Light in strongly scattering semiconductors - diffuse transport and Anderson localization
Gomez Rivas, J.

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Extrapolation length with an absorbing layer

The top of the Ge samples in chapter 4 is a thin absorbing layer. As it is demonstrated in this appendix, the absorption in the top layer affects the extrapolation factor (here called $\tau_e$) of the interface.

The calculation of the reflection coefficient of a double interface can be found in Ref. [135]. This calculation is here generalized for the case of an absorbing layer. With the reflection coefficient, $\tau_e$ can be evaluated as explained in section 2.2.2.

We assume a weakly or non-absorbing multiple scattering sample with an homogeneous and absorbing layer of thickness $\delta$ at one interface. The effective refractive index of the sample is given by $n_e$, while the absorbing layer has a complex refractive index $n_\delta^2 = n_\delta + i\kappa_\delta$. If $\kappa_\delta \ll n_\delta$ the absorption coefficient of this layer is given by $\alpha_\delta = 2\pi\kappa_\delta/\lambda$. The transmitted fraction $T_{ab}(\theta_1)$ of the diffuse light incident at the interface sample-layer at angle $\theta_1$ (see inset of Fig. B.1) is refracted according to Snell’s law and undergoes a ballistic propagation along the absorbing layer at angle $\theta_2$. Due to the absorption, the intensity of the transmitted fraction in attenuated by the factor $e^{-\alpha_\delta/\cos\theta_2}$. The light reaching the layer-air interface may be reflected with a probability given by the Fresnel’s reflection coefficient, $R_{bc}(\theta_2)$. The reflected fraction reaches the interface layer-sample, after being attenuated, where it may be reflected etc. Considering these multiple reflections at both interfaces the reflection coefficient of the absorbing layer is

$$R(\theta) = R_{ab}(\theta_1) + \frac{T_{ab}(\theta_1)R_{bc}(\theta_2)R_{ba}(\theta_2)e^{-2\alpha_\delta/\cos\theta_2}}{1 - R_{ba}(\theta_2)R_{bc}(\theta_2)e^{-2\alpha_\delta/\cos\theta_2}}. \quad (B.1)$$

In Eq. (B.1) the indexes a, b, c stand for medium a = sample, b = absorbing layer
and $c = \text{outside medium}$, as it is illustrated in the inset of Fig. B.1, and, for instance, $R_{ab}$ is the Fresnel’s reflection coefficient of the interface between medium $a$ and $b$.

With the reflection coefficient, given by Eq. (B.1), the extrapolation factor can be calculated following the procedure described in section 2.2.2.

In Fig. B.1 the extrapolation factor $\tau_e$ is plotted as a function of $(\delta \alpha_\delta)^{-1}$. In this example $n_c = n_\delta = 1.6$ and, for simplicity, the Fresnel’s reflection coefficients are calculated for dielectric media. As the absorption in the layer gets stronger, $\tau_e$ becomes smaller. The reason for the decrease of $\tau_e$ is the lower light intensity that leaves the sample due to absorption in the top layer.

**Figure B.1**: Extrapolation factor of a double interface or layer as a function of $(\delta \alpha_\delta)^{-1}$, where $\delta$ is the thickness of the layer and $\alpha_\delta$ its absorption coefficient. Inset: The light leaving the sample (medium $a$) at an angle $\theta_1$ is refracted according to Snell’s law. It propagates through the layer (medium $b$), where it is attenuated by absorption. At the interface between medium $b$ and $c$ the light may be reflected with a probability given by the Fresnel’s reflection coefficient. The reflection coefficient of the layer is given by the multiple reflections at both interfaces.