MSA Lecture Worksheet (Rev 10_15)

Photoresist coating is used in the microelectronics industry to etch integrated circuits for microprocessors, RAM, etc., onto silicon wafers.. The thickness of the coating affects how silicon wafers perform in microelectronics, so obtaining accurate measurements is critical. The specification is 120 $\pm$70 μm. (Tolerance = $\pm$70 = 140.) An assessment of the measurement system for the thickness of this photoresist coating is to be performed.

A Gage R&R study is to be performed. The data collection plan is outlined below:

- 10 wafers are randomly selected to represent the typical process performance.
- 3 operators are randomly selected.
- Each operator will measure each wafer with each gage three times.

The data has been entered into the collection sheet below

Gage Repeatability and Reproducibility Data Collection Sheet

Appraiser	Trial #	PART 1	2	3	4	5	6	7	8	9	10	
A	1	147	84	114	108	126	101	117	92	91	117	
	2	149	79	115	100	126	102	118	101	90	117	
	3	150	78	115	108	127	102	121	101	86	117	
Average		148.7	80.3	114.7	105.3	126.3	101.7	118.7	97.7	89.0	117.0	$\bar{X}_A = 109.9$
Range		3	6	1	8	1	1	4	9	5	0	$\bar{R}_A = 3.9$
B	1	151	86	116	115	131	104	123	103	102	121	
	2	154	87	118	114	130	106	123	107	98	120	
	3	155	86	119	112	125	106	124	109	100	120	
Average		153.3	86.3	117.7	113.7	128.7	105.3	123.3	106.3	100.0	120.3	$\bar{X}_B = 115.5$
Range		4	1	3	3	6	2	1	6	4	1	$\bar{R}_B = 3.1$
C	1	155	89	124	117	138	107	127	109	95	123	
	2	157	86	119	112	137	106	124	105	97	120	
	3	153	88	118	116	131	107	123	109	100	122	
Average		155.0	87.7	120.3	115.0	135.3	106.7	124.7	107.7			$\bar{X}_C =$
Range		4	3	6	5	7	1	4	4			$\bar{R}_C =$
Part Average		152.33	84.78	117.56	111.33	130.11	104.56	122.22	103.89			$\bar{\bar{X}} = 114.2$

$R_p = [Max\ Part\ Average] - [Min\ Part\ Average] =$

$\bar{\bar{R}} = {(\bar{R}_A + \bar{R}_B + \bar{R}_C)}/{3} =$

$\bar{X}_{DIFF} = [Max\ \bar{X}] - [Min\ \bar{X}] =$

$UCL_R = \bar{\bar{R}} * D_4 =$

(D4 = 3.27 for 2 trials, and 2.58 for 3 trials)

Verify all individual R's are less than the UCL_R before proceeding.

Gage Repeatability and Reproducibility Report

Date:	Part No:	Gage type:
Analyst:	Characteristic:	Gage #:
	Specifications:	
Data from Data Collection Sheet: $\bar{\bar{R}} =$	$\bar{X}_{DIFF} =$	$R_p =$

Repeatability – Equipment Variation EV

$EV = \sigma_{repeatability} = \bar{\bar{R}} * K_1$

=

$EV =$ _____

n=#of parts = _____

r=# of trials = # times each part measured = _____

r Trials	K_1		n # of Parts	K_3
2	.8862		5	.4030
3	.5908		6	.3742
			7	.3534
Appraisers	K_2		8	.3375
2	.7071		9	.3249
3	.5231		10	.3146

Constants from MSA Reference Manual, 3rd edition

Reproducibility – Appraiser Variation

$AV = \sigma_{reproducibility} = \sqrt{(\bar{X}_{DIFF} * K_2)^2 - {EV^2}/{nr}}$

=

$AV =$ _____

Gage Repeatability and Reproducibility (GRR)

$GRR = \sigma_m = \sqrt{EV^2 + AV^2}$

=

$GRR =$ _____

Part Variation (PV)

$PV = \sigma_p = R_p * K_3$

$PV =$ _____

Total Variation (TV)

$TV = \sqrt{GRR^2 + PV^2}$

=

Number of distinct categories

$ndc = 1.41 \frac{PV}{GRR} =$

$\%EV = \left(\frac{EV}{TV}\right) * 100\% =$

$\%AV = \left(\frac{AV}{TV}\right) * 100\% =$

$\%GRR = \left(\frac{GRR}{TV}\right) * 100\% =$

$\%PV = \left(\frac{PV}{TV}\right) * 100\% =$

$\%Tolerance = \left(\frac{6 * GRR}{Tolerance}\right) * 100\% =$