Thermal conductive properties of nanocellulose/hBN based substrates for flexible organic electronics

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Abstract

Green renewable biopolymers have attained extensive attention recently in advanced electronics and wearable sensing devices to decrease the cost and, above all, to replace nonbiodegradable dielectric thermoplastic polymers (e.g. BOPP and PVDF) while retaining device's flexibility and boosting their recyclability. Among them, nanocellulose/NC has gained particular attention due to its inherent biocompatibility, biodegradability, and cost-effectiveness [1]. NC consists of linear cellulose chains of repeating ß-D-glucopyranose units, covalently connected through b-1,4 glycosidic bonds, which symmetrical molecular structure with dipole moments of C–H and C–OH bands generate a strong polarity, and yield differently semi-crystalline structures by intra- and intermolecular H-bonds between adjacent glucose groups, all beneficial for dielectric properties. / A dielectric substrate with attached electronics should also possess good thermal transport capability to dissipate the heat produced by the Joule (resistivity) effect during its operation, thus not affecting its function adversely. The thermal diffusivity of NC films can be obtained by reducing the thermal resistance at the interface between the fibrils/crystals with an increased interaction (chemical and/or H-bonding) through their highly aligned anisotropic (LbL) structure and/or the introduction of thermally-conductive 2D nanofillers [2]. Herein, films were prepared from differently semi-crystalline and surface-charged NC (nanofibrils / CNFs, nanocrystals / CNCs), with and without the addition of 2D mono/multi-layered hBNs, to examine the impact of polar (−OH, −COOH, $-SO_3$) surface groups, NC crystallinity, hBN lateral size (0.1 – 30 μm) on the film morphological (Figure 1), dielectric and thermal dissipation (through-plane, in-plane) properties. The electrostatic repulsion, hydrogen bonding and hydrophobic interaction between the hydrophilic surface/terminal groups on NC and hBNs were shown to render their self-assembly distribution and organization into morphologically differently structured films prepared by up-scalable vacuum filtration and, consequently, different thermally conductive and mechanical properties. Acknowledgement: This work was supported by the Slovenian Research and Innovation Agency (J2-60048, P2-0424), and the Ministry of High Education, Science and Innovation (Flag-Era 2D-PAPER).

References

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Figures

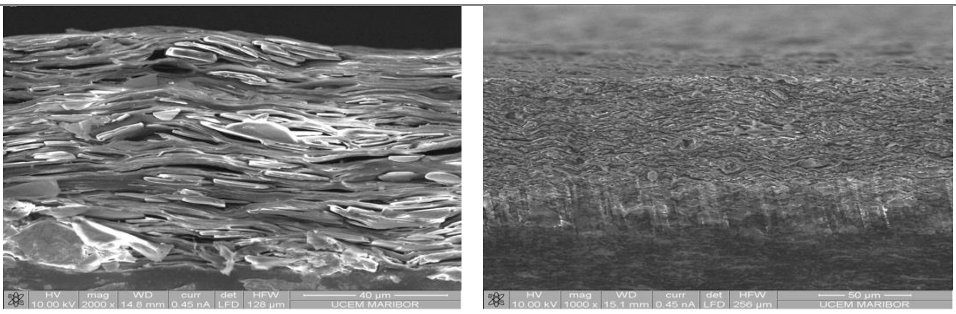

Figure 1: Morphology of CNF films prepared with 20 μm (left) and 5 μm (right) hBNs.