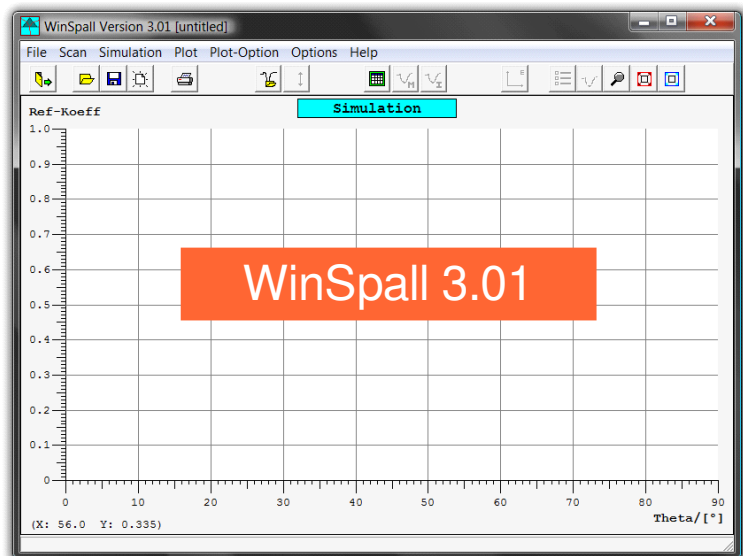


Surface Plasmon Resonance Simulate your reflectivity curve with WinSpall

Introduction

WinSpall is a software for the simulation of surface plasmon resonance curves based on the Fresnel formalism. WinSpall is easy to use and lets you model reflection curves pretty much „right away“. This slide show walks you through the first steps.

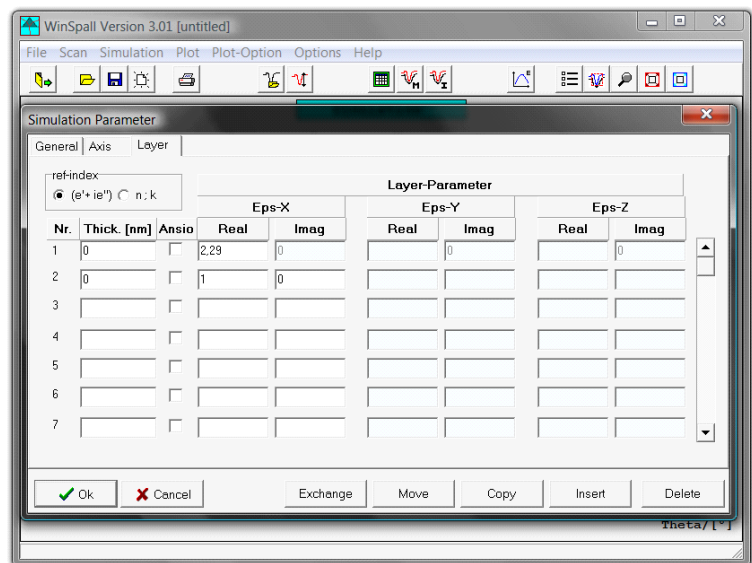


Take a few minutes and learn how to translate simple multilayer configurations into surface plasmon resonance curves.

Note: WinSpall can be downloaded at:
<http://res-tec.de/downloads.html>

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Let's get started: The layer system table

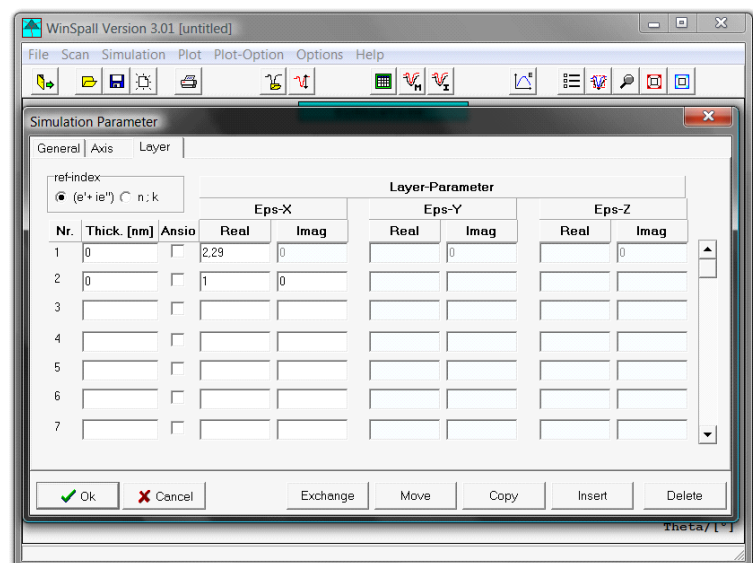


Generating a layer system is easy. Pick "Simulation » Parameter" to open the multilayer table. Don't be scared! It looks a lot more complicated than it is.

For the moment, we don't care for anisotropy or other complicated layer systems. All we need are the columns "Thickness" and "Eps-X". The latter describes the real and imaginary part of the dielectric constants of all materials and media involved. Not so much, as you will see.

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A simple start: a laser beam, a prism and air

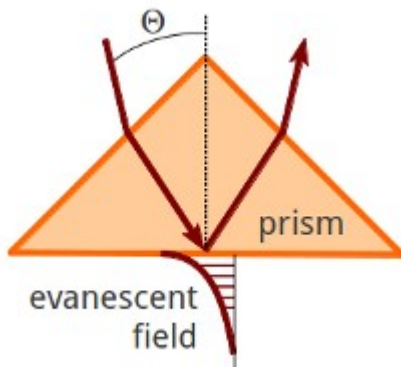


Let us consider the simplest experiment: A laser beam is reflected from the base of a prism and the reflected light is collected as a function of the angle of incidence (taken against the surface normal). We need the optical constants of the prism and of air.

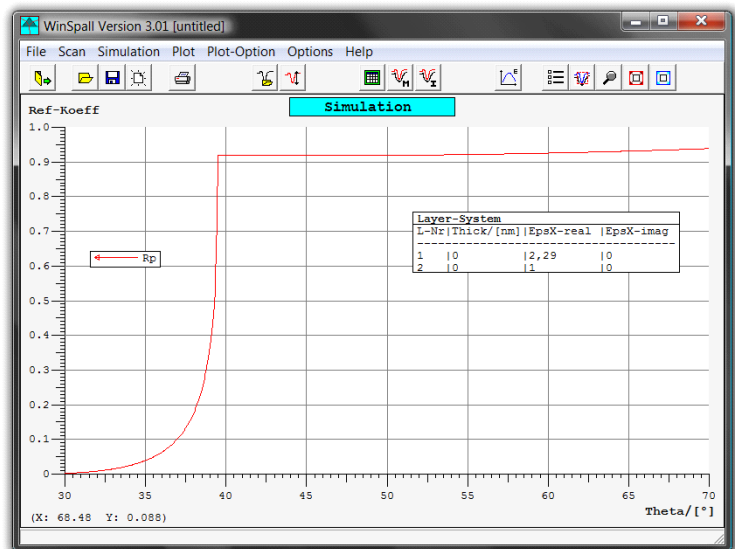
This is what we need to fill into our table of optical components: No. 1 is the prism. Not a layer and so we chose "0" for the thickness. The real part of the dielectric constant is $\epsilon' = 2.29$ in our example (corresponding to a refractive index of $n=1.51$). There is no adsorption in the glass and, hence, the imaginary part is zero. The next component (No. 2) is air with "no thickness", and $\epsilon'=1$ ($n=1$), and $\epsilon''=0$ (no absorption). We are done. Let's click "Ok".

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Total reflection at a glass-air-interface



Here is what we get: A typical curve describing total internal reflection. Light is reflected from an interface separating high index from low index material.

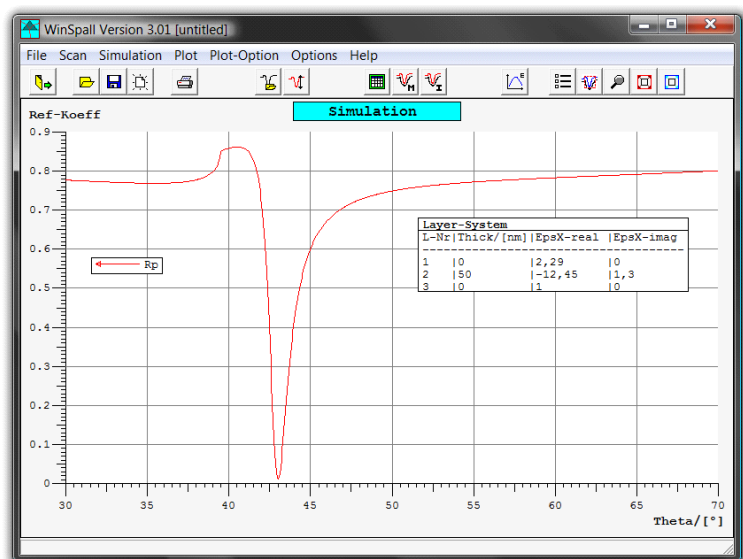


At low angles basically all light passes through the interface without any reflection. Just below about 39° more and more light is reflected until total internal reflection is reached.

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Time for plasmons: let us add a some gold

We go back to our simulation table and add an optical component between the glass and the air: a 50 nm thick gold layer with the optical constants "Eps-X real"=-12.45 and "Eps-X imag"=1.3. Those are typical values for gold but can vary to some extent due to slight differences in the evaporation process.

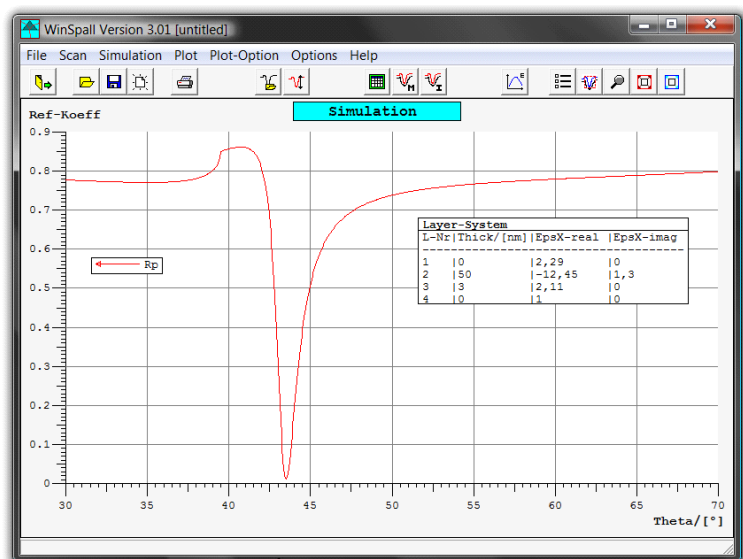


The reflectivity curve we get looks totally different: First, the strong increase from 0 to almost 1 around the angle of total internal reflection is much more shallow due to the reflective properties of the gold. Secondly, a surface plasmon shows up as a strong dip in reflectivity at around 43°. The entire intensity or the laser beam is now bound in this plasmon and no part of the light is reflected. This curve now describes the optical properties of a typical "blank substrate" used for surface plasmon measurements.

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Get real: plasmons and thin layers

We have now added a 3 nm layer on top of the gold with a dielectric constant of $\epsilon=2.11$ ($n=1.45$) – maybe some polymer or a protein. The plasmon resonance has shifted a little. The arrow marks the previous minimum. We are now about half a degree higher.



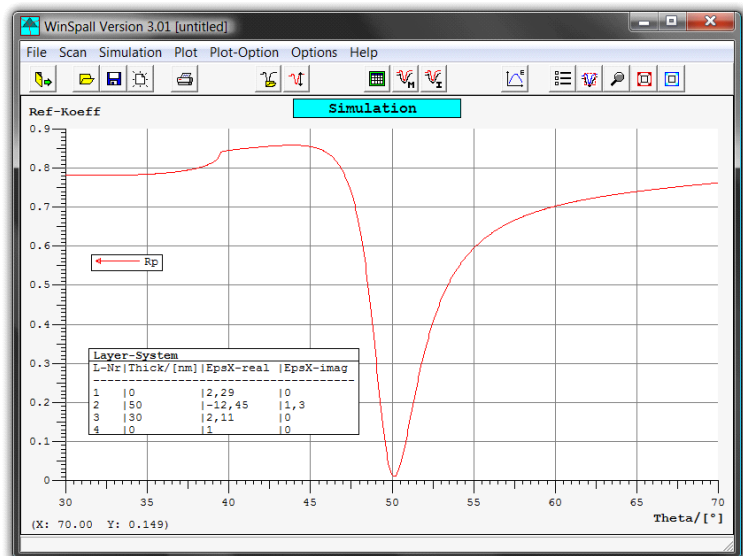
Such a shift is easily measured and we see right away that Surface Plasmon Spectroscopy is well suited for the investigation of such thin layers.

Additionally, evaluation of the reflectivity curves is quite simple with WinSpall: all we had to do is to fill in the simulation parameter table.

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Getting thicker: 30 nm

Thicker layer, now 30 nm,
leads to a stronger shift of the
plasmon resonance.

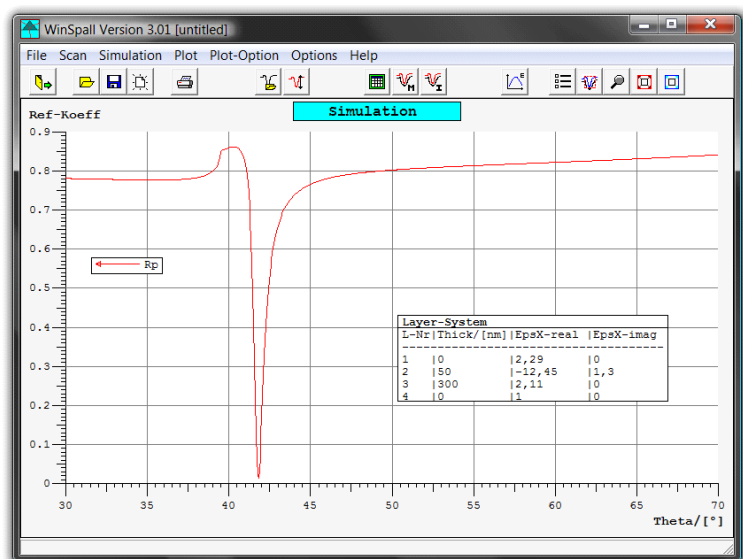


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Getting thicker: 300 nm

Even thicker: 300 nm and we find something new. A very sharp dip in the reflectivity curve but at a smaller angle. This is not a plasmon, this is a waveguide mode. The first waveguide for this layer system.

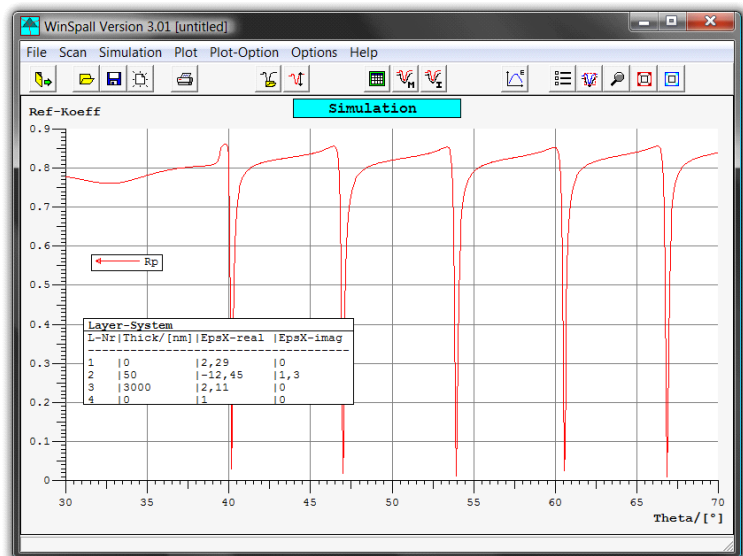
There are more to come as the layer gets thicker ...



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Many waveguide modes

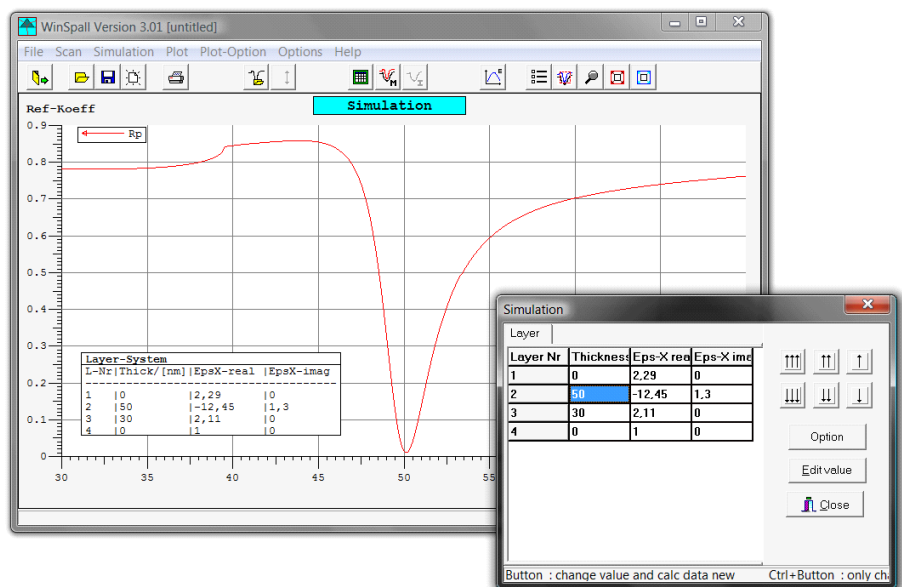
As we go to even thicker layers we find more and more waveguides in our reflectivity spectrum. Above you see five modes in the range up to 70° for a 3 μm thick layer. Note, that waveguides can also be found for s-polarized light.



This can, of course, also be simulated using WinSpall. It is easy to find. Try it out yourself and you will quickly get the result.

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Manual simulation



Res-Tec tutorial #2

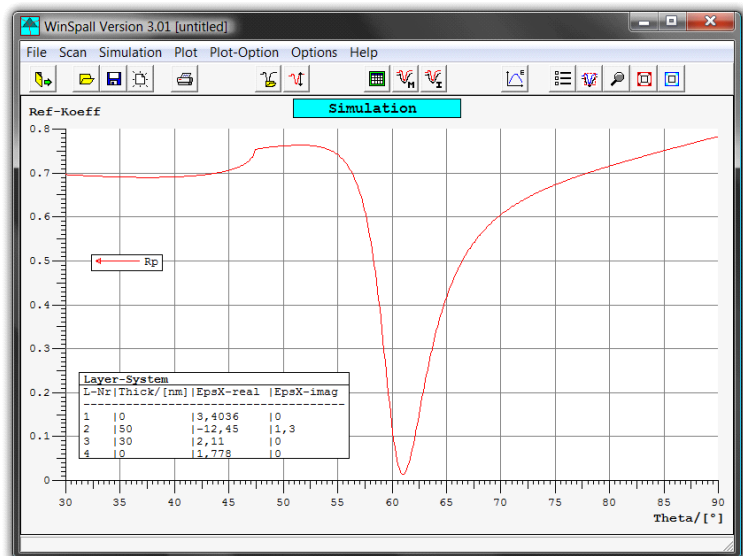
Over time it gets somewhat troublesome to edit the parameter table. “Manual simulation” is the more convenient tool to change parameters of your layer system. Pick the tool from the “Simulation” menu and a small version of your multilayer system will appear. Note the triple, double, and single arrows pointing up and down on the buttons next to the table. Highlight any parameter in your table and use the arrow buttons to quickly change the parameter in big, medium or small steps.

You will very quickly learn how the different values influence your simulated reflectivity curve. A good way to get “a feeling” for your measurements.

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Out of the air and into the water

Our last topic in this tutorial deals with a measurement of a layer against water. Water has a rather high refractive index as compared to air and it is the difference between this quantity and the refractive index of the prism that determines the angular range available



It is necessary to use a high refractive index glass prism and this is accounted for in our table: $\epsilon' = 3,4$ for the glass and still the edge of total reflection of our system shifts to about 47° and the resonance minimum of a 30 nm thick layer is found at an angle higher than 60° .

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Summary, or “Where is the beef!”

Some “take-home-messages”:

- WinSpall is a fairly simple and user-friendly software to model surface plasmon resonance curves.
- Rather small thickness changes translate into quite remarkable shifts of the resonance angle.
- Model calculations can help to decide if a certain question can be addressed using SPR or not.
- The “manual simulation” mode allows for a quick adjustment of individual parameters.
- Waveguide modes may be useful to characterize thicker layers.