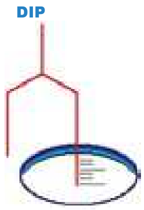
Improving layer thickness determination by the combination of depth profile modelling and DiP



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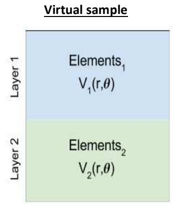
1. Motivation

Glow discharge optical emission spectroscopy (GDOES) is a technique to analyse depth profile composition of multi-layer materials and coatings by detecting emissions from sputtered atoms. However, the eroded crater shape has a significant impact on GD analysis and especially on the shape of the interfaces. This leads to layer broadening on one side and uncertainty on interface positioning on the other side. The goal of this work is to better understand the impact of crater shape on intensity signals. For this purpose, we use a numerical modelling based on a virtual sample.



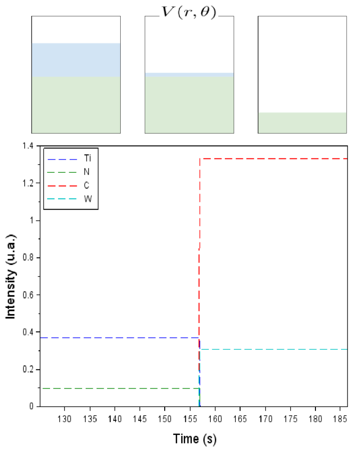
2. Crater shape

The sputtered atoms are excited by collision and finally emit photons when returning to a steady state. We simulate the depth profile measurement by modelling photon flux intensity analysed with the spectrometer, The intensity of the photon flux is related to the erosion rate in this way :

$$\mathcal{I}(t) \propto V_0(t) \int_r \int_\theta V(r,\theta)\ r\mathrm{d}r\mathrm{d}\theta$$

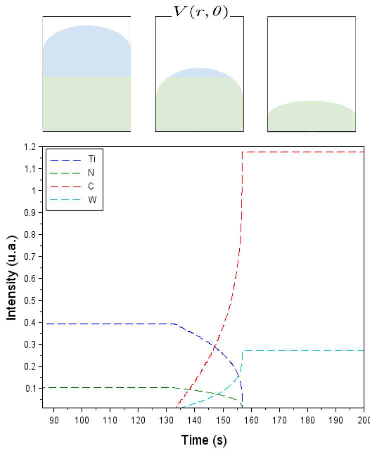
Flat crater

The erosion rate is presumed constant in a given layer. Moreover, the crater is flat. So the number of photons from a same layer is constant.



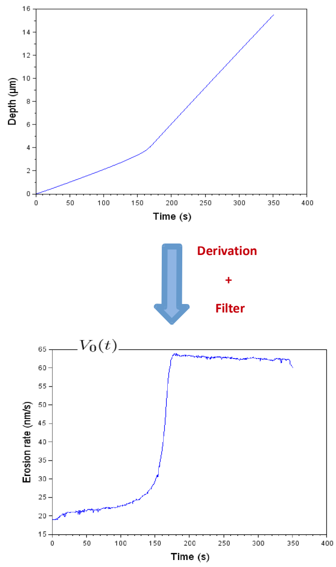
Non flat crater

In this example, the erosion rate is lower at the center. That induces a smooth transition between the layers and an uneasy interface positioning.



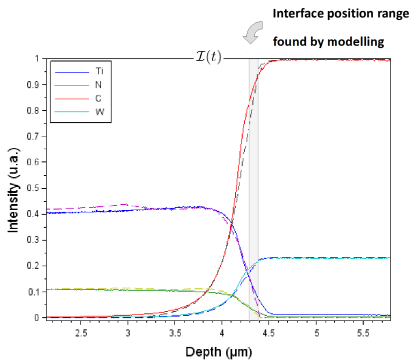
3. Erosion rate at the center of the crater

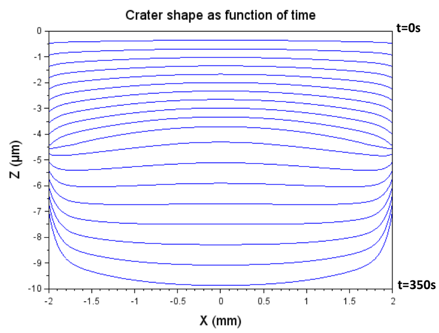
The erosion rate are material dependent. Thanks to DiP, we have a direct measurement of the depth as a function of time. A laser source is separated into two beams. The interference between the two reflected beams is measured as the sample is sputtered, simultaneously with the GDOES analysis, giving a direct measurement of the crater depth.



4. Model / experiment comparison

The fitting strategy is to describe the erosion rate V(r,θ) as a polynomial function of the radial coordinate, resulting in a non flat crater shape, and to model the sample as a stack of layers, with thickness as a parameter (virtual sample). Then, we can calculate the corresponding depth profile, and fit to the data. For this purpose, we have to adjust several parameters including polynomial coefficients of the erosion rate and layer thickness. By combining the modelling of GDOES signals and an in situ measurement of the depth as a function of time (DiP), we succeed to refine the determination of layer thickness thanks to a better understanding of erosion rate and crater shape impacts on depth profile.





5. Conclusion

This preliminary research work aimed at improving the estimation of layers thickness. Combining DiP measurement and intensity profiles modelling is a promising tool to have a better understanding of crater shape impact on GD analysis. But, the model is still vulnerable to roughness, thin layers and measurement conditions.