

Table of contents

1	Introduction	1
2	State of the art	3
2.1	Manufacturing of plastic parts	3
2.2	Manufacturing of structured surfaces	6
2.2.1	Laser processing	7
2.2.2	Multi-beam interference in USP laser technology	9
2.3	Coating of the tool surface	10
2.3.1	Physical vapor deposition processes	10
2.3.2	Physical vapor deposition coating materials	11
2.3.3	Laser processing of PVD hard coatings	18
2.3.4	Conclusion from the state of the art	20
3	Main research approaches	21
4	Continuous wave laser heat treatment	25
4.1	Materials and synthesis of a CrAlN/AlCrN nanolaminate hard coating	25
4.2	Nanoscratch test using a berkovich diamond	26
4.3	Continuous wave laser heat treatment of the coating	27
4.4	Methods for analysis of the coating	28
4.4.1	Morphology and topography using scanning electron microscopy	28
4.4.2	Chemical composition using electron probe microanalysis	28
4.4.3	Phase analyses using X-ray diffraction	29
4.4.4	Crystallinity and phase composition using transmission electron microscopy	29
4.5	Results concerning the continuous wave laser heat treatment	32
4.5.1	Coating properties of the as-deposited CrAlN/AlCrN	32
4.5.2	Coating properties after the nanoscratch test	38
4.5.3	Coating properties after laser heat treatment	41
4.5.4	Conclusion drawn from the nanoscratch test and laser heat treatment results	52
5	Ultra-short pulsed laser structuring	54
5.1	Materials and synthesis of three different PVD hard coatings	54
5.2	Ultra-short pulsed laser structuring	56
5.3	Methods for analysis of the ultra-short pulsed laser-structured coatings	59
5.3.1	Surface roughness and topography using confocal laser scanning microscopy	60
5.3.2	Specific heat capacity using differential scanning calorimetry	61
5.3.3	Reflectance using ultraviolet visible near-infrared spectrophotometry	62
5.3.4	Phase analyses using X-ray diffraction	64
5.4	Results concerning the ultra-short pulsed laser structuring	65
5.4.1	Morphology prior to laser structuring	66

Table of contents

5.4.2	Chemical composition prior to laser structuring	67
5.4.3	Reflectance prior to laser structuring	68
5.4.4	Specific heat capacity prior to laser structuring	68
5.4.5	Topography after laser structuring	70
5.4.6	Interferece structures after laser structuring	71
5.4.7	Phase analyses in relation to laser structuring	74
5.4.8	Structural analyses in relation to laser structuring	78
5.4.9	Conclusion of the results in relation to laser structuring	106
6	Industrial application of laser structured tools	107
6.1	Injection molding of laser-structured tools	107
6.2	Methods for analyzing tools and plastic parts after injection molding	109
6.3	Results of the injection-molded laser-structured tools and plastic parts	110
6.4	Conclusion of the results in relation to the industrial application	114
7	Conclusion and future perspectives	115
8	Literatures	118
9	Appendix	132