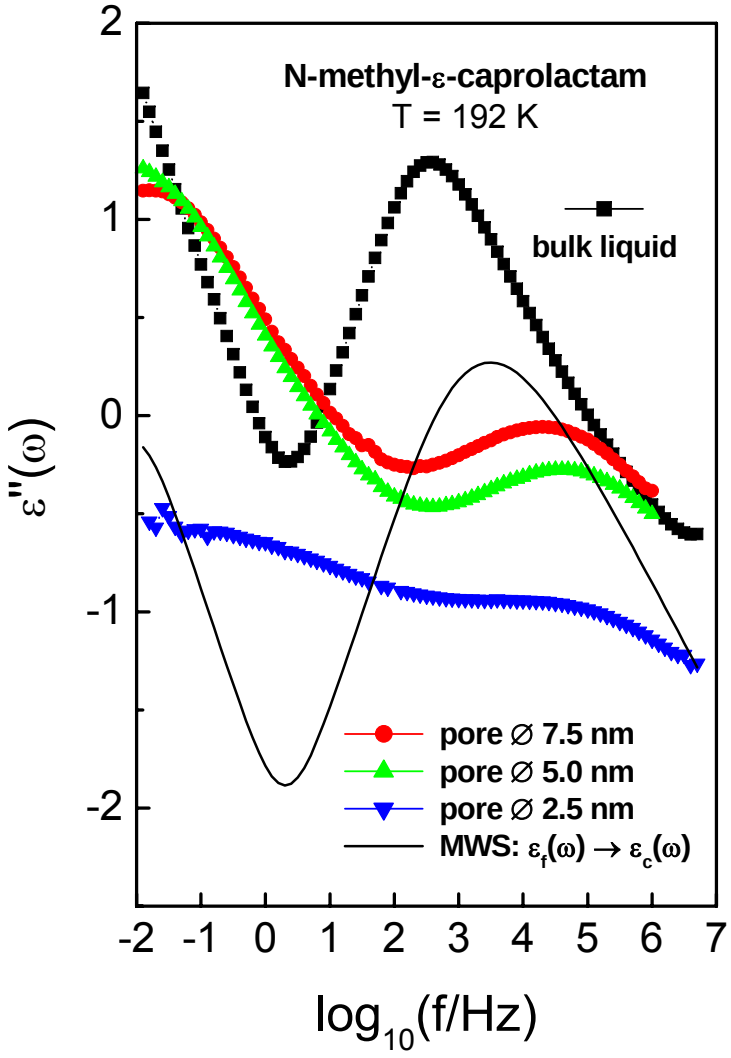
dielectric relaxation in porous glasses

nominal size	pore diameter	pore fraction	surface area
25 Å	26 Å	0.39	609 m^2/g
50 Å	46 Å	0.68	594 m^2/g
75 Å	84 Å	0.72	342 m^2/g

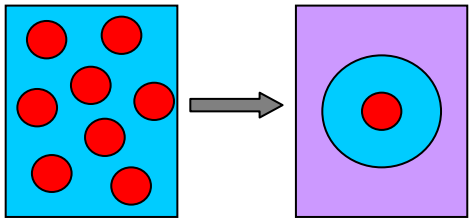




X. Yan, C. Streck, R. Richert, Mater. Res. Soc. Symp. Proc. 464 (1997) 33

dielectric relaxation in porous glasses

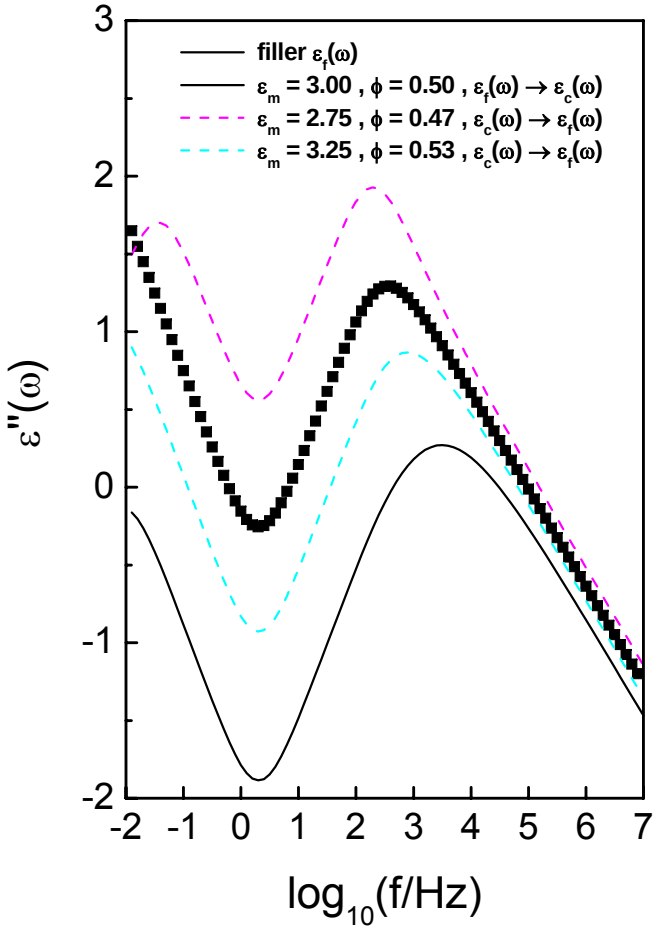
Maxwell-Wagner-Sillars



ε_f : filler
ε_m: matrix
ε_c : composite

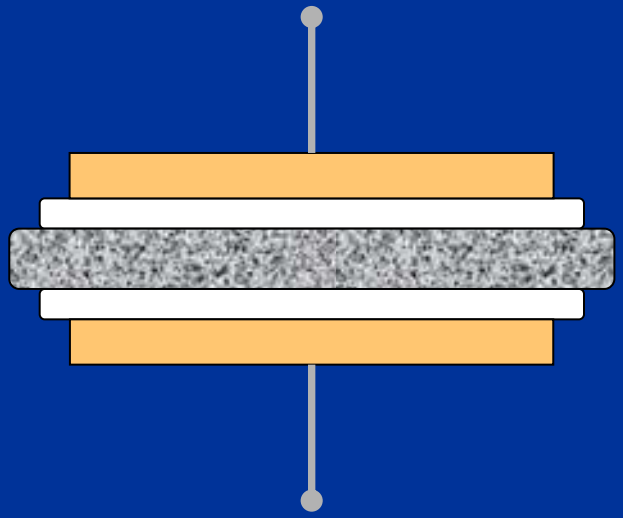
$$\varepsilon_c^*(\omega) = \varepsilon_m^*(\omega) \cdot \frac{\left[n \cdot \varepsilon_f^*(\omega) + (1-n) \cdot \varepsilon_m^*(\omega)\right] + (1-n) \cdot \left[\varepsilon_f^*(\omega) + \varepsilon_m^*(\omega)\right] \cdot \varphi}{\left[n \cdot \varepsilon_f^*(\omega) + (1-n) \cdot \varepsilon_m^*(\omega)\right] - n \cdot \left[\varepsilon_f^*(\omega) + \varepsilon_m^*(\omega)\right] \cdot \varphi}$$

R.W. Sillars, J. Inst. Electr. Eng. 80 (1937) 378



X. Yan, C. Streck, R. Richert, Mater. Res. Soc. Symp. Proc. 464 (1997) 33

CONCLUSIONS



- **Insulation will not help finding peaks that are otherwise hidden under dc-conductivity signal.**
- **Because of the necessary correction, the only effect is to add errors.**
- **Simple reason: proximity of PTFE will not change properties of sample.**
- **Only use of insulating is to prevent additional charges being added, but noble metals usually do the same.**

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