**Surface impedance of thin films**

**Definition**
The measured electrical resistance of our a-C films is $2.5 \times 10^5 \, \mu\text{Ohm.cm}$. The surface impedance calculations are done assuming $\varepsilon=\varepsilon_0$.

The film is deposited on stainless steel which has a resistivity of 75 $\mu\text{Ohm.cm}$. The frequency of the calculation is 40 MHz (arbitrary). All values reported are in MKS units.

**Calculations**

*Surface resistance as a function of thickness*

This plot gives the surface impedance of an a-C film deposited on stainless steel, as a function of its thickness. Red is real part, green is imaginary part.

Same, but zoomed at small thickness (note the different resistance scale):

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**Conclusion:** a-C is practically transparent for thickness < 1 µm and it has the surface impedance of stainless steel (0.01088 Ohm). At very large thickness (> 1 cm) it stabilizes to its own surface impedance.

**Surface resistance as a function of resistivity**
This plot gives the surface impedance of a film 100 nm thick and variable resistivity deposited on stainless steel. Red is real part, green is imaginary part.

![Surface Resistance vs Resistivity Graph](image)

Same, but zoomed at low resistivity:

![Surface Resistance vs Resistivity Graph Zoomed](image)

**Conclusion:** a film of 100 nm thickness deposited on stainless steel is practically transparent if it has a resistivity larger than that of stainless steel

**Note:** the calculation has been repeated assuming the relative dielectric constant $\epsilon_r$ equal to the graphite value of 5.4, considered as a reasonable benchmark. This gives results indistinguishable from $\epsilon_r=1$, since at these low frequencies the propagation coefficient $k$ is dominated by conductivity. (The dielectric (real) and conductive (imaginary) part of $k$ become of comparable magnitude only at about 40 THz.)

**To be done:** Frequency change (3D plots?)

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