

1 Introduction	11
2 Scientific background	13
2.1 Polyelectrolytes and polyelectrolyte multilayers	13
2.1.1 Polyelectrolytes	13
2.1.2 Polyelectrolyte multilayers	13
2.1.3 Energetic considerations	14
2.1.4 Build-up mechanism of PEMs	15
2.1.5 Preparation conditions	16
2.2 Mechanical properties	16
2.2.1 Elasticity: Stress and strain	17
2.2.2 Viscoelasticity	18
2.3 (Nano-)mechanics of polymer materials and membranes	19
2.3.1 Mechanical properties of polyelectrolyte multilayers	20
2.3.2 Mechanical properties of biomaterials	20
2.4 Poly(L-lysine) / hyaluronic acid multilayer film	21
2.5 Collagen scaffolds	21
2.6 Heterogeneous polymer gels	22
3 Methods	25
3.1 Atomic force microscopy (AFM)	25
3.1.1 Principles of atomic force microscopy	25
3.1.2 Scanning probe AFM	26
3.1.3 Static force measurements	27
3.1.4 Hertz-, JKR-, DMT- and Dimitriadis model	28
3.1.5 Dynamic force measurements	30
3.1.6 Relaxation measurements	34
3.2 Quartz crystal microbalance with dissipation monitoring	37
4 Experimental section	39
4.1 Materials	39
4.2 Preparation	40
4.2.1 HA/PLL multilayers: Layer-by-Layer method	40
4.2.2 HA/PLL crosslinking	40
4.2.3 NIPAM microgel particles	41

4.2.4 Native collagen fibers	41
4.2.5 Heterogeneous and homogeneous pNIPAM gels	42
4.3 AFM experiments	43
4.3.1 Colloidal probe attachment	43
4.3.2 Static force measurements on HA/PLL multilayers	44
4.3.3 Dynamic force measurements on HA/PLL multilayers	45
4.3.4 Relaxation measurements	46
4.3.5 Force measurements on heterogeneous pNIPAM gels	46
4.4 Quartz crystal microbalance with Dissipation monitoring	47
5 Nanoscale separation of storage and loss modulus of a PLL/HA multilayer Film using dynamic force measurements	49
5.1 Abstract	49
5.2 Introduction	50
5.3 Hydrodynamic drag correction	51
5.4 Results	52
5.5 Discussion	55
5.6 Summary and conclusion	58
6 Effects of environmental parameters on the mechanical properties of PLL/HA multilayer films	59
6.1 Abstract	59
6.2 Introduction	60
6.3 Results and discussion	60
6.4 Summary and conclusion	64
7 PLL/HA multilayers coated with pNIPAM microgels and their potential use as drug delivery system	65
7.1 Abstract	65
7.2 Introduction	65
7.3 Results	66
7.4 Discussion	73
7.5 Summary and conclusion	76
8 Comparison between macroscopic and microscopic elasticity of heterogeneous polymer gels	77

8.1 Abstract	77
8.2 Introduction	77
8.3 Results and discussion	78
8.4 Summary and conclusion	87
9 Measuring of cell effective stiffness of macroporous collagen scaffolds	89
9.1 Abstract	89
9.2 Introduction	89
9.3 Sample preparation	90
9.4 Results	91
9.5 Discussion	96
9.6 Summary and conclusion	97
10 Summary and Outlook	99