3.4.2 Summary to: Dynamic Properties - Dielectric Losses

- The frequency dependent current density *j* flowing through a dielectric is easily obtained. ⇒

$$j(\omega) = \frac{dD}{dt} = \epsilon(\omega)\cdot\frac{dE}{dt} = \omega\cdot\epsilon''\cdot E(\omega) + i\cdot\omega\cdot\epsilon'\cdot E(\omega)$$

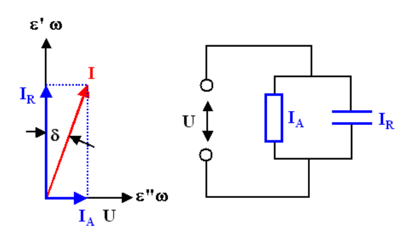
in phase — out of phase

  - The in-phase part generates active power and thus heats up the dielectric, the out-of-phase part just produces reactive power
  - The power losses caused by a dielectric are thus directly proportional to the imaginary component of the dielectric function

$$L_A = \text{power turned into heat} = \omega\cdot|\epsilon''|\cdot E^2$$

- The relation between active and reactive power is called "tangens Delta" (**tg(δ)**); this is clear by looking at the usual pointer diagram of the current

$$\frac{L_A}{L_R} := \text{tg}\,\delta = \frac{I_A}{I_R} = \frac{\epsilon''}{\epsilon'}$$



  - The pointer diagram for an *ideal* dielectric **σ(ω = 0) = 0**can always be obtained form an (ideal) resistor ***R***(ω) in parallel to an (ideal) capacitor ***C***(ω).
  - ***R***(ω) expresses the apparent conductivity **σ_DK**(ω) of the dielectric, it follows that

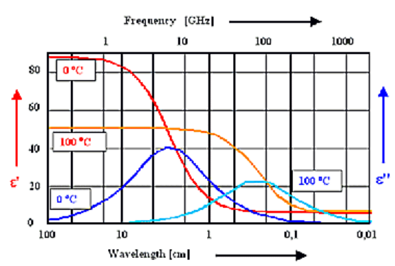
$$\sigma_{DK}(\omega) = \omega\cdot\epsilon''(\omega)$$

- For a *real* dielectric with a non-vanishing conductivity at zero (or small) frequencies, we now just add another resistor in parallel. This allows to express *all* conductivity effects of a real dielectric in the imaginary part of its (usually measured) dielectric function via

$$\epsilon'' = \frac{\sigma_{total}}{\omega}$$

  - We have no *all* materials covered with respect to their dielectric behavior - in principle even metals, but then resorting to a dielectric function would be overkill.

- A good example for using the dielectric function is "dirty" water with a not-too-small (ionic) conductivity, commonly encountered in food.



  - The polarization mechanism is orientation polarization, we expect large imaginary parts of the dielectric function in the **GHz** region.

  - It follows that food can be heated by microwave (ovens)!

Questionaire

Multiple Choice questions to all of 3.4