Structural insights into semicrystalline states of electrospun nanofibers by SAXS and WAXD

Empa
Materials Science and Technology

1. Introduction

- Electrospinning has been established as a technique to produce nano- and micron-sized fibers, seeking to address a growing interest in biomedical and tissue engineering, energy storage, and environmental applications
- The effectiveness of these fibers is sensitive to variation in molecular arrangement affecting the internal structure, being highly dependent on the polymer type, the spinning solution properties, and the spinning parameters
- Through small-and wide-angle X-ray scattering detailed structural insights of Poly(vinylidene fluoride-co-hexafluoropropylene) (PVDFhfp) has been obtained

2. Fabrication

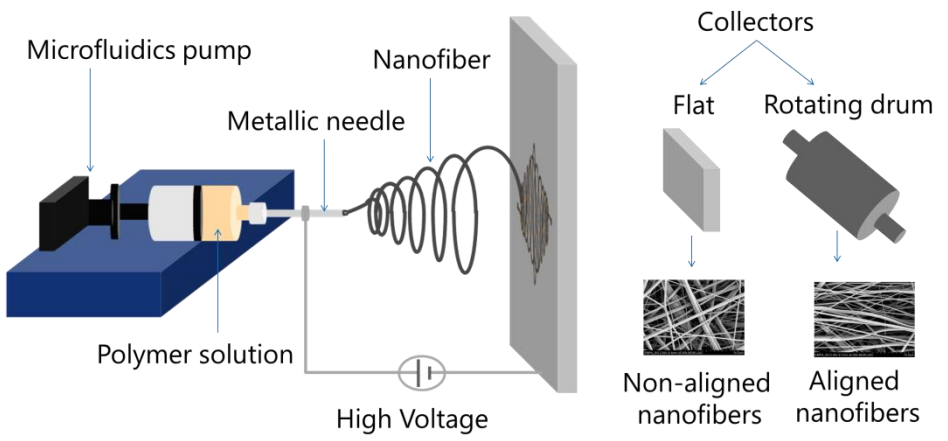
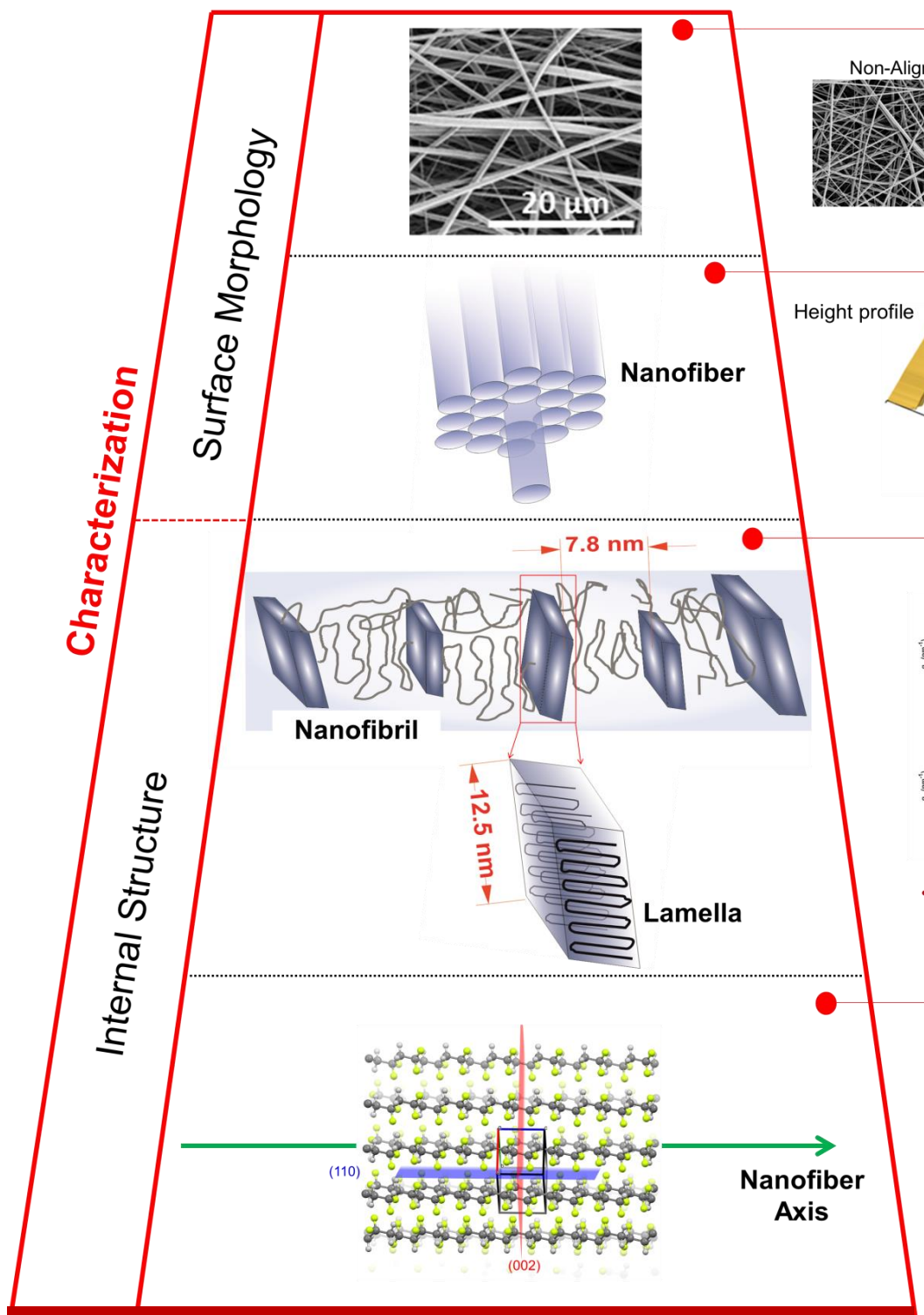
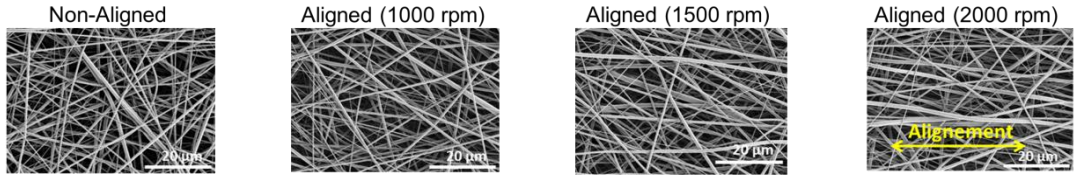


Figure 1. Schematic of electrospinning setup for producing alinged and non-aligned nanofibers.

3. Results



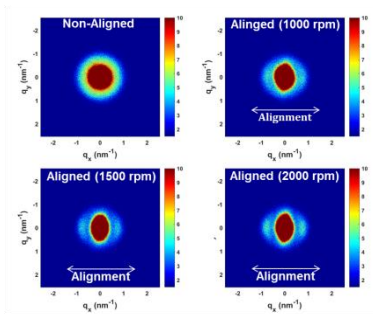
Scanning Electron Microscopy (SEM), > 1µm



- Average diameter of the nanofibers in all samples = 500±230 nm

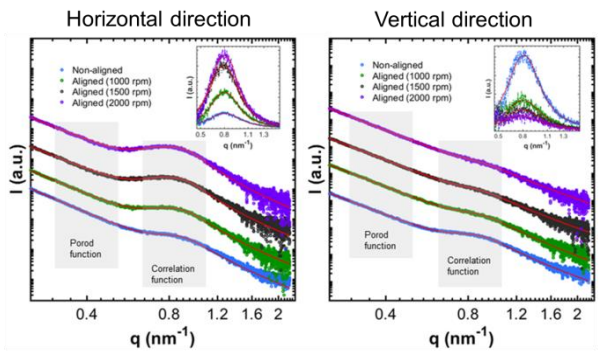
Atomic Force Microscopy (AFM), < 1µm

Small Angle X-ray Scattering (SAXS), 1-100 nm



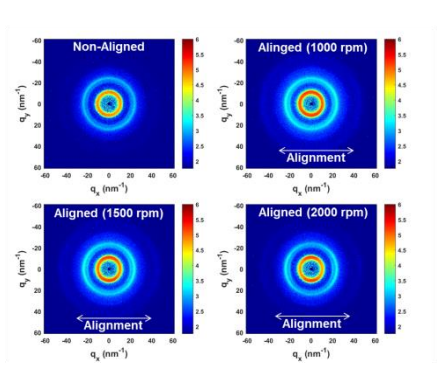
- Porod-Correlation peak model

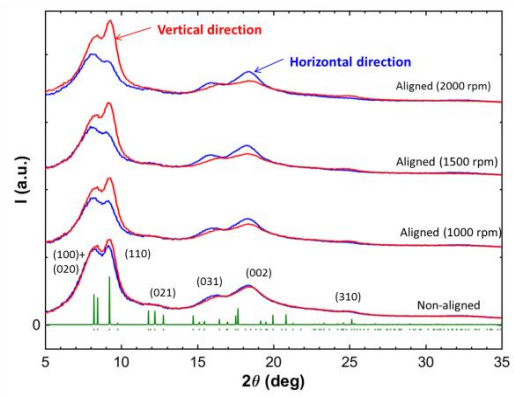
$$I(q) = \frac{A}{q^{\alpha}} + \frac{B}{1 + \left(\frac{2|q - q_0|}{w}\right)^m}$$



- Average spacing between two lamella = 7.8±0.1 nm
- Average thickness of lamella = 12.5±0.1 nm
- Varying surface roughness along and perpendicular to nanofiber axis

Wide Angle X-ray Diffraction (WAXD), <1 nm





- The diffraction peaks were indexed based on the PVDF α phase (CCDC No 1207416)
- Diffraction plane is based on the monoclinic space group symmetry P21/c within an orthorhombic cell setting (a=4.96 Å, b=9.64 Å, c=4.62 Å, α=β=γ=90°)

4. Conclusion and Outlook

X-ray scattering-based approach has been developed to understand the nanofiber morphology which will allow an improved control of nanofiber development during fabrication through detailed feedback and further attunement of nanofiber properties.

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Anjani K. Maurya, Lukas Weidenbacher, Fabrizio Spano, Giuseppino Fortunato, René M. Rossi, Martin Frenz, Alex Dommann, Antonia Neels and Amin Sadeghpour, Nanoscale. 2019, 11(15):7176-87