Investigations on various approaches in order to reduce droplet incorporation into films produced by Pulsed Laser Deposition

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The emission of particles during the ablation process is a commonly known issue for Pulsed Laser Deposition (PLD). Especially formerly melted material (droplets) can be found incorporated on nearly every as deposited film surface. Besides the obvious decrease in surface quality, these droplets also may influence the microstructure of the growing film or may even result in pinholes in the thin films.

Since droplets severely affect the functionality for sensitive applications, like spintronic or sensor layer systems, there have been already published numerous research results concerning their reduction. In general, the various approaches can be classified according to the time of access within the emission and incorporation progress. It starts with the influence of the target structure, the ablation process and the laser parameters on the emission of the droplets and ends with the impact of the droplets on the substrate surface.

The different approaches on the droplet reduction that we will present, access the droplet transfer from the target to the substrate. We produced thin films of boron carbide (B_4C) on silicon substrates using PLD because of the very high number of droplets occurring with boron carbide (see fig. 1a).

The first approach simply increases the distance between target and substrate up to 150 mm. Since most of the other setups only allow very near distances, the severe effect of that increase (see fig. 1b) hasn't been reported yet.

The second approach uses a second laser pulse in order to evaporate the already melted particles. The fluence of the second pulse is too low to ablate more material, but sufficient to increase the droplets temperature above their evaporation temperature.

The last approach uses a magnetic filtering technique similar to filtered arc evaporation. Due to the high contend of ions within the ablation plume these film forming particles can be deflected within a strong magnetic field while the non-ionized droplets move straight ahead. This technique allows the production of almost completely droplet free thin films (see fig. 1c).

The effects of the various approaches on the droplet transfer, the droplet incorporation as well as on the properties of the films are discussed.

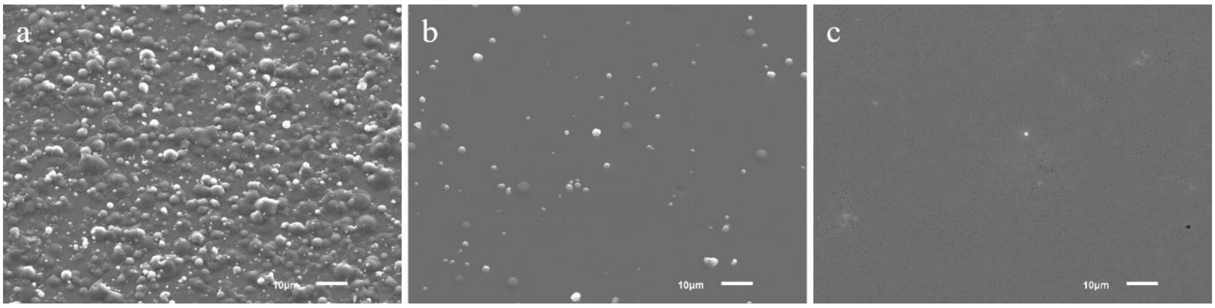

Figure 1: SEM micrographs of different stages of the droplet reduction.
(a – no droplet reduction, b – reduction by increasing the substrate distance, c – magnetic filtering)