Characterization of growth rate and interfacial roughness of Multilayer Optical X-ray Coatings

GOAL OF PROJECT:

- CHARACTERIZING THE NEW PROFILE COATING SYSTEM
- DEPOSIT MONO AND MULTILAYERED THIN-FILMS
- USING XRR AND IMD SIMULATIONS FOR D-SPACING ANALYSIS

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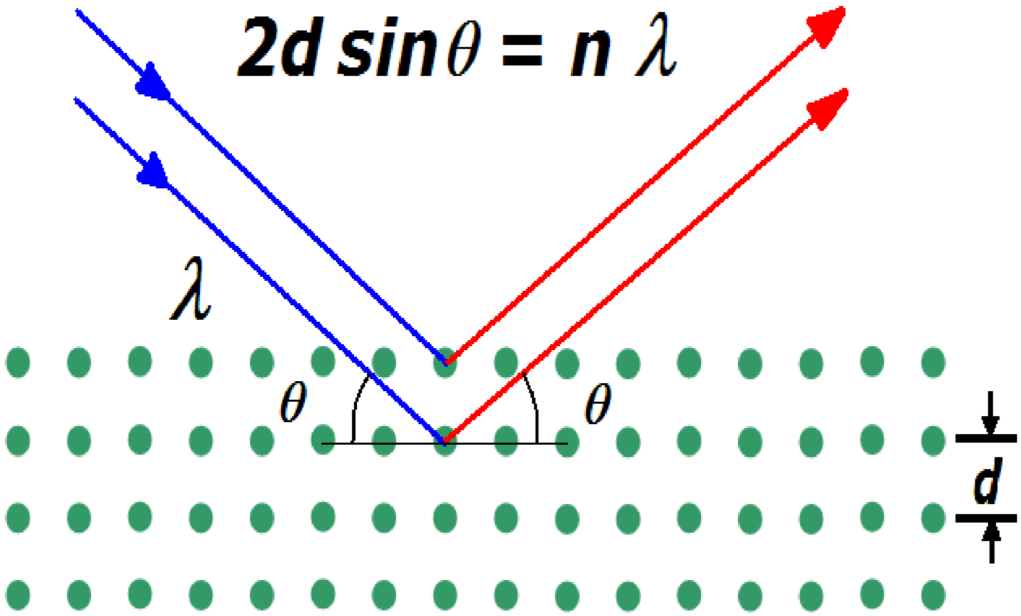
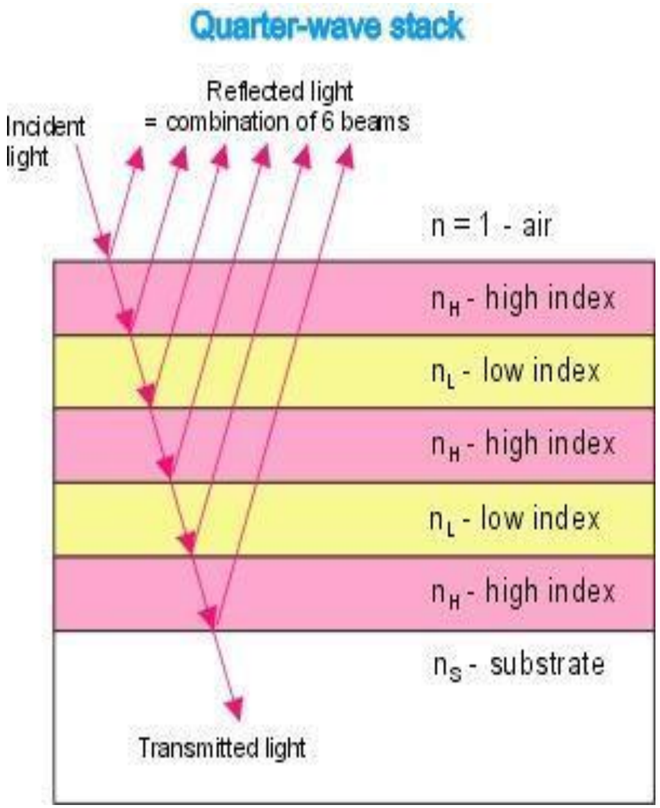
BRAGG'S LAW



Crystal

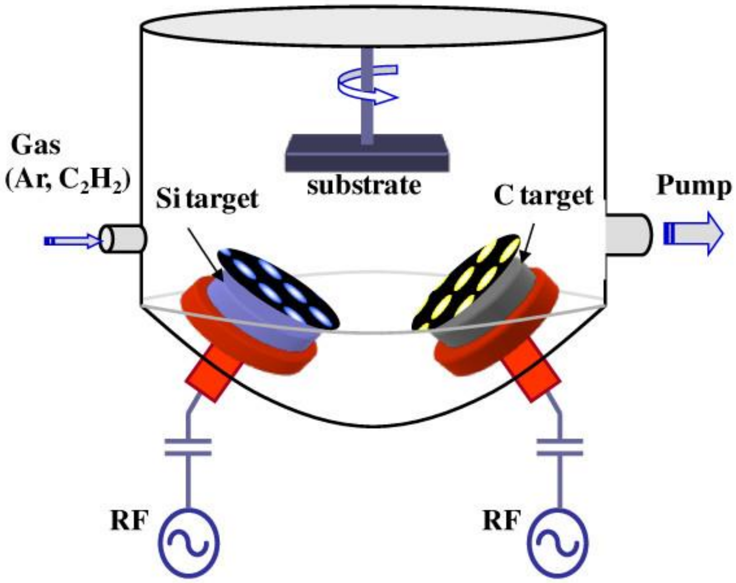
vs

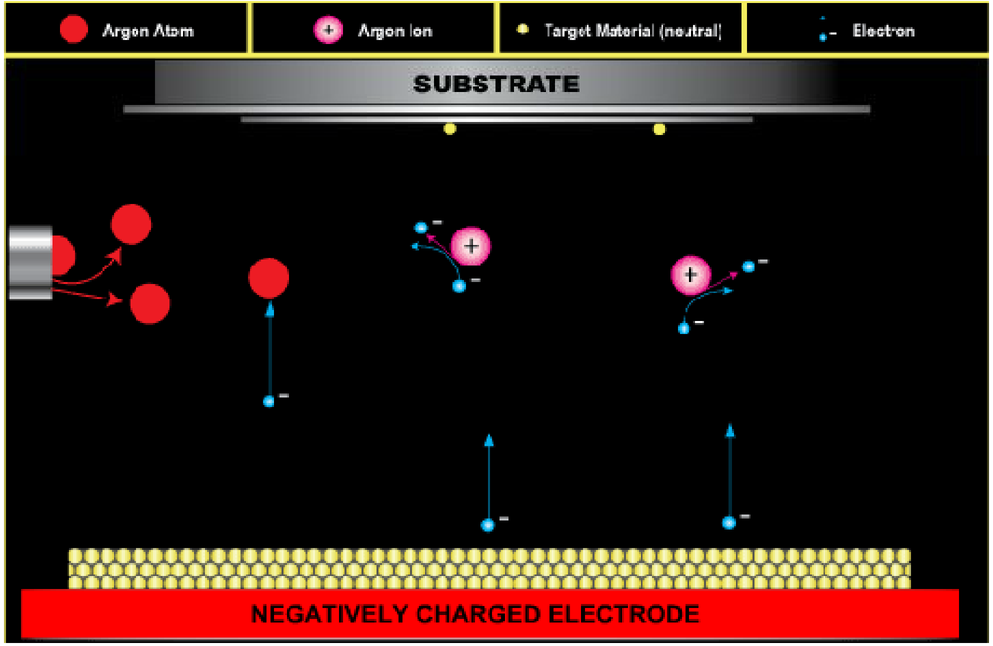


Thin film

Experiment

- MAGNETRON SPUTTERING





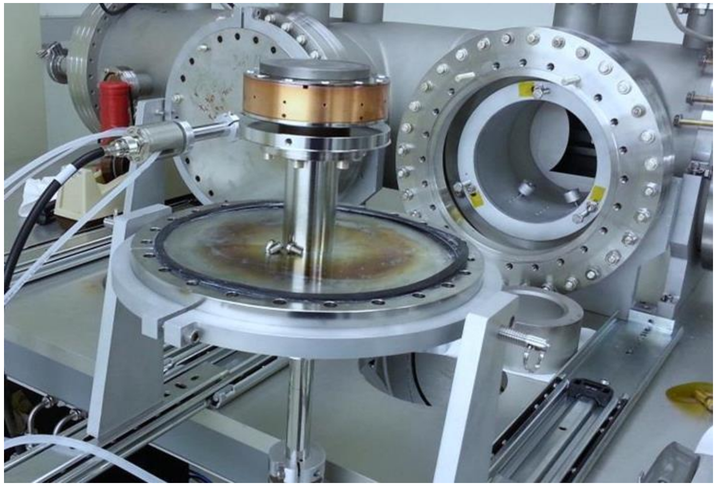
Parameters

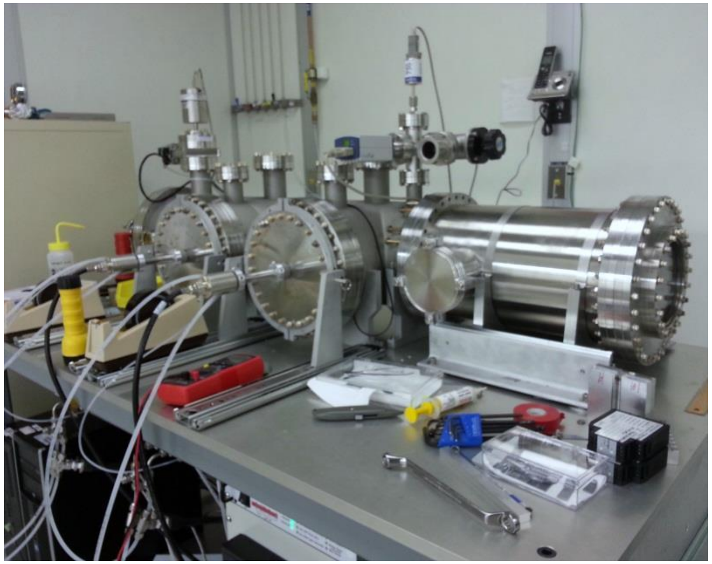
- INVESTIGATE SPUTTERING PARAMETERS
  - INDEPENDENT VARIABLES
    - Power
    - Gas-mixture percentages (N_2)
    - Substrate target distances
  - DEPENDENT VARIABLES
    - Growth Rate
    - Interfacial Roughness

Experiment

Argonne NATIONAL LABORATORY

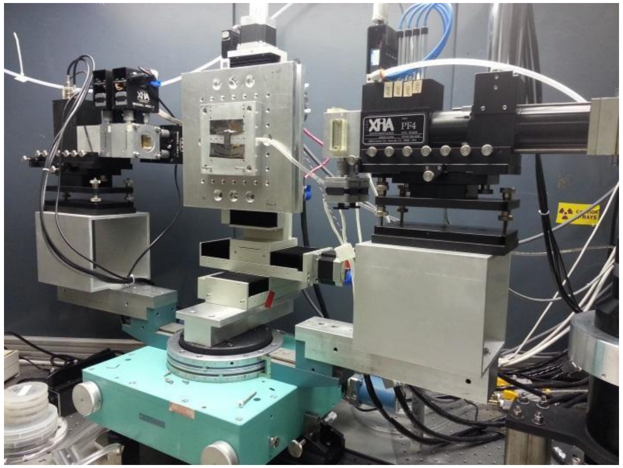
- DEPOSITION SYSTEM
  - Uses Magnetron Sputtering
  - Tungsten and Boron Carbide bilayers
  - Gaseous (Ar + N_2) plasma
  - 1 mT vacuum conditions
  - High performance servo drive

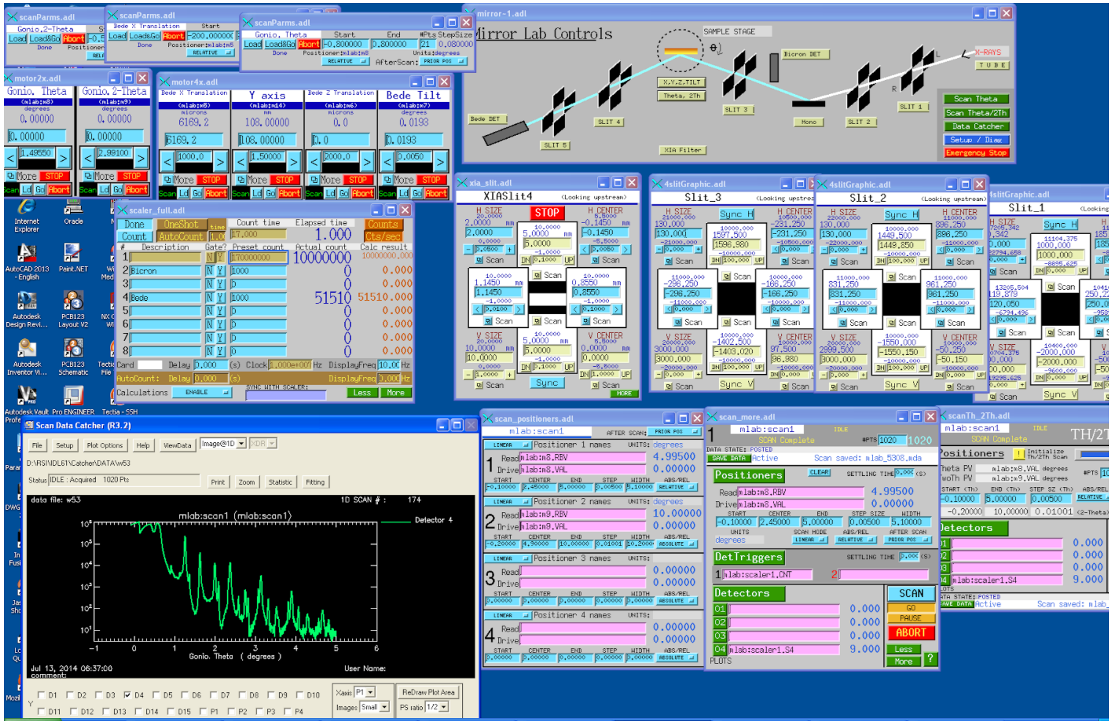




Experiment

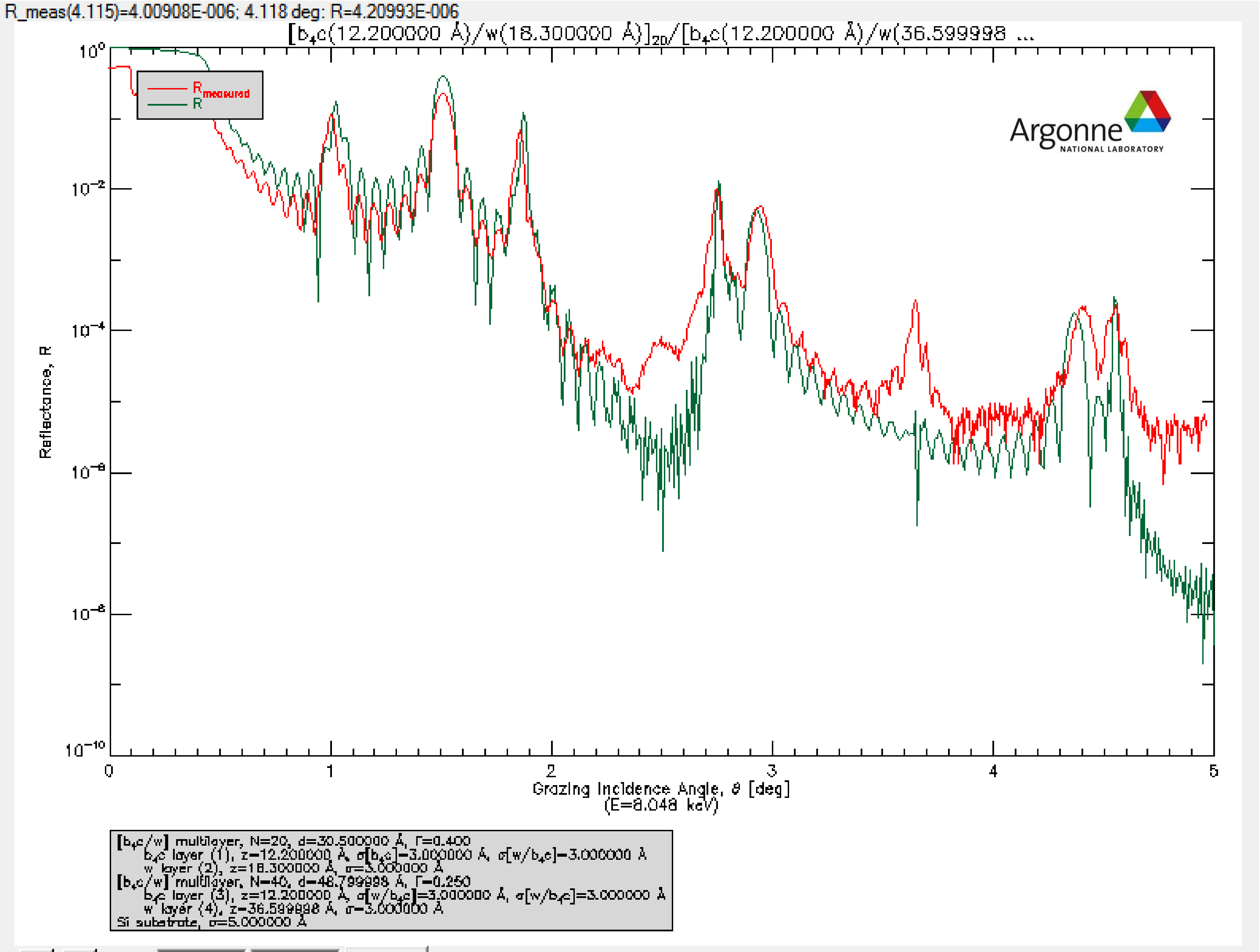
- XRR
  - E = 8.048Kev or 1.54Å
  - Bragg’s Law
  - -0.1 to 5 degrees grazing angle
  - X-Ray Reflectivity inversely proportional to interfacial roughness





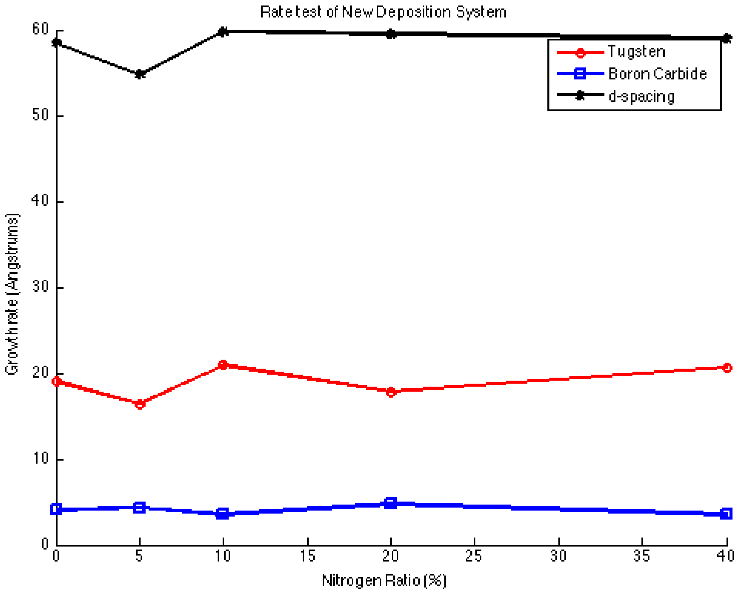
Experiment

- SIMULATIONS
  - XOP IMD Program
  - Adjust d-spacing, gamma ratio and surface roughness to create simulations
  - Find growth rate during rate test to create monolayers of $\gamma = 0.5$
  - Finding relationship between the independent and dependent variables

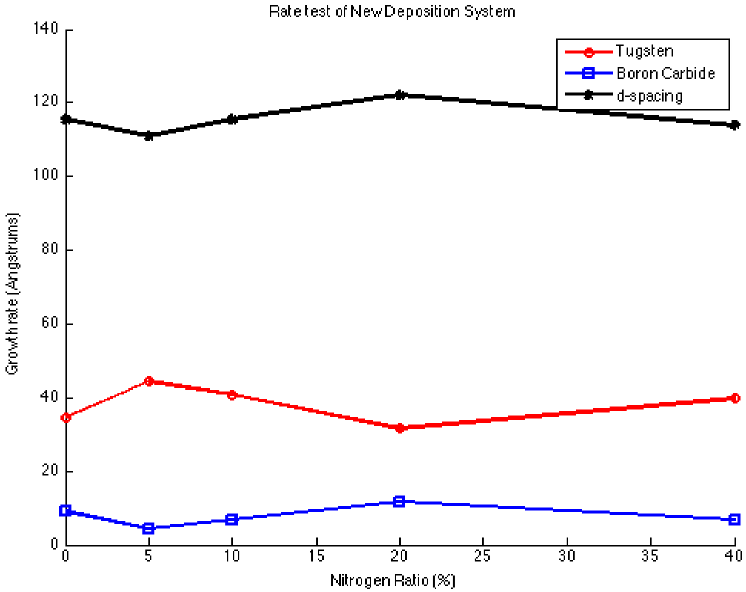


R_meas(4.115)=4.00908E-006; 4.118 deg: R=4.20993E-006

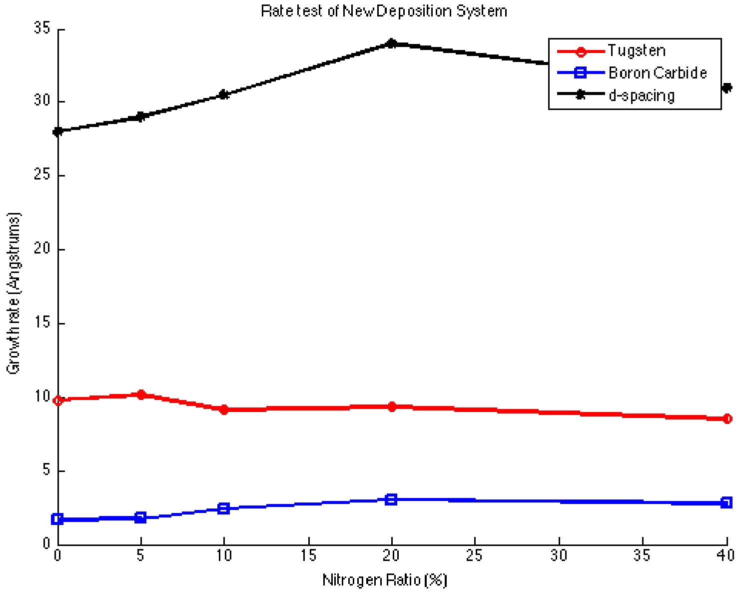
[b$_4$c/w] multilayer, N=20, d=30.500000 Å, Γ=0.400
b$_4$c layer (1), z=12.200000 Å, σ[b$_4$c]=3.000000 Å, σ[w/b$_4$c]=3.000000 Å
w layer (2), z=18.300000 Å, σ=3.000000 Å
[b$_4$c/w] multilayer, N=40, d=48.799998 Å, Γ=0.250
b$_4$c layer (3), z=12.200000 Å, σ[w/b$_4$c]=3.000000 Å, σ[w/b$_4$c]=3.000000 Å
w layer (4), z=36.599998 Å, σ=3.000000 Å
Si substrate, σ=5.000000 Å

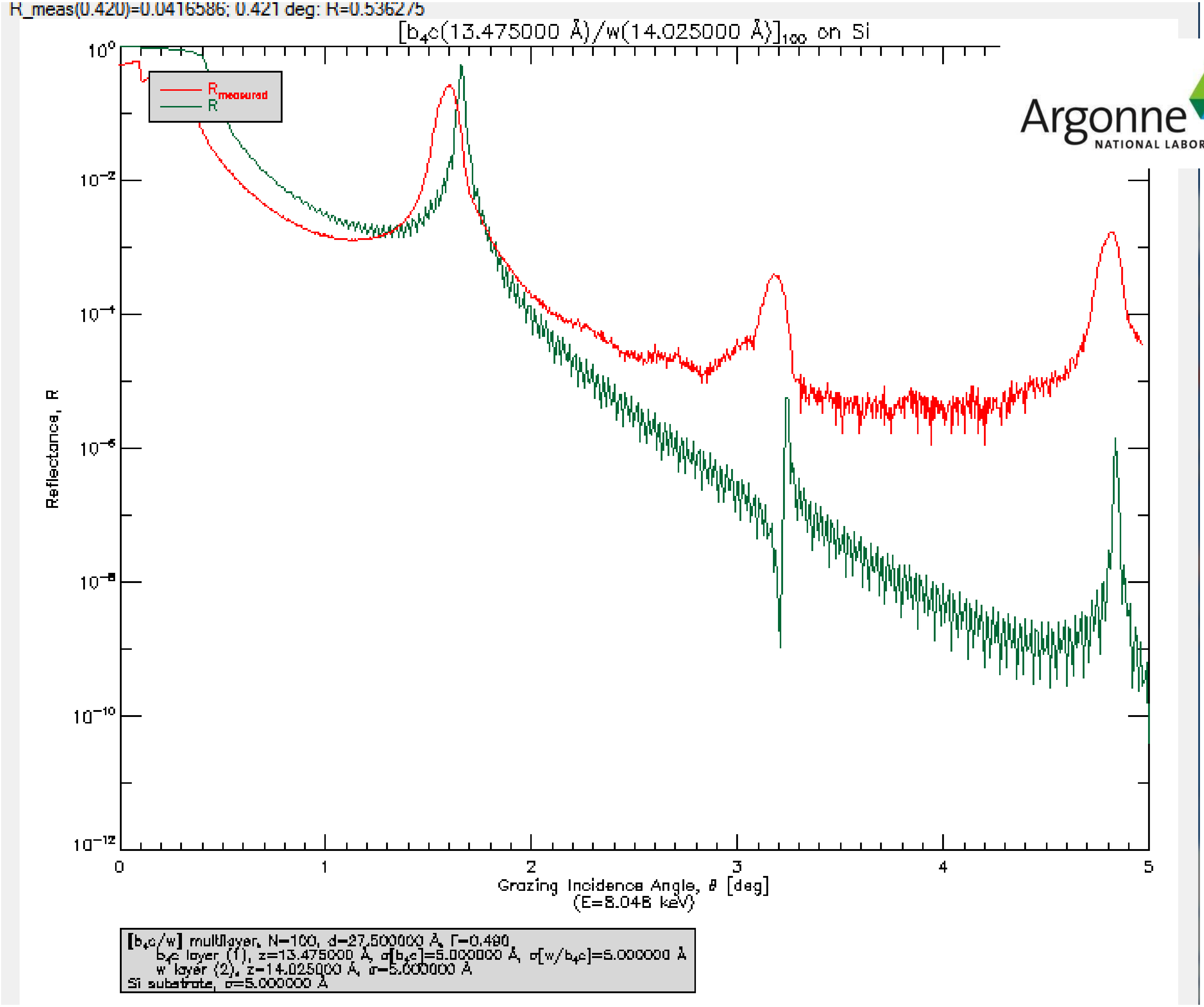


Power at 160W



Power at 80 W

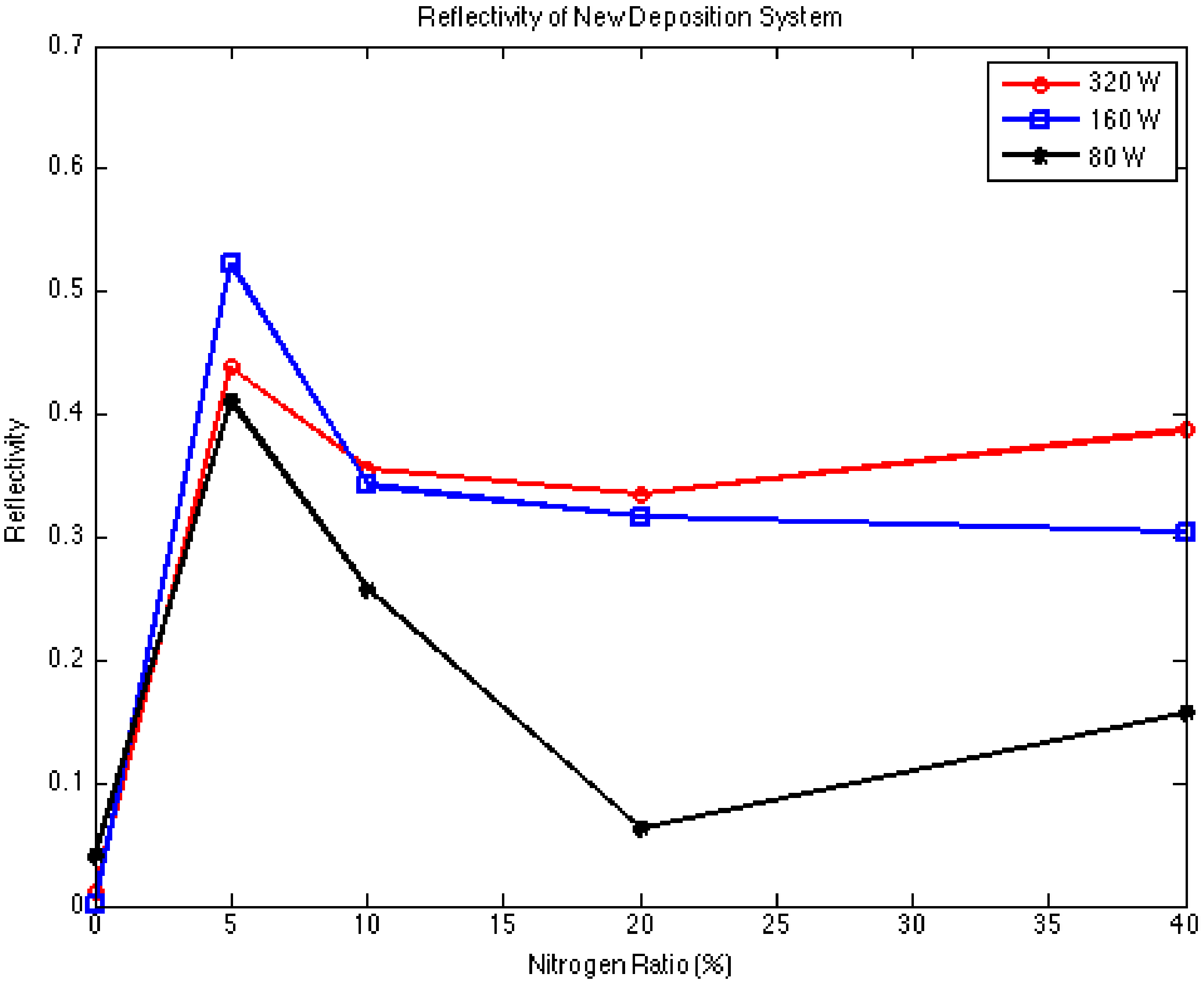




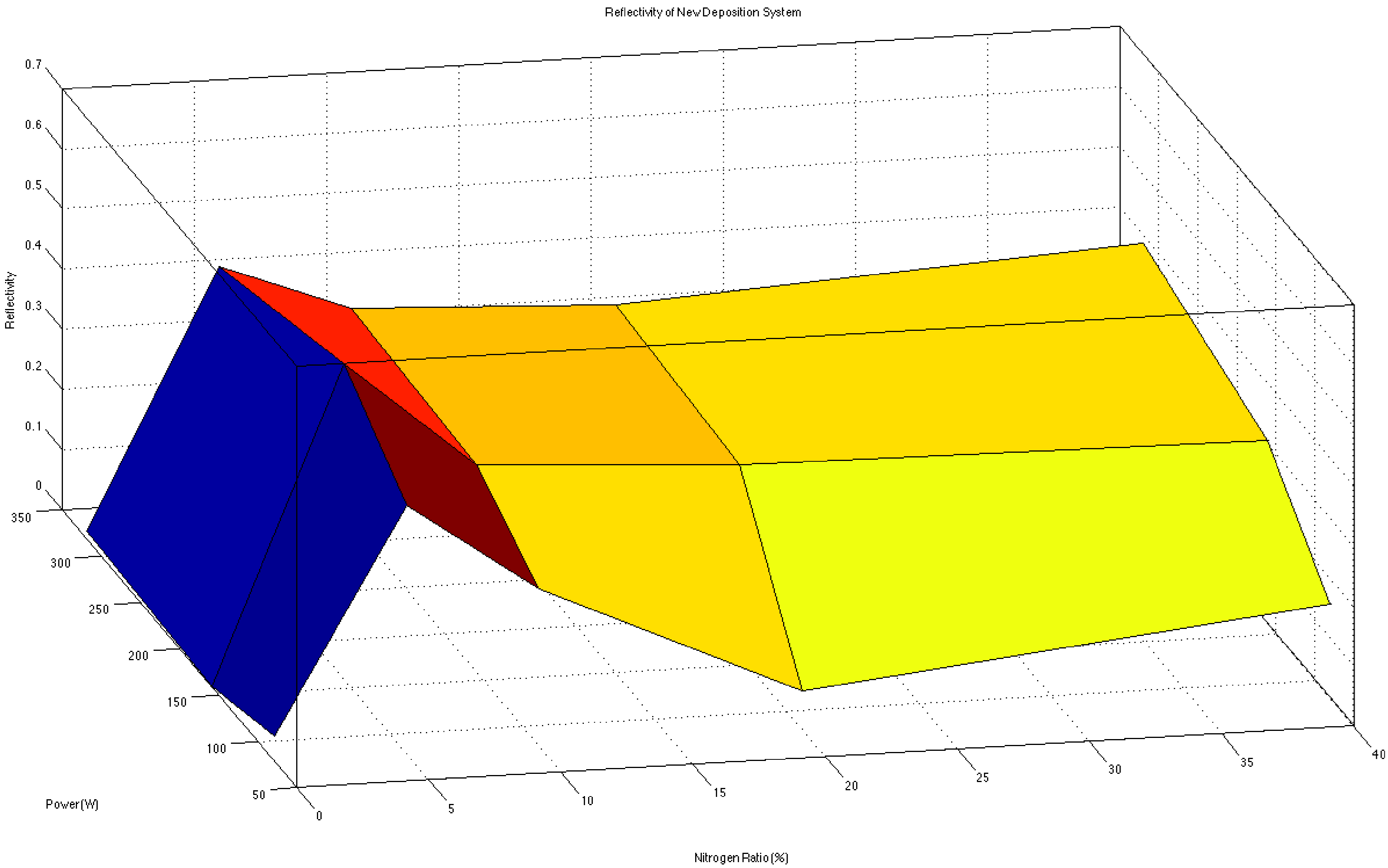
R_meas(0.420)=0.0416586; 0.421 deg: R=0.536275

[b$_4$c/w] multilayer, N=100, d=27.500000 Å, Γ=0.480
b$_4$c layer (1), z=13.475000 Å, σ[b$_4$c]=5.000000 Å, σ[w/b$_4$c]=5.000000 Å
w layer (2), z=14.025000 Å, σ=5.000000 Å
Si substrate, σ=5.000000 Å

Results


Reflectivity of New Deposition System
Reflectivity
Nitrogen Ratio (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
5
10
15
20
25
30
35
40
320 W
160 W
80 W

Results


Reflectivity of New Deposition System
Reflectivity
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Power(W)
350
300
250
200
150
100
50
Nitrogen Ratio (%)
0
5
10
15
20
25
30
35
40

Conclusions & Outlook

- 5% N seems to be the best performance
- Power level indeed also has an impact on performance
- Different target-substrate distances