Statistical Analysis of Droplet Epitaxial Nano-structure Growth Parameters – as Preliminary for Technological Support

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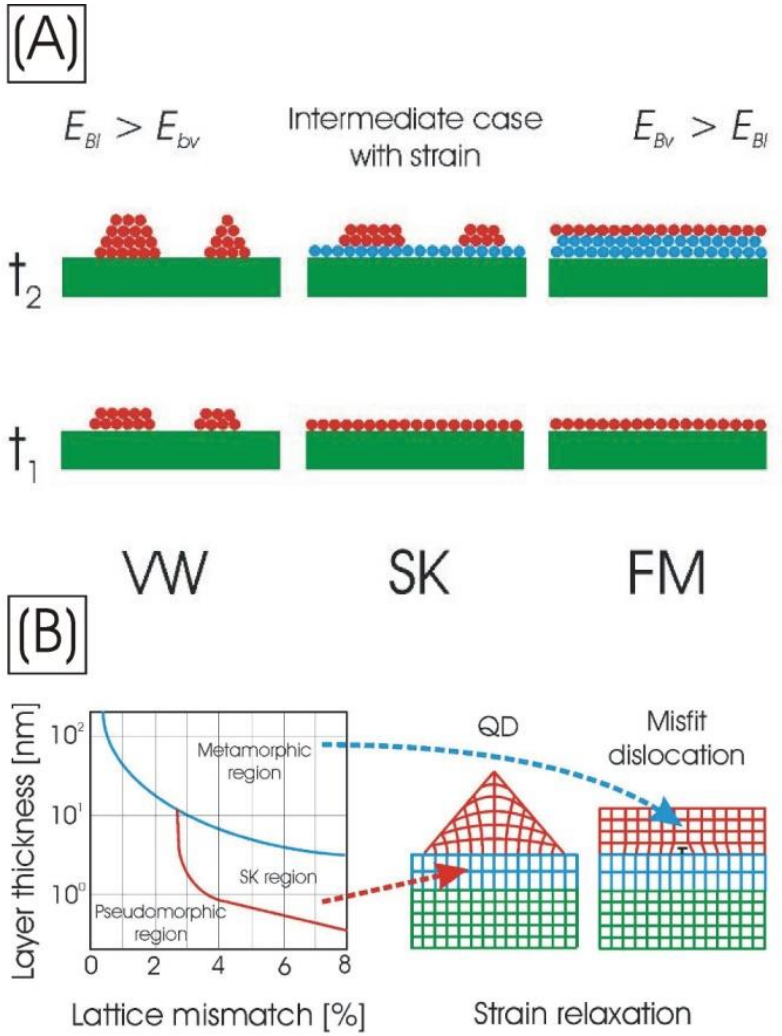
Why are nanostructures important?

- Generally application of nanostructures improves the yield of fabricating electronic devices
  - E.g. Improving efficiency of solar cells
  - E.g. improving LED emission
- Novel devices
  - Cellular automate
  - Advances in the field of computer parts (processors, memories, etc)
  - Optoelectronics
  - Quantumcomputation

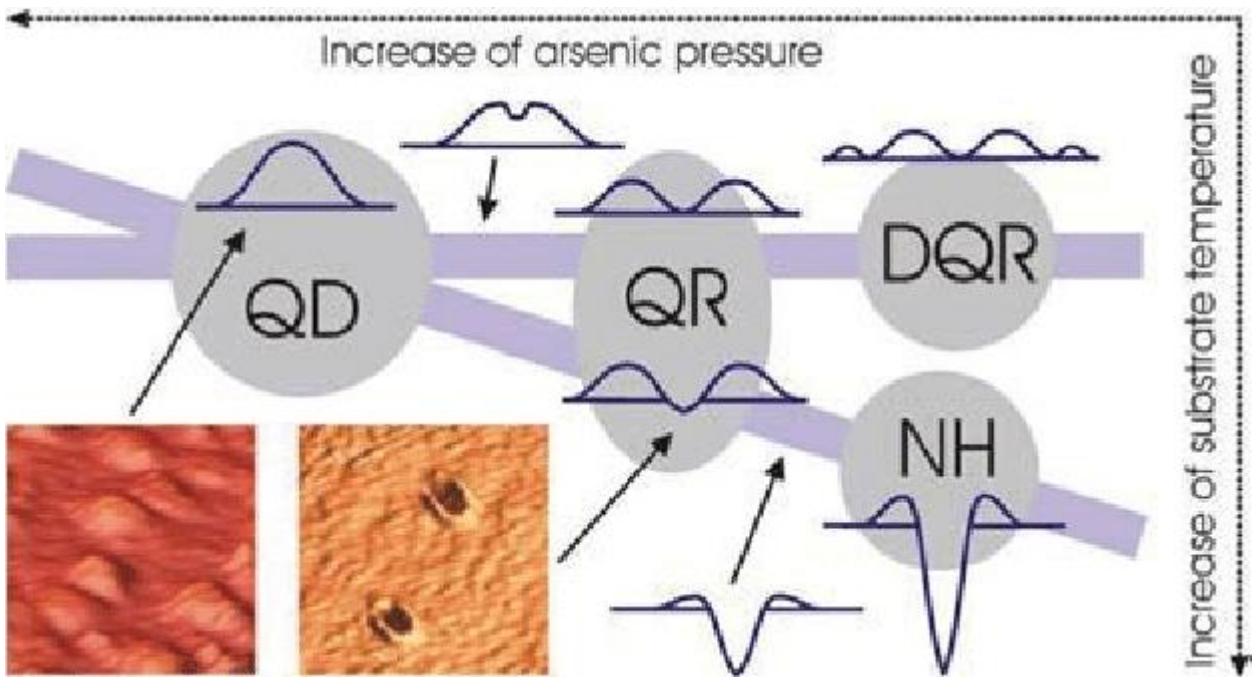
Fabrication of nanostructres

- Strain induced epitaxial process
  - Limited range of shapes
  - Limited sortiment of materials
  - Limited distribution homogenity
- Droplet epitaxial process
  - Wide range of shapes
  - Large sortiment of materials
  - Wide range of surficial density



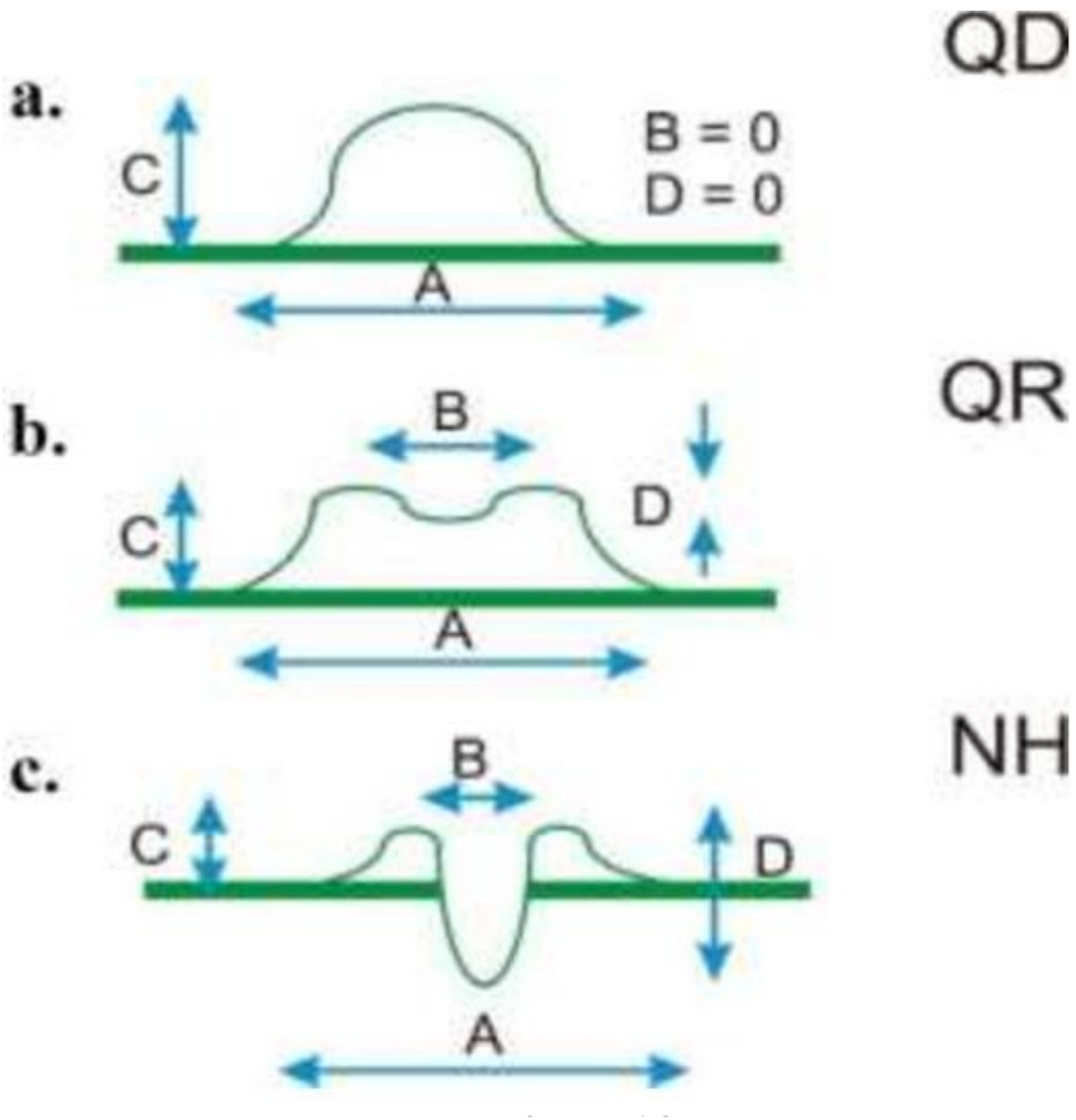
Types of **dropletepitaxial** nanostructures

- Quantum Dots (QDs)
- Quantum Rings (QRs)
- Nanoholes (NHs)



Dimensions of droplet-epitaxial nanostructures

- a) conventional shaped quantum dot (QD)
- b) cross section of nano-sized quantum ring (QR)
- c) cross section of a nano-hole, where the thick green line represents the substrate surface (NH)



Looking for the connection between technological and geometrical parameters I.

Linear approximation

- Simple linear regression (setting up and testing linear relationship between any two variables)
- Multiple linear regression (technological parameters as independent variables, surficial density and geometric parameters as dependent variables)

Looking for the connection between technological and geometrical parameters II.

- Principal Component Analysis

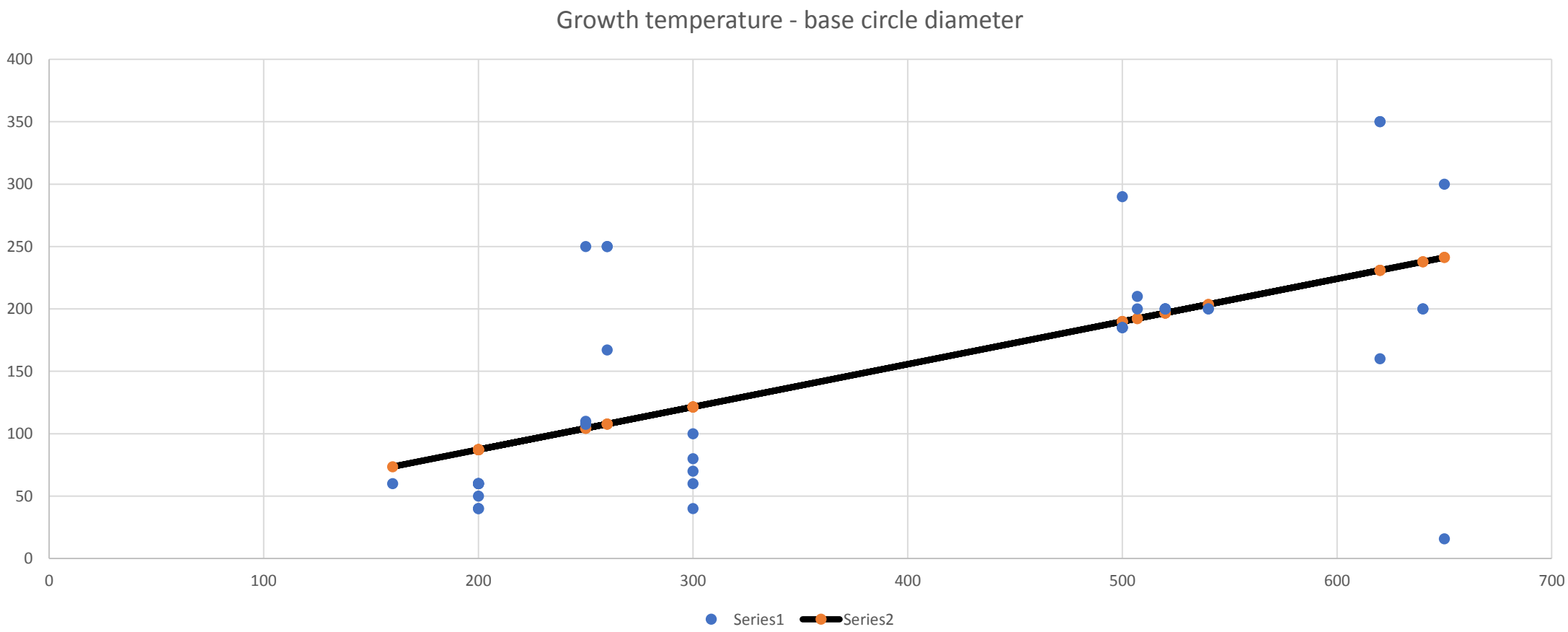
Returns as many pairwisely orthogonal vectors as the dimension of data set; the first vector points to the direction of maximal variance; the second vector points to the direction of maximal variance still available AND orthogonal to the first vector and so on;

PCA can be used to reduce the number of dimensions of data set at the expense of minimal loss of information

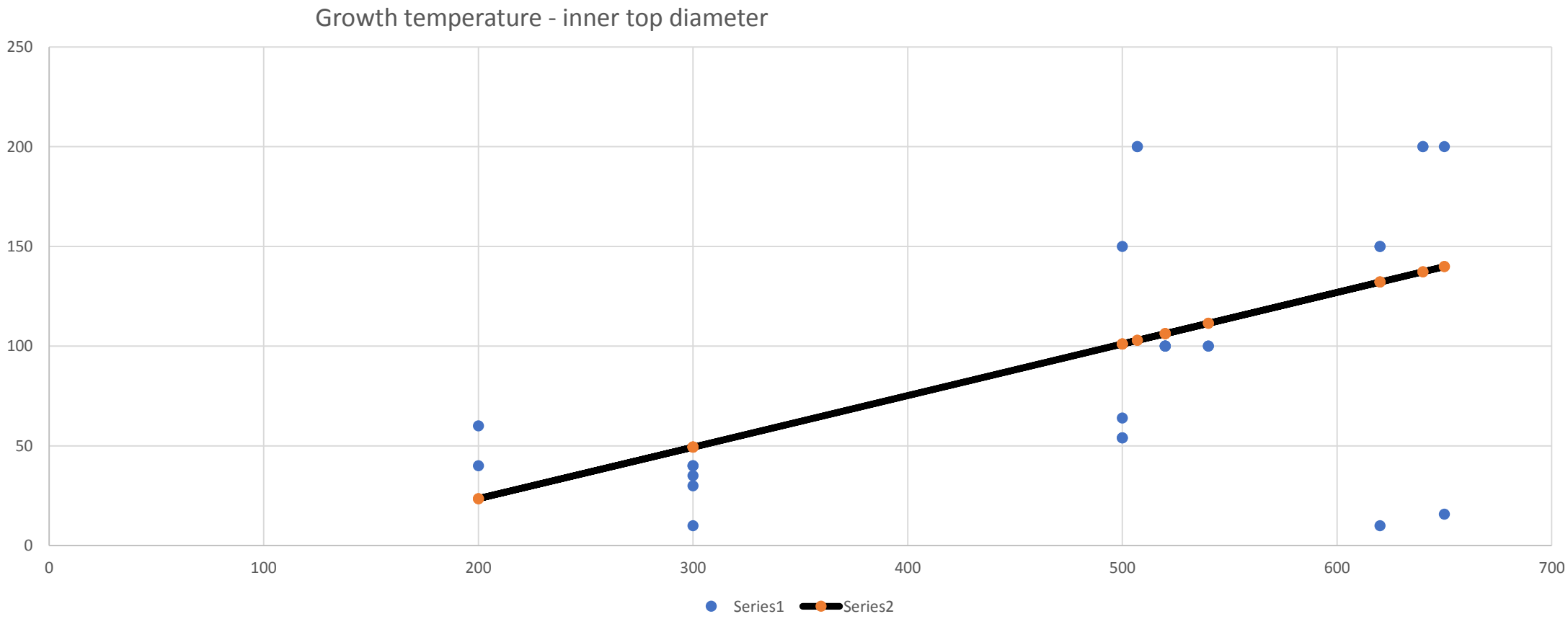
- Soft computing methods (neural networks etc)

Unfortunately our present database below 100 vectors is insufficient for soft computing methods

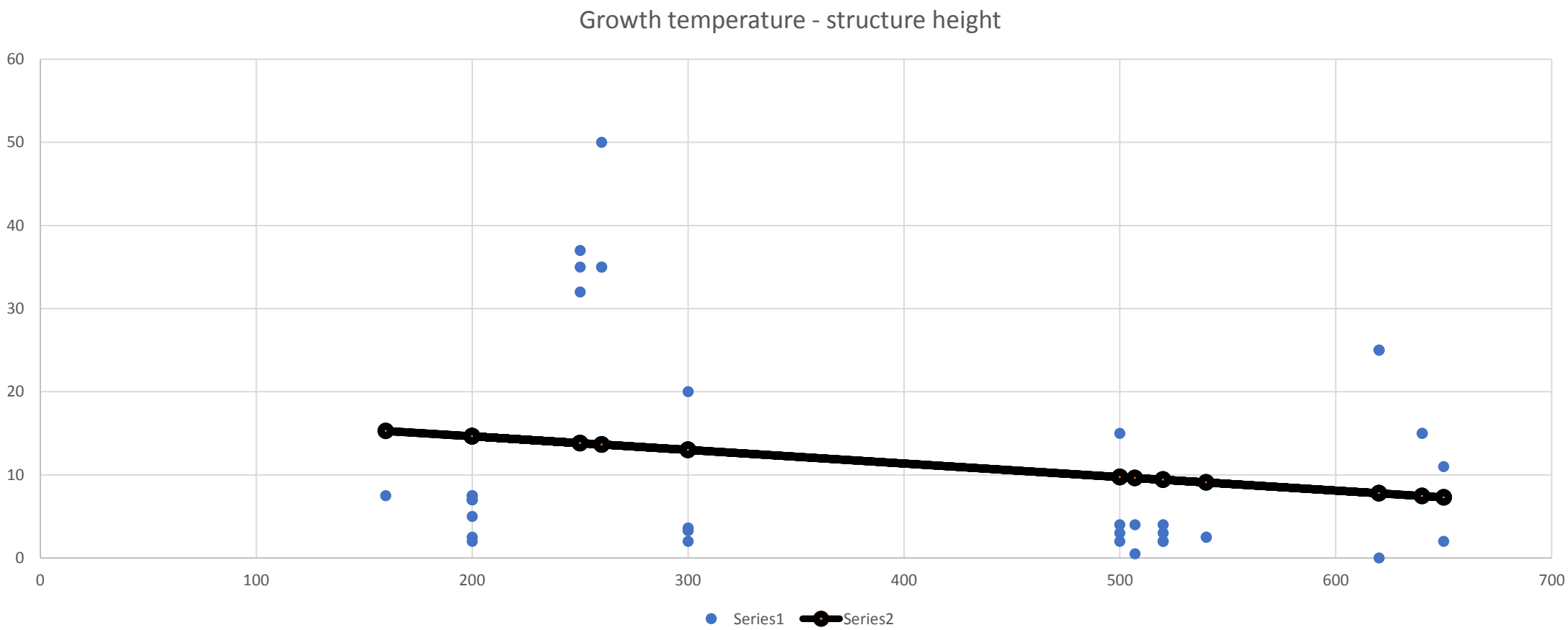
Simple linear regression results (Base circle diameter regressed on growth temperature)



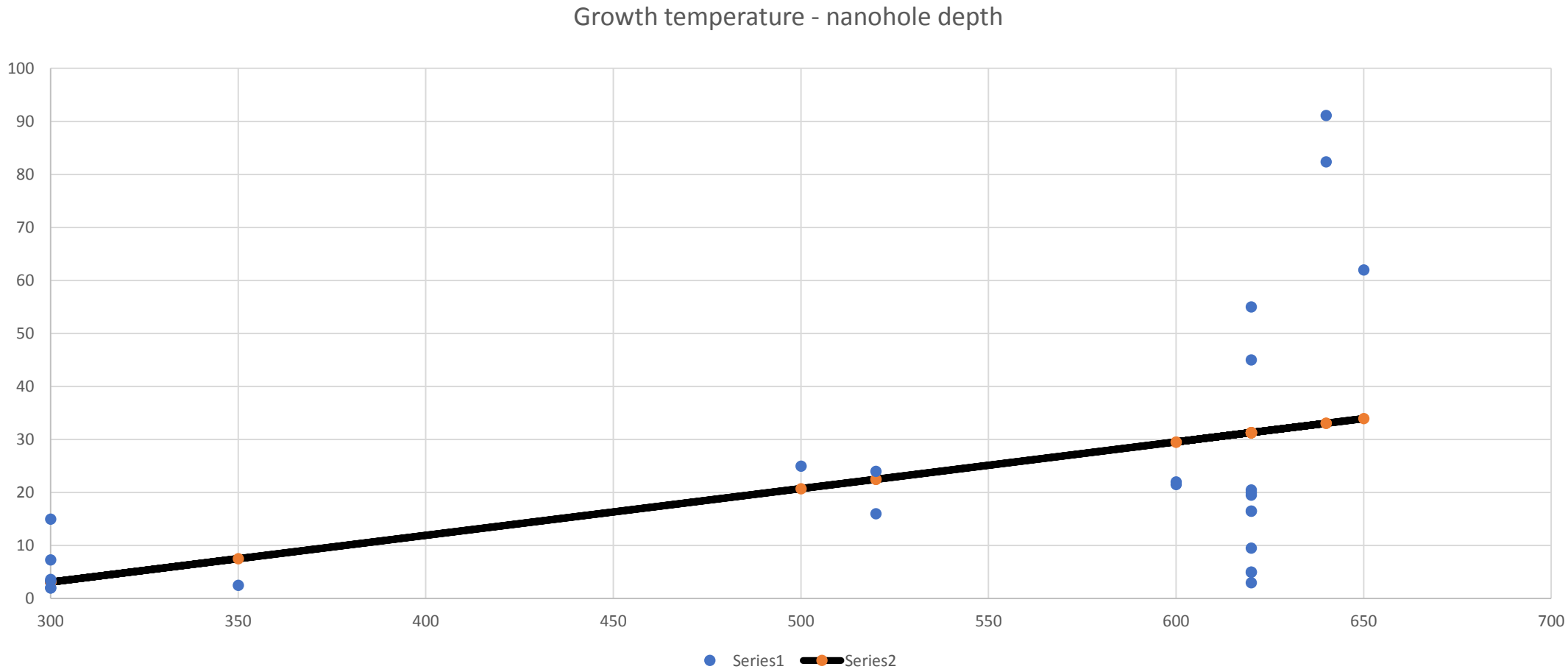
Simple linear regression results (inner top diameter „ring diameter” regressed on Tg)



Simple linear regression results (structure height regressed on growth temperature)



Simple linear regression results (NH/QR depth regressed on growth temperature)



Explanation to multiple regression results

- Estimate: estimate of coefficient of regression
- SE: standard error of the estimate
- pValue: the null hypothesis of the coefficient being zero can be rejected at 1-pValue certainity

Multiple regression results (base circle diameter regressed on technical parameters)

Var1	Estimate	SE	tStat	pValue
Intercept	46.3155	36.7202	1.2613	0.2143
TGrowth	0.5223	0.0902	5.7884	0.0000
FluxGa	-29.4996	19.0196	-1.5510	0.1286
PressAs	17.4656	10.0012	1.7464	0.0882
AnnealT	3.3025	1.3206	2.5007	0.0165

Multiple regression results (ring diameter regressed on technical parameters)

Var1	Estimate	SE	tStat	pValue
Intercept	-82.7849	24.4773	-3.3821	0.0016
TGrowth	0.2642	0.0601	4.3936	0.0001
FluxGa	-25.0765	12.6783	-1.9779	0.0547
PressAs	-9.5948	6.6667	-1.4392	0.1577
AnnealT	0.3498	0.8803	0.3974	0.6931

Multiple regression results (nanostructure height regressed on technical parameters)

Var1	Estimate	SE	tStat	pValue
Intercept	31.29396	5.58941	5.59880	0.00000
TGrowth	0.03788	0.01373	2.75806	0.00865
FluxGa	-3.68565	2.89509	-1.27307	0.21016
PressAs	6.41142	1.52234	4.21156	0.00014
AnnealT	0.81436	0.20102	4.05115	0.00022

Multiple regression results (QR/NH central depression regressed on technical parameters)

Var1	Estimate	SE	tStat	pValue
Intercept	-20.75379	8.72290	-2.37923	0.02209
TGrowth	0.10693	0.02143	4.98898	0.00001
FluxGa	2.02108	4.51811	0.44733	0.65699
PressAs	1.42182	2.37578	0.59846	0.55282
AnnealT	0.19196	0.31371	0.61190	0.54398

Conlusion and outlook

- Mathematical description of the relationship between technological and geometrical parameters

- Support of the technology of the droplet epitaxial nano-structure preparation

Thank you your attention