Laser-Assisted Zone Crystallization in Superscalable, Contactless Wet Coating of Ultrathin Films for Flexible Piezoelectrics and Electronics

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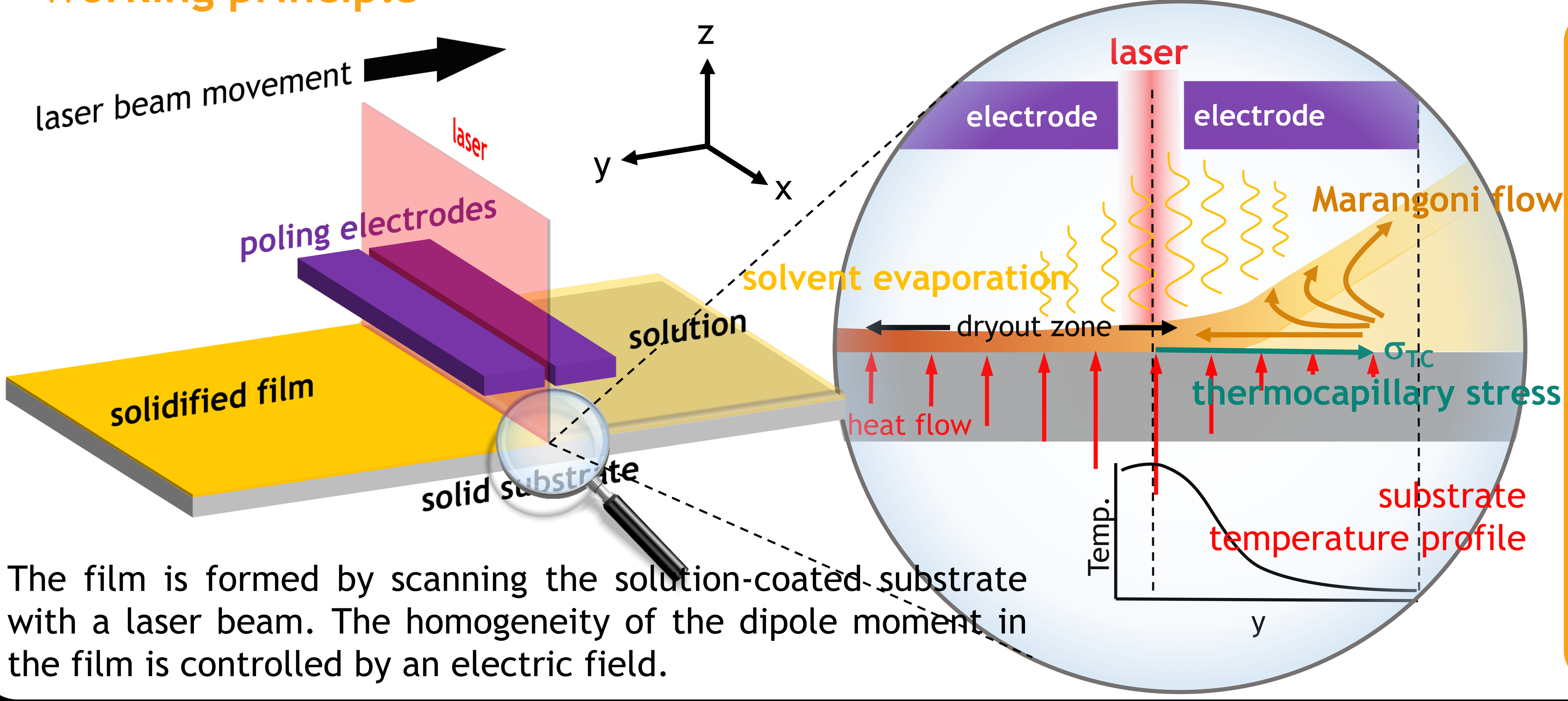
Motivation

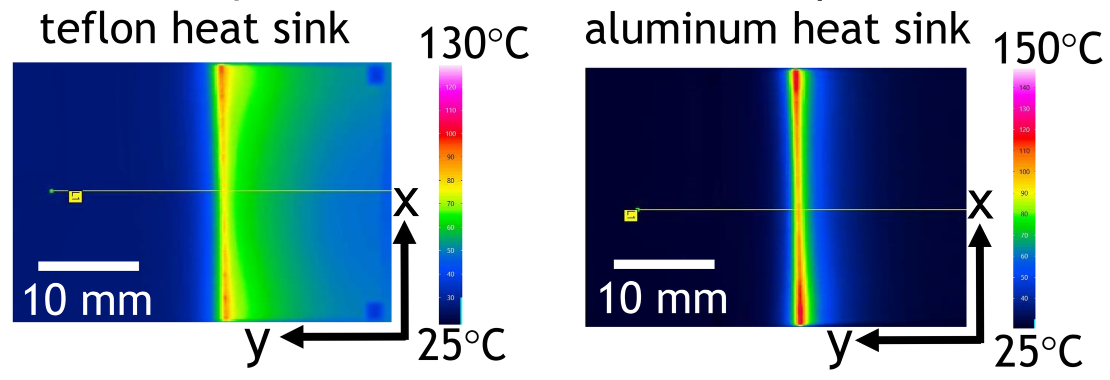
Fabrication of flexible thin-film-based electronic devices, represent examples of a growing number of material technologies that require large-scale thin functional films deposition. There are several technologically-proven deposition solutions available such as roll-to-roll (roto)gravure/doctor blade coating, spray coating, or inkjet printing. Quite often, however, implementation of a particular thin film deposition technology is limited by scalability of the deposition method. The other challenge today is coating films on wavy, dimpled or other non-flat surfaces. Contact methods, like most of the listed above, typically fail in film deposition on non-flat surfaces. Hence, we are developing a contactless method of surface coating. We use lasers to manipulate solutions on solid surfaces and induce crystallization. Hence, we call the method Laser-Assisted Zone Crystallization (LAZEC). We demonstrate here the working principle and exemplary applications of LAZEC.

Working principle



The film is formed by scanning the solution-coated substrate with a laser beam. The homogeneity of the dipole moment in the film is controlled by an electric field.

Temperature profiles on glass substrates

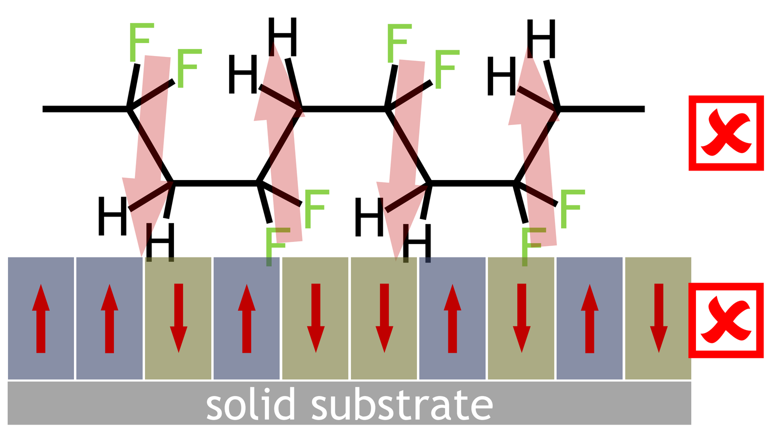


Substrate temperature and its gradient can be controlled by the laser power and heat dissipation. Electric field (E) was controlled within the range of 0-0.2 MV/m by changing the voltage at poling electrodes (the counterelectrode under the substrate is not shown in the graphics)

Ultrathin polymer films for piezo-writing

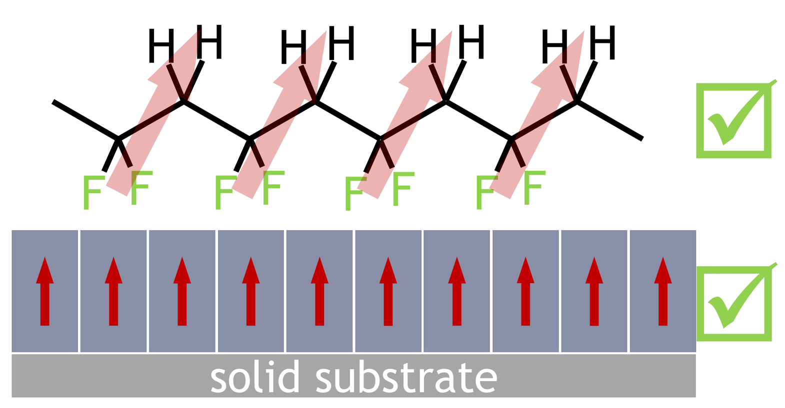
The challenge is to fabricate piezoelectric poly(vinylidene fluoride) (PVDF) thin films. Rendering PVDF piezoelectric requires fabrication of the oriented β-polymorph crystals at the large scale. PVDF spontaneously crystallizes into the α-polymorph. The α-polymorph is electrically inert.

α-polymorph/unpoled: crystal dipole moments cancel out

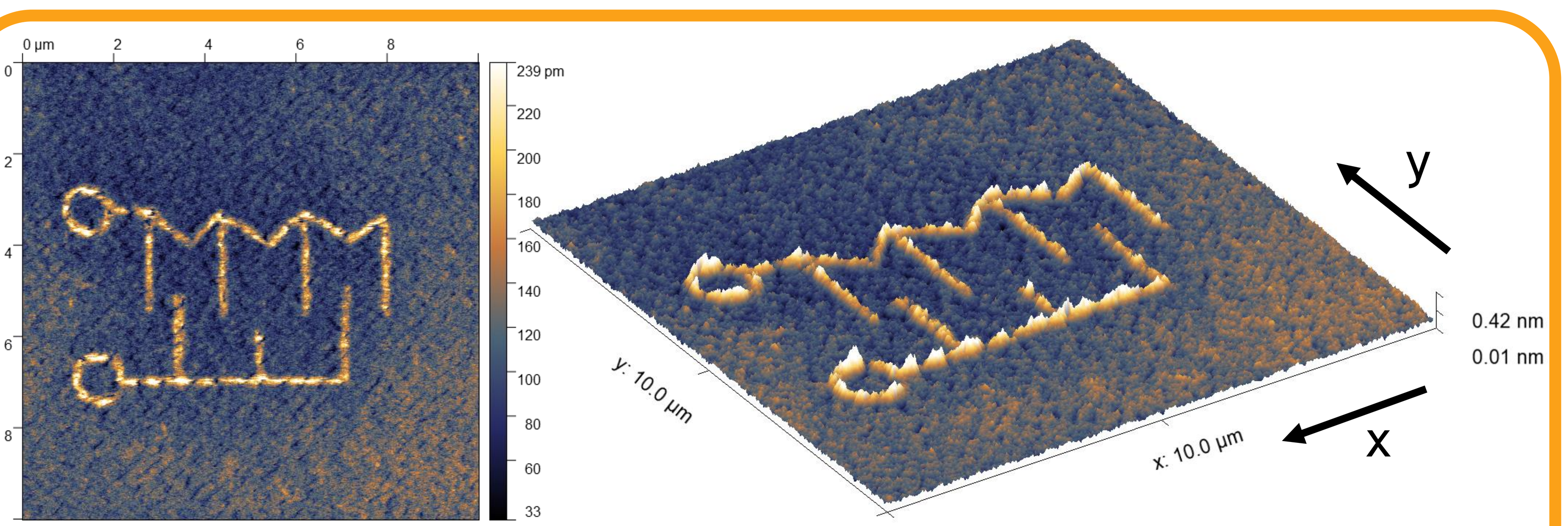


E=0 MV/m

poled β-polymorph: the crystal dipole moments unidirectional



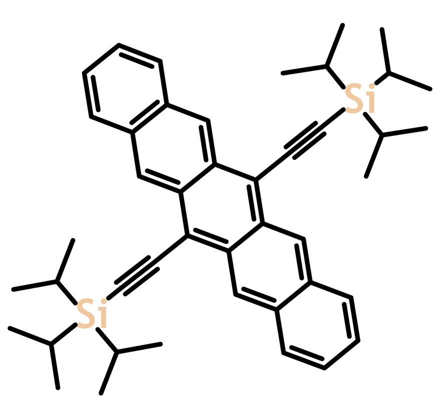
E=0.2 MV/m

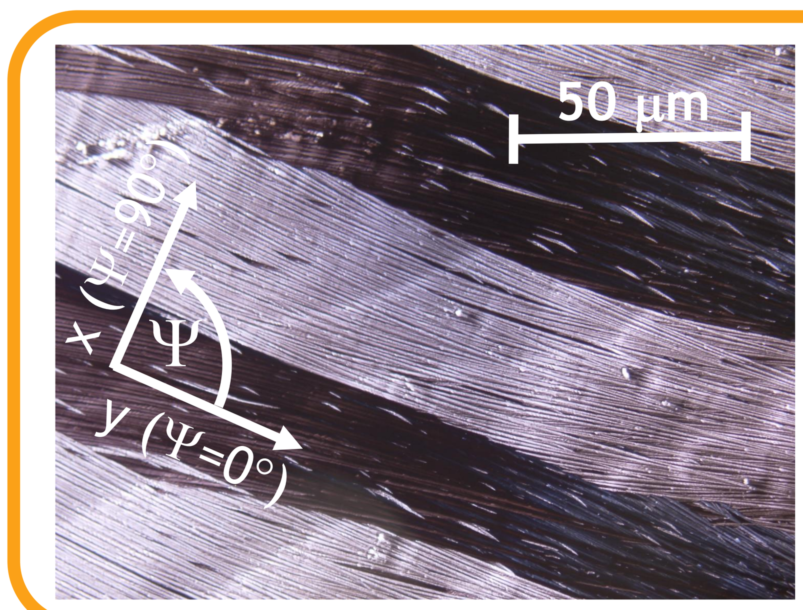


AFM topography of the 50 nm, poled β-PVDF film LAZECoated from DMA solution on glass-ITO ultra-flat substrate. The poling field was 0.2 MV/m. Formation of the β-PVDF was controlled by appropriate solvent/temperature selection.

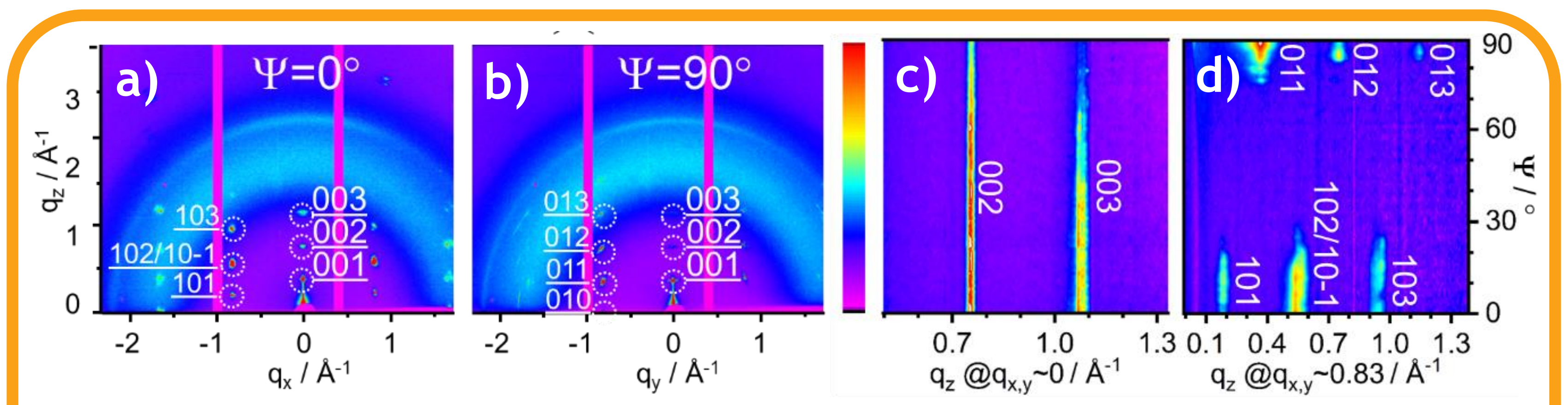
Anisotropy control in organic semiconductors

Organic semiconductors are typically used in the form of thin films. At the laboratory scale they are often fabricated by spin coating or contact methods, such as Dr Blade or meniscus-guided coating. Scalability and therefore implementation of the laboratory methods in real life technologies in such cases is an issue.





Polarized optical micrograph of the 30 nm TIPS-pentacene film. The apparent hole mobility determined from series of thin-film field-effect transistors was $\mu_{h(y)}$**=0.09 cm^{2}V^{-1}s^{-1}** in the coating direction (y) and, **0.02 cm^{2}V^{-1}s^{-1}** in transverse direction (x).



GIXD patterns (12.85 keV, P03/PetraIII) of the 40-nm LAZEC-coated TIPS-pentacene exposed to X-ray beam along the y- (a) and x-axis (b). Intensity variation of 00l (c), h0l and hk0 (d) as a function of the angle (Ψ) between x- and y-axis

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Interesting work? Ask the presenter about the movies showing how does the LAZEC perform and what we coat with it. We are open to cooperation ☺

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