Full Wafer Map Response Surface Models for Combinatorial Chemical Vapor Deposition Systems

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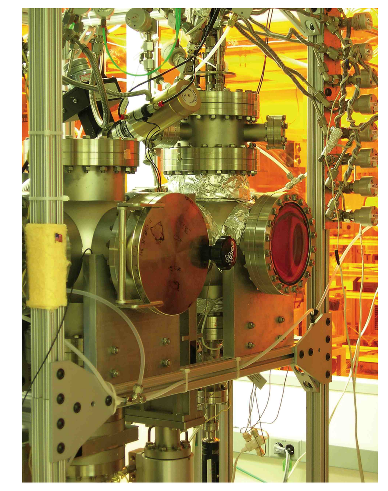


Combinatorial CVD

Chemical Vapor Deposition (CVD) is a method for building layers of non-volatile solids in a wafer through the decomposition of relatively high vapor pressure gases. The gaseous compounds of the materials to be deposited are transported to a substrate surface where a thermal deposition occurs.

In some CVD processes, it is necessary to control a film property profile (thickness, microstructure, composition, etc.) to a specific, spatially non-uniform distribution. Through a combinatorial approach it is possible to

- Reproducibly deposit intentionally non-uniform films across the substrate
- Model the deposition system to correlate processing conditions to desired film qualities

⇒ Rapid development of new materials and corresponding process recipes becomes possible

Response Surface Models

The Response Surface methodology may be divided in three major steps:

- Design of Experiments
- Regression Analysis and Statistical Analysis
- Predictions and Desired Response

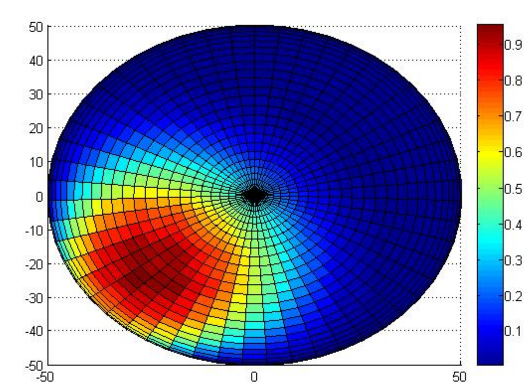
RSM computational toolbox

- A library of MATLAB object-oriented functions, based on accurate quadrature methods, used for wafer map representation, interpolation and analysis
- Wafer modeling methods that take as input a vector of wafer objects and construct response surface models with output in the form of *full-wafer maps*
- Performs Statistical Analysis on the obtained models

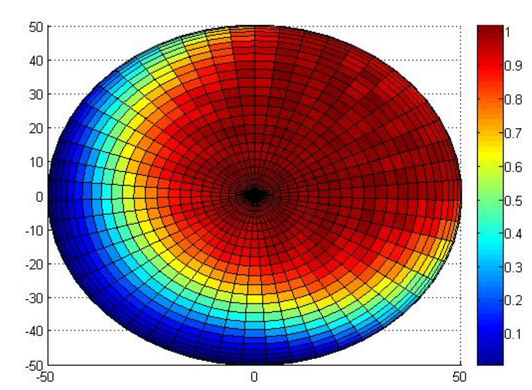
Artificially Generated Wafers

To test the *RSM computational toolbox* a set of artificial wafers were generated using different values for a and b and following the function

$$W = Wo + WA(a-3)(a-0.3)(a+6) + \ldots$$
$$WB(b+5)(b-0.1) + WA\ WB(a-0.3)(b-0.1)$$

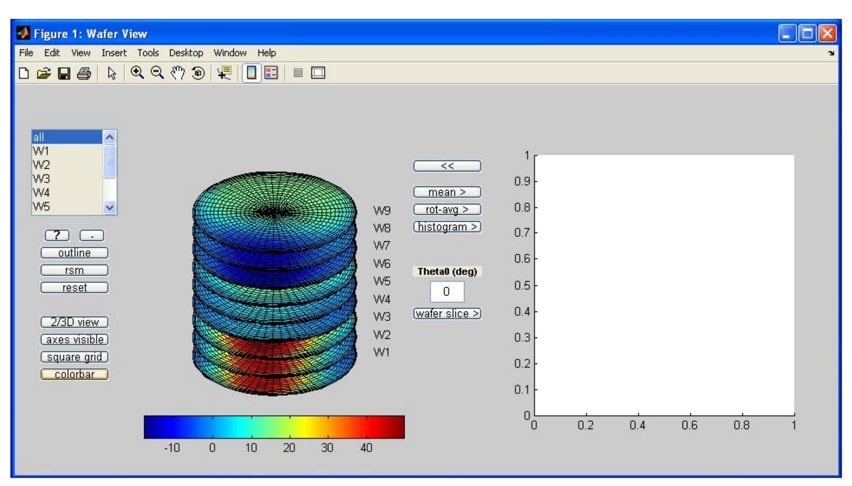


WA



WB

The data generated was given as input to the *waferview* function and a response surface model (2^{nd} order) was calculated



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Terms :  mean Bcoeff  (mean std error)
----------------------------------------
   b0 : 1.88625e+000 (6.81773e-002)
   b1 : -3.39826e+000 (1.86711e-002)
   b2 : 3.32279e+000 (1.86711e-002)
 b1,1 : 6.14341e-001 (1.61697e-002)
 b1,2 : 1.18834e-001 (1.14337e-002)
 b2,2 : 6.85457e-001 (1.61697e-002)

mean(R^2) : 0.99977
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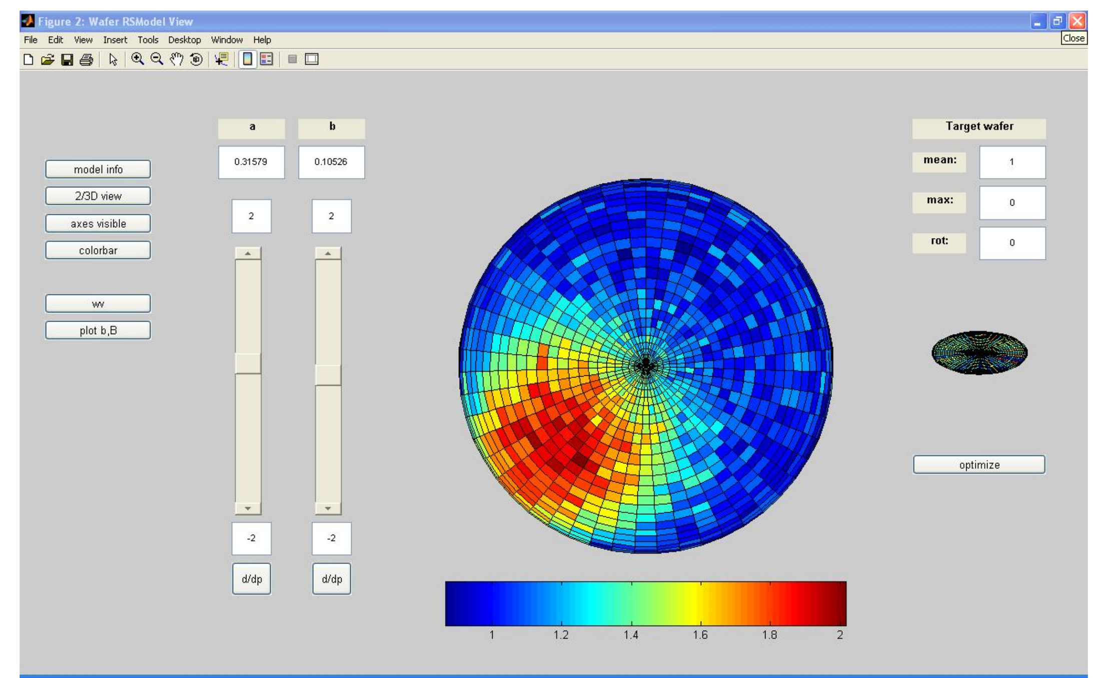
Uniformity as a Desired Response

The "optimal" values for the variables a and b that will give a uniform wafer with a mean thickness of 1 are calculated using the *optimize* command on the *Wafer RSModel View* window



- From the formula used to generate the artificial wafers it is clear that uniformity is achieved when $a = 0.3$ and $b = 0.1$
- The calculated "optimal" values using the *wafermodelview* function are $a = 0.316$ and $b = 0.105$

Conclusions

- The usefulness of the *rsmodel* toolbox was demonstrated using artificially generated data
- The toolbox is being extensively used for data obtained with a CVD programmable reactor
- Future work includes applying the toolbox on rectangular substrates for CVD of solar energy materials

†**For more information: http://www.isr.umd.edu/Labs/CACSE/A-Team**