A setup for in-situ optical, thermal and X-ray imaging of laser sintering of polymer particles

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Selective laser sintering is a 3D printing technology with the potential to fabricate lightweight products with complex design. During the manufacturing process polymer particles are locally heated with a laser beam and thereby melt and sinter together. The final material macrostructure and its porosity as well as the crystal microstructure depend on the processing conditions. Whereas most studies focus on ex-situ characterizations of the printed part, little is known about the time-dependent structure evolution during printing. Recently, we have developed a setup that allows in-situ visualization of the sintering process on the level of a particle pair (Fig. 1), by optical microscopy (Fig. 2), thermal imaging (Fig. 3) as well as X-ray characterization (Fig. 2). From the optical images, the growth of the neck radius formed between both particles is analyzed as a function of time. Moreover, the time-resolved 2D-WAXD images allow to analyze the crystallization kinetics and crystal type formation. To demonstrate the capabilities of the device, we studied laser sintering of spherical PA12 particles. The setup provides crucial real-time information concerning the sintering dynamics as well as crystallization kinetics, which was not accessible up to now. In conclusion, we present a unique laser sintering setup that allows real time studies of the structural evolution during laser sintering of polymer particles. The device incorporates the main features of classical selective laser sintering machines for 3D printing of polymers, and at the same time allows in-situ visualization of the sintering dynamics with optical microscopy, thermal imaging and X-ray scattering.[1,2,3]

[1] P. Hejmady, L.C.A. van Breemen, P.D. Anderson, R. Cardinaels, Soft Matter, 1373-1387, 2019.
[2] P. Hejmady, L.C. Cleven, L.C.A van Breemen, P.D. Anderson, R. Cardinaels, Review of Scientific Instruments, 083905, 2019
[3] https://www.youtube.com/watch?v=mBBop81S44

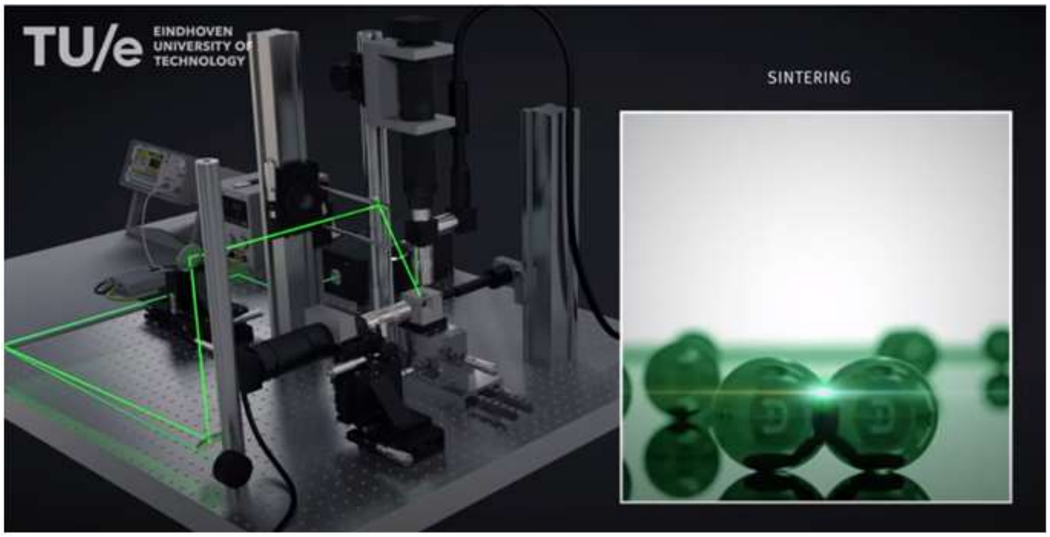

Figure 1: Schematic of the laser sintering setup.

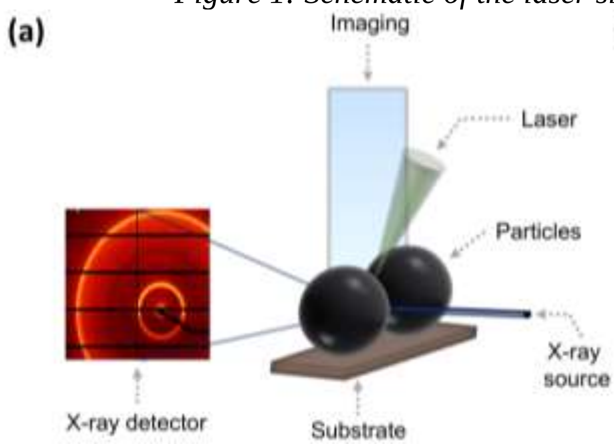

Figure 2: (a) Schematic of the characterization methods, (b) Particle doublet during laser sintering.

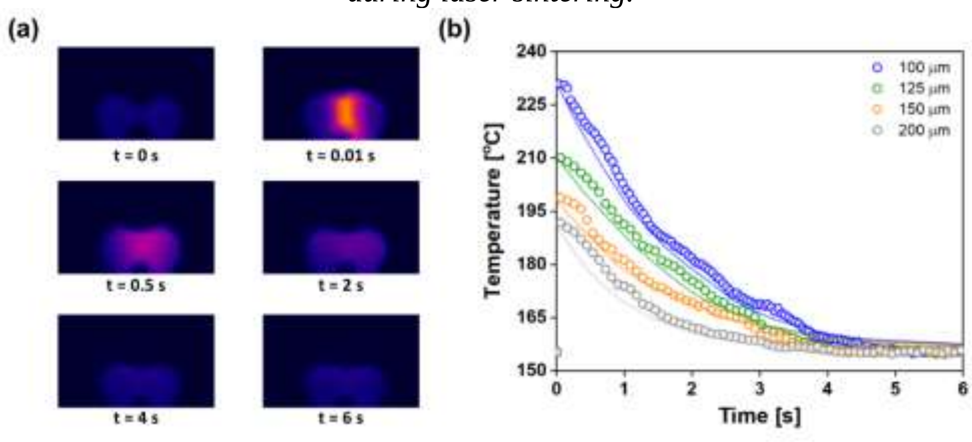

Figure 3: (a) Thermal images during laser sintering, (b) Temperature evolution during laser sintering.