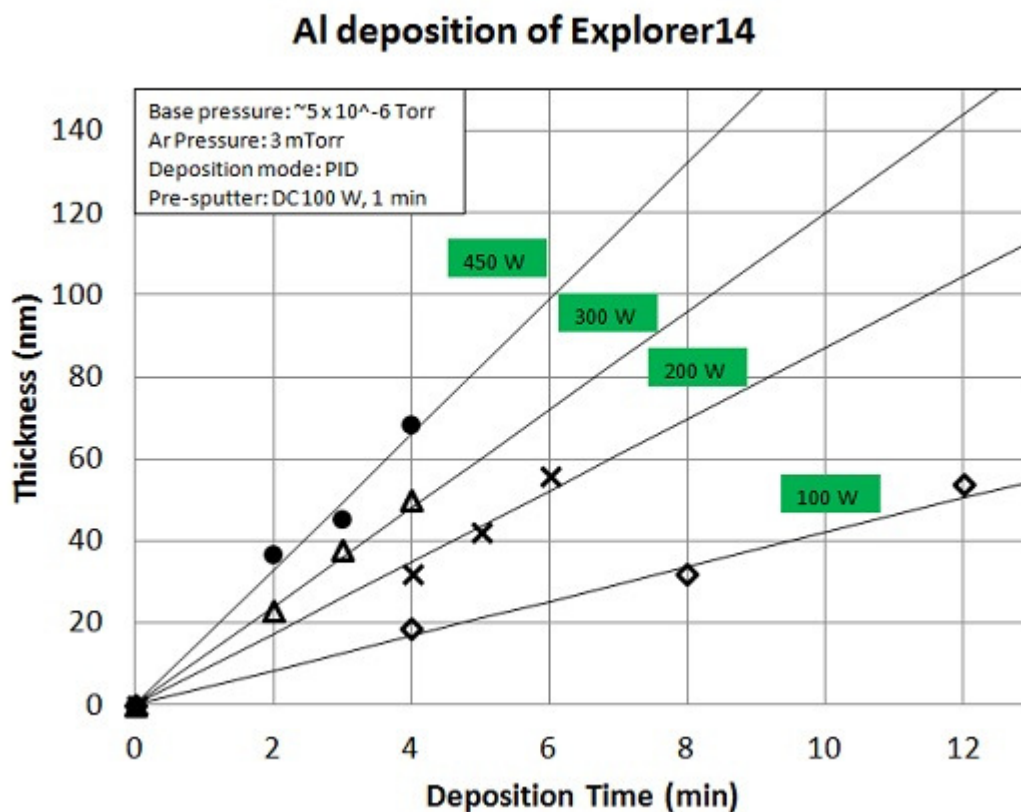


Deposition Rate, Surface Roughness, Morphology, and Film Stress of Al films prepared by Explorer14 Magnetron Sputterer (Graduate Student Fellow Program)

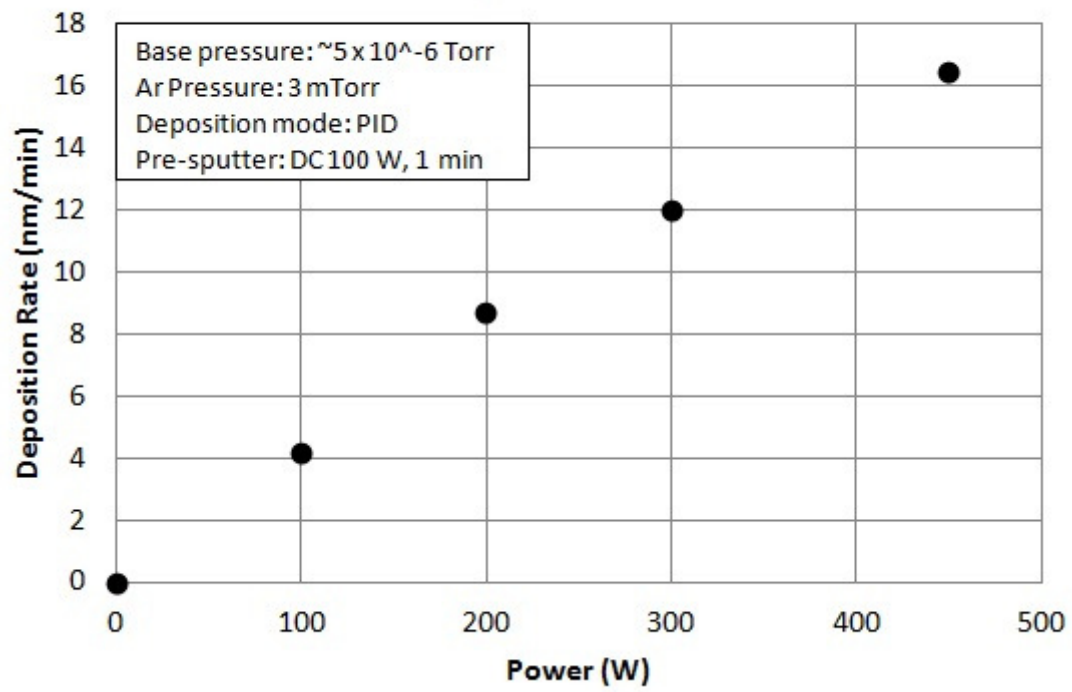
prepared by Zisong Nie (updated on 8/28/2014)

- Thickness measurement: P7 stylus profiler

power (W)	deposition rate (nm/min)
100	4.2
200	8.7
300	12.0
450	16.5



Power Dependence of Al Deposition Rates of Explorer14



Surface Roughness

prepared by Zisong Nie (9/22/2014)

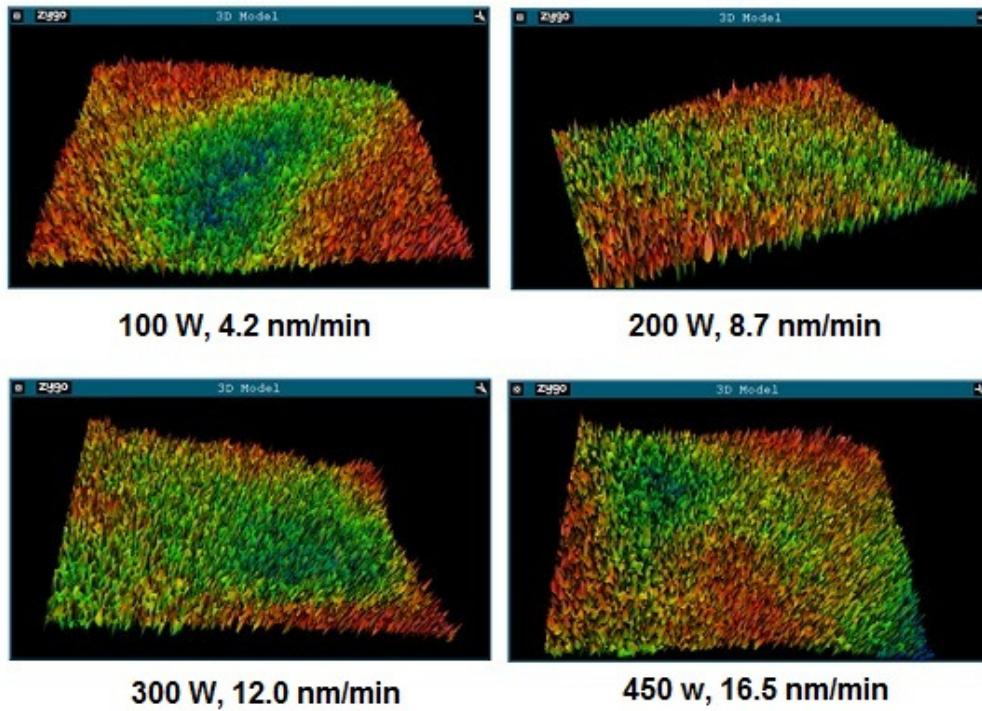
- **Zygo 3D optical profiler**

- Measured area (Field of View): 280 μm x 210 μm , 140 μm x 110 μm , 70 μm x 50 μm
- PV (Peak-to-Valley): The distance between the highest and lowest points within the sample.
- rms: The root-mean square deviation from the center line. The center line is defined as the best fit surface selected with the Remove control.
- Ra: The average deviation from the center line.

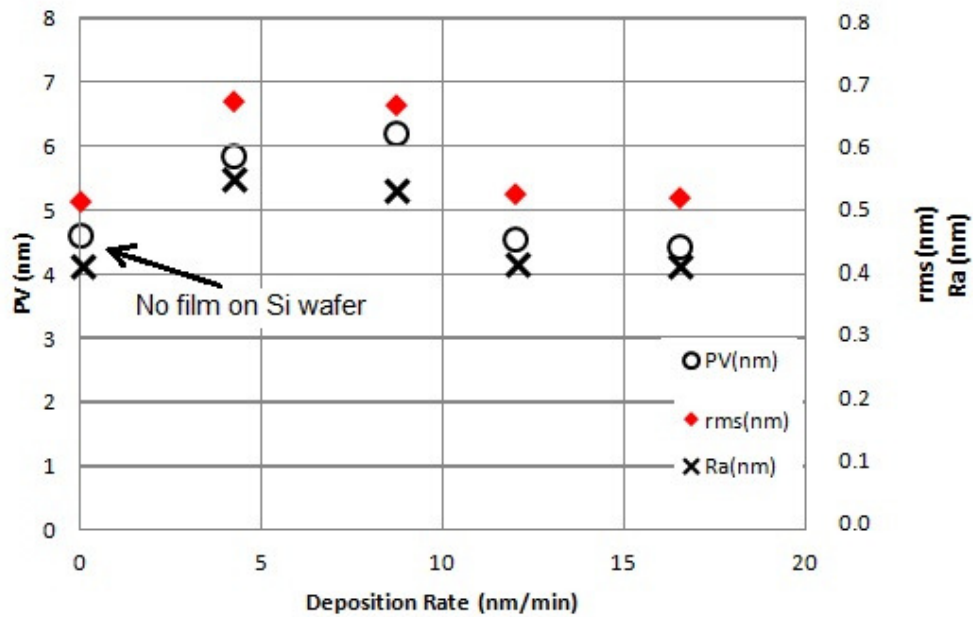
Surface roughness parameters of Al film prepared by Explorer14

	Image Scale (μm)	PV(nm)	Ra(nm)	rms(nm)
100W, d = 43nm 4.2 nm/min	280 x 210	19.422	1.038	1.304
	140 x 110	7.697	0.673	0.852
	70 x 50	5.836	0.551	0.67
200W, d = 46nm 8.7 nm/min	280 x 210	16.882	1.124	1.363
	140 x 110	9.019	0.645	0.798
	70 x 50	6.201	0.532	0.665
300W, d = 41nm 12.0 nm/min	280 x 210	11.637	1.471	1.792
	140 x 110	7.315	0.834	1.05
	70 x 50	4.54	0.417	0.524
450W, d = 58nm 16.5 nm/min	280 x 210	11.324	1.551	1.877
	140 x 110	6.975	0.64	0.822
	70 x 50	4.418	0.413	0.52
450 W, d = 65nm 16.5 nm/min	280 x 210	19.935	1.604	1.967
	140 x 110	10.507	0.773	0.93
	70 x 50	8.593	0.475	0.57
450 W, d = 72nm 16.5 nm/min 5nm Ti capped	280 x 210	30.363	1.318	1.582
	140 x 110	12.472	0.744	0.893
	70 x 50	6.21	0.355	0.444

Surface roughness of Al film prepared by Explorer14
(70 μm x 50 μm)



Surface roughness (Zygo) of Al film
prepared by Explorer14



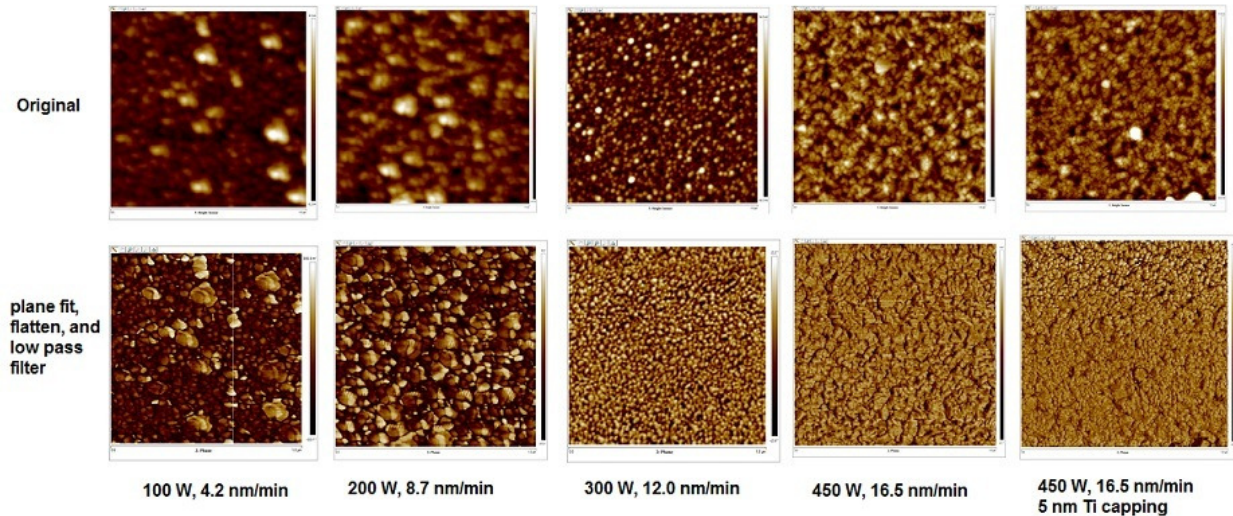
- **Atomic Force Microscopy**

- Measured area (Field of View): 1 μm x 1 μm
- PV (Peak-to-Valley): The distance between the highest and lowest points within the sample.
- rms: The root-mean square deviation from the center line. The center line is defined as the best fit surface selected with the Remove control.
- Ra: The average deviation from the center line.

AFM surface roughness parameters of Al film prepared by Explorer14

Deposition rate (nm/min)	Thickness (nm)	PV(nm)	Ra(nm)	rms(nm)	Grain size (nm)
0	0	6.24	0.20	0.29	...
4.2	43	14.4	1.87	1.32	35.2
8.7	46	13.2	1.9	1.49	48.4
12	41	14.8	1.71	1.34	34
16.5	58	31.1	4.01	3.15	64
16.5	65	25.7	2.38	2.99	...
16.5	72 (5 nm Ti capped)	51.2	2.46	3.35	...

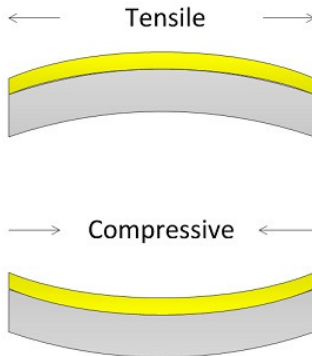
Dependence of Surface Morphology of Al film on Deposition Rate



Film Stress

prepared by Zisong Nie (10/17/2014)

- Film stress measurement: P7 3D stylus profiler



Film Stress Type

- Note:** It turns out that the film stress of 300 nm thick Al is compressive.

Power (W)	deposition rate (nm/min)	Thickness (nm)	Film stress (MPa)
100	4.2	268	-140.2
200	8.7	286	-136.7
300	12	310	-89.48
450	16.5	275	-68.26

Film Stress of ~300 nm thick Al film prepared by EXplorer14

